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)

Report on Regional Baselines

Deliverable D1.1

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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 NbS beyond the NBRACER regions and across biogeographical areas.

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Summary

This Deliverable 1.1 document describes the process of working on the regional baselines within the NBRACER project. This document is a cover note describing principles, the content and the results of the baselines. The regional baseline reports will be separately submitted as annexes.

The regional baseline describes the current situation in each region and is to be seen as a common starting point for the regional transformation adaptation journey of the partner network.

The making of the baselines started with the creation of a framework for setting up the regional baselines, which are based on the Mission Adaptation Climate Change and its underlying concepts, incorporating the principles of regional, transformative and systemic approaches.

The framework and the relevant approaches have been made operational by developing a template for the regions, to describe the current situation in the region, from the perspective of the natural system (soil, water, morphology, landscape) as well as from the social system (policies and governance, economy, social). Next to this basis of regional information, a description of the Climate Risks assessment in the region is part of the regional baseline.

All NBRACER demonstrator and Replicating regions have contributed to the inventory of regional information by filling in the templates. Wageningen Research did additional desk-research to complete the set of information to produce the regional baselines. The regional baselines have been described in reports. Also PowerPoint presentations have been prepared for sharing the baseline information at the Regional Workshops in the NBRACER Demonstration and Replication regions. In these workshops, the baseline has been presented and discussed, to create a common starting point among partners for the Transformative Adaptation Journey.

After the regional workshops, the baseline reports have been drafted and reviewed by the regions, before finalizing the reports.

Within the NBRACER partners network, a feedback session on the process of creating a regional baseline process and of the value of the baseline for the regions has been conducted. Also, the potential future use of the baseline and the value of the baseline as a living document has been discussed. This evaluation was part of the General Assembly (March 2025) and took place in a MIRO environment.

Keywords

Nature-based Solutions, Climate Risks, Landscapes, Natural System, Social System, Governance, Regional Development, Transformative Adaptation Journey, Mission Adaptation Climate Change.

Abbreviations and Acronyms

Acronym	Description
CINEA	Climate, Infrastructure and Environment Executive Agency
GDP	Gross Domestic Product
KCS	Key Community Systems
MACC	Mission on Adaptation to Climate Change
NbS	Nature-based Solutions
SDG	Sustainable Development Goals
TAJ	Transformative Adaptation Journey
WP	Work Package

Introduction

This Deliverable 1.1 is a cover note on the development of regional baseline reports for NBRACER regions, focusing on the function and the structure of the regional baseline, and on the process of the making and the sharing of the Baseline with regional partners.

All Demonstrating Regions (five) and Replicating Regions (three) have developed a Baseline as starting point for their collaborative Transformative Adaptation Journey. For all Demonstration Regions, reports have been made as a Deliverable. All Replicating regions have presentations of the Baseline, used in their regional workshops. The reports and the presentations are submitted as Annex to this D1.1 cover note.

1 Regional Baseline and the Transformative Adaptation Journey

As NBRACER aims for systemic transformation at the regional level, the Transformative Adaptation Journey (TAJ) (which can be referred to the Regional Resilience Journey from Pathways2Resilience) will be used to bring forward the regional transformation. This approach is originally based on the climate adaptation policy cycle, but is extended with elements of regional development, as the interplay and collaboration between public, private, knowledge and societal partners is relevant to embed the approach optimally at the regional scale.

The first phase of the TAJ (Figure 1) - preparing the ground – is focusing on understanding and bringing together what is already being done in the broader policy, social, environmental, and economic contexts, understanding who are the key actors and institutions needed to involve, understanding the socio-economic context and available resources, and providing evidence to determine regional priorities and opportunities for sustainable, climate-resilient regional development. Climate risks and opportunities for prosperity also need to be assessed. At the end of this phase, regions should have a comprehensive baseline covering, among others, risk assessments, adaptive capacity needs, a stakeholder map and a monitoring framework that will act as a solid foundation for the journey[1].

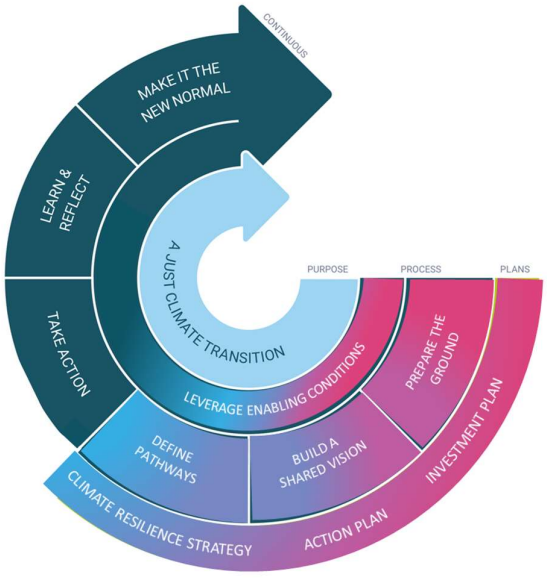

Figure 1: Transformative Adaptation Journey[2].

The baseline plays a crucial role in preparing the ground for the regional adaptation journey. The baseline is a report describing the characteristics of the region, the natural system as well as the social system, and the way they are connected. In the baseline also the climate risks of the regions are described. The baseline is being developed by regional partners themselves, bringing together

[1] The Transformative Adaptation Journey - DesirMED
[2] Pathway2Resilience

the basic information of the region and sharing it with each other. The baseline is to be seen as a common starting point for partners for the co-design process of developing a shared vision and defining pathways, the next phase of the TAJ.

The connection of this vision and its pathways within the region is constantly affected by dynamics from climate change, both for ecological and social-economic systems. It will be important for a region to be aware of these dynamics and to constantly adapt to these changes and find new opportunities to optimize visions and pathways. The concept of the baselines and the base of information and insights of the region are a tool to provide continuity across these actions. The required regional information should subsequently be updated or added, if necessary. With both social and environmental dynamics constantly in flux, the baseline itself should reflect this dynamic nature. As the regional passport, it should evolve as a living document, reflecting the development of a region.

2 Regional Baseline and NBRACER Approach

The NBRACER Approach is built on a system of systems, comprising of three interconnected core domains: the biophysical, socio-cultural and governance. The baselines are a first qualitative and quantitative step in bringing these aspects together. Connecting these systems and domains is facilitated through the making of a baseline and fits within the steps of the NBRACER Approach.

The first NBRACER step of embarking on a journey of regional resilience is *establishing a regional baseline for joint understanding among stakeholders of natural and social systems*. This consists primarily of a *Regional Systems Analysis*, in the baselines and the respective first regional workshops, of Work Package (WP) 1. Therefor we have collected data and information about the natural, human and governance systems that are forming unique characteristics of the region, enhancing or affecting its regional resilience.

More specific resilience characteristics will be elaborated using a multi-hazard approach and spatial data to map Key Community Systems (KCS). This quantitative exercise provides the mapping that provides the basis for an analysis of appropriate adaptation solutions. These qualitative and quantitative parts of the *Regional Systems Analysis* provide the corresponding language for both the quantitative and qualitative actions in NBRACER.

The regional workshops are organized with a mixed group of stakeholders, and provide further input for the baselines. The baselines have, prior to these workshops, figured as a knowledge tool for project officers working in NBRACER. The baselines have been deployed to varying degrees between the regions.

The following step of the baseline involves risk and resilience assessments, which align more closely to the quantitative exercise undertaking. Based on the baseline, within the regional workshops, the partner network will go to the next step in the TAJ and the NBRACER approach, forming a regional vision and developing the pathways. These pathways rely on the qualitative aspects in the baselines, as they shape an understanding of the inclusive governance strategies, NbS tools and the interaction between human-social-governance aspects overarching these actions.

Here, the link to WP 5 and their action of providing *Decision Support for Portfolio/Pathways* is of relevance. The action in this WP should take into account the qualitative interactions of the region, where especially social and governance aspects, and in turn environmental characteristics, are *not always easily quantifiable*. As such, the baselines provides a marker to align between the dynamic process framework of WP 6 and activities in WP5.

For the successive steps, the baselines serve as a reference for the interaction between social, environmental and governance aspects.

3 The Aim of the Regional Baseline

3.1 Overall Aim

The regional baselines serve a crucial role in the TAJ journey. The main objective of this task to develop regional baselines is;

> *To prepare a common ground on the current state and preparedness of the region to climate change and NbS, from natural and social systemic perspective, to create a basis for developing and a drive for engaging towards a resilient region.*

The regional baselines aim to bring together regional information that is deemed crucial for a systems transformation approach. Such an approach requires a joint understanding of the regions' natural and social systems and how these two are interrelated. A regional baseline provides the starting information required for co-developing this common understanding of the region among its associated partners, by collecting information, sharing the baseline information and discussing the findings. It provides information for the process to develop the *regional narrative* as the basis for adaptation efforts. This common ground will open up about the potential for change and dynamics in the region, will help to drive collaboration among people and organizations and will encourage commitment for progress towards systemic nature-based resilience/adaptation.

A regional baseline is a stocktaking exercise to map regional climate change impacts and the potential role of NbS in adaptation efforts. As a *common exercise*, the regional baselines thus also aim to support in the design, planning and implementation of NbS that address and fit the regional characteristics. A baseline gives direction to a region's specializations, unique characteristics, as well as the region's potentialities and challenges concerning climate adaptation, by using NbS.

NBRACER uses a systems-based approach. This means it relationally considers the social, environmental and economic aspects of a region. By engaging with the regional partners in the making of a baseline, a baseline also aims to contribute to this practice of common sense-making. A joint commitment to mapping the issues in a region starts with the assumption that social and natural issues are to be considered in tandem. Our aim is that a baseline facilitates this connection, and provides the start for common visions of the future, and relational pathways to match.

3.2 Systemic Approach and Key Community Systems

A baseline adopts a systemic approach to comprehend the challenges that climate change poses on a region. The systemic approach is used to better understand the intricate relationship between the natural system and the social system. This approach originates from the Sustainable Development Goal's wedding cake (Figure 2) that illustrates the connection of economies and societies with the natural system. In order to have a well-functioning economy and society, these aspects should be accounted for in dealing with the underlying natural system.

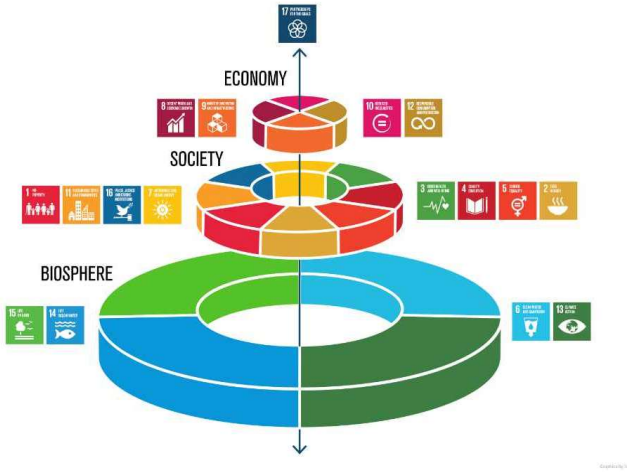

Figure 2: Wedding Cake of Sustainable Development Goals (SDG), United Nations.

In the baseline, the various aspects of the natural and social systems and their connection are being analyzed. This aims to move away from a sectoral approach, which is often used in climate change assessments that considers nature separate from society and economy. Instead, our interconnected take promotes a more systemic approach that focuses explicitly on the interrelationship between natural and social systems. NbS should have the inherent potential to strengthen this connection by sustainably leveraging the natural system's capabilities to address societal issues and to balance with the social system.

Within this approach, three key components are delineated: the natural system, the social system, and the connection between these two systems. This includes the governance that is in place to ensure natural and human systems are in balance. Or, to develop an integrated approach to observe how the regions functions, how the systems are related and how the systems interact. Approaching climate change in a systemic way enhances understanding of the systemic issues that lead to climate change impacts. It aims to provide a better understanding of how systems can be adapted in order to (re)gain a balance between the natural and social systems given the context of climate change.

Related to this systemic approach are the "Key Community Systems (KCS)", a new concept defined by the European Mission on Adaptation (European Commission, 2021). KCS are systems that meet basic needs for society but might be impacted by climate change. As the climate risks in most of the regions already have been assessed at the start of the NBRACER project, the concept of KCS (Figure 3) is a new concept for project partners, with no clear operationalization and with limited available information. The baselines summarize the available regional information on climate change risks, often based in regional risk assessments, and try to assess the related vulnerabilities of the KCS due to climate change. The assumption is that, to safeguard our wellbeing, we need to assess the needs for transformation that ensure that the KCS keep on meeting basic needs. The EU distinguishes five KCS: the land use and food system; water management system; critical infrastructure system; the health and wellbeing system and, the local economic system. The Mission Climate Adaptation envisions 'ecosystems and nature-based solutions' as the overarching means to protect these so-called KCS against negative impacts of climate change, and to

contribute to regional resilience. In this sense, the regional ecosystems provide a framework that sees social functional systems aligned with its biophysical realities.

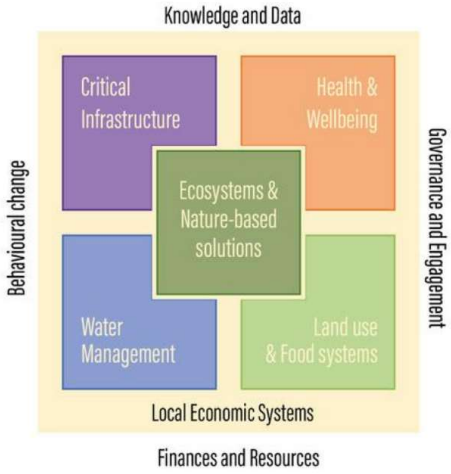

Figure 3: Key Community Systems according to the EU Mission Adaptation Climate Change Implementation plan (2021).

3.3 Collaborative and Inclusive Approach

The European Mission on Adaptation to Climate Change acknowledges the need to involve organisations beyond the conventional public actors when it comes to building resilience. It is crucial that private, knowledge and societal partners are involved in the regional TAJ. Alongside public actors, this is encapsulated under the 'Quadruple Helix' umbrella. The inclusion of these actors means that these partners need to be mobilized and engaged in the various phases of the transformational process. This mobilisation starts with collaborating on directions and solutions to cope with climate change, and to create dynamics and initiatives within the specific regional context. All regions have specific characterization and qualities and should be able to develop specific solutions and services for climate adaptation and Smart Specialization.

The European Strategy on Climate Adaptation (European Commission, 2021) also promotes the principle of just resilience, indicating that adaptation processes have to be inclusive in order to avoid the risk that adaptation measures put an uneven burden on some groups and that marginalised groups may not be properly included in planning and decision-making processes. Therefore, it is crucial to better understand who in the region might be unequally affected due to climate change and to ensure that they are well engaged in the development and implementation of adaptation measures.

The interactions between environments, people and their social functions are well seen by research. As such, extreme climates and their impacts are of urgent issue, with vulnerability being a key concept to guide action. Maladaptation, where adaptation efforts create or exacerbate existing vulnerabilities, help provide a normative guide on what 'counts' as vulnerability (IPCC, 2018). More on the natural and social aspect below.

4 Regional Baselines: Method and Content

In this section, we detail the process of constructing the baselines and the type of content covered.

4.1 The Method

To creation of the Baseline consist of different phases (Figure 4). We first defined and listed the required information topics to get a better understanding of the systems characteristics. As mentioned earlier, the baselines examine both the natural and social systems, with a focus on their interconnections and the KCS. For each component, we identified the specific information needed to gain the desired insights for the baseline. The approach has been discussed among NBRACER WP1 partners, with all the WP-leads and shared with the regional partners. More detailed information about this systemic approach and its individual components are detailed below.

Figure 4: The process steps of the regional baselines.

To gather basic information for the baseline, we distributed a template / questionnaire (Annex 1) with the relevant aspects to regional NBRACER partners based on the list of required information topics. All WP-leads have been invited to comment on the online draft version. The region, with its valuable insights into local conditions, significantly provided information to the understanding of vulnerabilities, challenges, and opportunities. This collaborative collection and exchange of knowledge and information formed the foundation of our regional baseline.

Additionally, this information has been extended and with desk research, mainly by search in online sources. We thoroughly reviewed existing reports, data, and materials to enhance the insights shared by the regions. Our goal was to create an initial overview of the region's current state—a snapshot that captures its unique characteristics, risks, and adaptive potential.

The baseline serves as a starting point for the NBRACER project within the Demonstration and Replication regions. During the regional workshop, the Baseline has been presented with the regional stakeholders who participated. Also additional information has been collected and was incorporated it into the baseline when needed. Our aim is to align with the regional perspective and regional expertise, ensuring that the baseline reflects the region optimally. The Baseline has the potential to evolve dynamically throughout the NBRACER project and to function as a living document.

4.2 The Content

The baseline comprises a collection of general regional information, both qualitative and quantitative data. The baseline adopts a systemic approach to comprehend the intricate relationship between the natural system and the human/social system. Within this framework, three key components are delineated: the natural system, the social system, and the connection between these two systems. Through this systemic approach, a clearer vision on mechanisms to create a resilient region and to define pathways by using NbS can be attained.

4.2.1 The Natural System

Climate risks often arise when there is an imbalance between the natural system and how we, as humans, have structured and utilized it. Therefore, it is crucial to understand the natural system. To create this shared understanding and knowledge, we aimed to combine insights from various aspects of the natural system to understand how it has shaped the region today and how it has changed over time.

If available, the sections included are:

- Landscape
- Soil system
- Water system
- Biodiversity
- General climate data

The narrative of the landscape was developed by integrating data on how the natural system has changed due to natural processes and human activities. This included examining the geomorphology, climate, soil systems, water systems, and natural ecosystems, and understanding their development through time. Examples of data used are maps of the soil, water and nature system, hydrological data, scientific reports on regional morphology, soil, water and nature, and climate data.

The analysis combined the various data sources to gain insights into the role of the natural system over time and the current state. By building our narrative from the foundation of the region's formation history, we aimed to provide a comprehensive understanding of how the natural system has evolved. Combined with the insights on the social-ecological system, it helps to improve understanding on regional climate risks and NbS opportunities.

4.2.2 The Social System

The social system contains the societal and economic characteristics of the region, and the current policies and strategies relevant to cope with climate change, climate adaptation and NbS.

The description of the regional social structure covers various demographic aspects, some brief statistics on income, poverty and unemployment. From the concepts of "just transition", "climate justice" and "just resilience", we can learn that there are vulnerable groups (elderly people, immigrants, poor people) in society which are not able to take adaptation measures by themselves, due to a combination of low income and unawareness. These people often live in vulnerable areas. The inventory gives insight into the presence of those groups in NBRACER regions.

Next to the demographic structure, the regional economic structure is described: Gross Domestic Product (GDP), employment rate, economic structure; presence and characteristics of primary sector, industry and service-related private sector. Also, the strategies of regional development are described, regional innovation strategies on smart specialization (RIS3), based on the regional characteristics, strength and qualities, compared to other regions, potential to develop place-based value added activities. Regions are challenged to define missions at regional level, on finding out how to cope with transition, and to find answers to grand challenges, like solutions for dealing with climate change.

The regional innovation strategy and the Mission-driven approach are both based on the concept of quadruple helix interplay, focussing on the interplay and collaboration between partners representing the domains of public sector, private sector, knowledge domain and society (Figure 5). Within the baseline, we have mapped the current participation and the representation of organizations.

Figure 5: The quadruple helix.

Further, the mapping of relevant policies is part of the regional baseline, with a focus on coherence between policies of different levels (EU, national, provincial, regional and local), and on the multi-sectoral policy approaches on climate change (climate policy, policy on soil, water, nature, spatial planning, agriculture, circular bio-economy etc.).

By mapping the aspects above, the governance of the region can be characterized (the organisation of policy responsibility, decision-making characteristics, the interaction of regional partners around adaptation) and directions for improvement of enabling factors and conditions for transformative change can be formulated.

4.2.3 Connection Between the Natural and Social System

Various ecosystems are facing (future) risks due to human activities and climate change. Climate change is impacting ecosystems due to sea level rise, increased storm intensity, temperature changes, and altered precipitation patterns. Such climate changes are projected to contribute to habitat loss, altered species compositions, and disrupted ecological balances.

The social system in Atlantic Regions is dependent on the local natural system, mainly because of the significant importance of the agricultural (pollination, water availability, soil fertility) and tourist sectors (recreational activities in nature and along the coast) for the regions, but also for the health and wellbeing of the people living there. Another economic sector that relies on natural systems is the energy sector, which consists largely of wind energy.

The regional approach of the MACC indicates that the connection between the natural and social system is acknowledged. NbS do play a role in this green transition. In the identification of benefits, the (co-)benefits of adaptation action for strengthening regional resilience, nature and biodiversity, as well as for leisure and recreation are obvious for most of the regions. The contribution and the (co-)benefits of NbS for preserving the KCS are often less acknowledged.

Within the regional baselines, the interaction between the natural and social systems has been described briefly. The lessons are at the level of regional abstraction, giving an overview of the issues of governance, particularly focused on policy and local/regional government. This section also provides a very brief inventory of existing NbS and their role in bridging the systems.

5 The Regional Baseline Results

5.1 The Regions

The baseline study has been conducted for all the NBRACER regions. All regions have filled the template and have presented the baseline report during the Regional Workshops. The Demonstration Regions have organized their workshops in May-June 2024. For these workshops, WR team has prepared the draft Baseline report and a PowerPoint presentation. The Baseline reports have been finalized in the second part of 2024. The Replicating regions have started their collection of basic information on the region in Q3/Q4 2024, by also filling in the templates. The regional workshops took place in Feb 2025. WR has prepared a PowerPoint presentation for all three of Replicating regions. The presentation is for the Replicating regions to be seen as the final Baseline product for D1.1. The products are Annex (2-9) to this Deliverable. Below we show some insights (descriptions and preview slides) in the Baseline results of NBRACER regions.

Demonstrating region Central Denmark

The Baseline in Central Denmark was the first finalized baseline because this region has planned the first regional workshop. The template was filled in by Aalborg University, and Wageningen Research has searched online for additional information, in order to understand the systems and to be able to write the report and prepare a presentation at the Regional Workshop.

It became clear that only a part of Central Denmark belongs to the Atlantic Biogeographical Region. Also, it became clear that also Northern as well Southern Denmark face similar challenges with climate change and NbS can be applied on whole of the Atlantic Coastline. Main risk is flooding due to sea level rise, water transported by rivers and precipitation. Climate Adaptation plans have been prepared at local level. Coordination from regional government is lacking. Focus is on City of Lemvig and the Klimatorium concept in this city. Connection of Climate cluster with cluster of Water Valley is key. The baseline has been presented at the regional workshop (Figure 6) and is used in a common exercise to explore the relation to the KCS.

Figure 6: Slides from baseline presentation Central Denmark.

Demonstrating region West Flanders

The regional baseline has been prepared in an interplay between Wageningen Research, the Province of West-Vlaanderen and VITO. Within the Baseline, general information on the Province

of West Flanders has been described. Also, specific information on the focus area of Maleveld, East of Bruges, has been added. The Baseline study has been presented at the Regional Workshop (Figure 7). At this workshop, participants have worked on a shared vision. The regional information has also been used at local workshops with stakeholders in order to plan and design pathways for NbS.

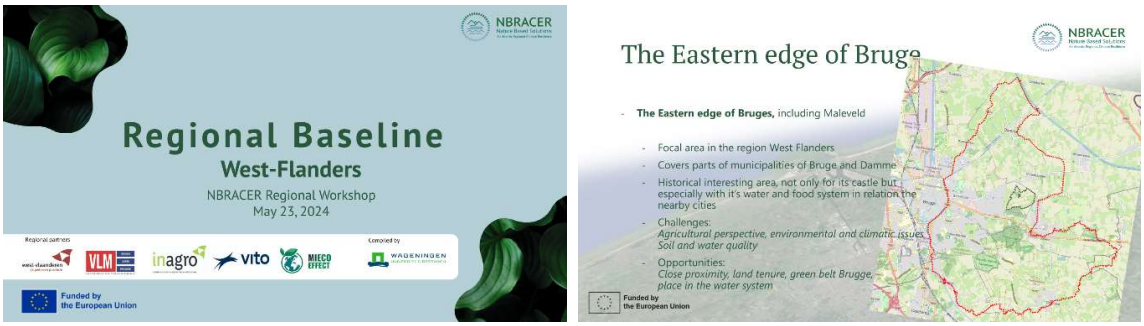

Figure 7: Slides from baseline presentation West Flanders.

Demonstrating region Nouvelle-Aquitaine

The regional knowledge broker organization ('regional IPCC') Acclimatera has provided the template for the regional baseline. Acclimatera is connected to the knowledge domain, and has already collected much information on the regional characteristics and potential directions for climate adaptation. There is a clear connection with leading scientific institutes as well as with the region of Nouvelle-Aquitaine. At the regional workshop, the introduction of the Baseline (Figure 8) has been done by Climate KIC, introducing the frameworks, approaches and principles of the Mission, the TAJ and the baseline, and presenting the social system. The natural system has been presented by regional scientists.

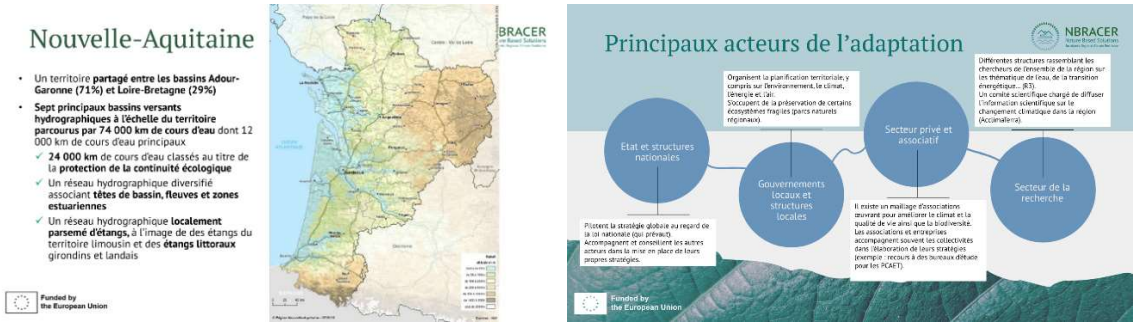

Figure 8: Slides from baseline presentation Nouvelle Aquitaine.

Demonstrating region Cantabria

The regional information on Cantabria has mainly been collected by the regional knowledge partner IHC. As a regional research partner, IHC is well informed on the basic functioning of the region, with focus on the natural system. This organization was also responsible for organizing

the regional workshop, where the NBRACER approach and the Baseline have been introduced by Climate KIC (Figure 9). Many regional partners, for example the project leads on the Demonstrators have been mobilized. The region consists of multiple catchment areas from the mountains to the sea. The governance of the region for the Mission driven approach seemed to be complex, due to mainly political reasons.

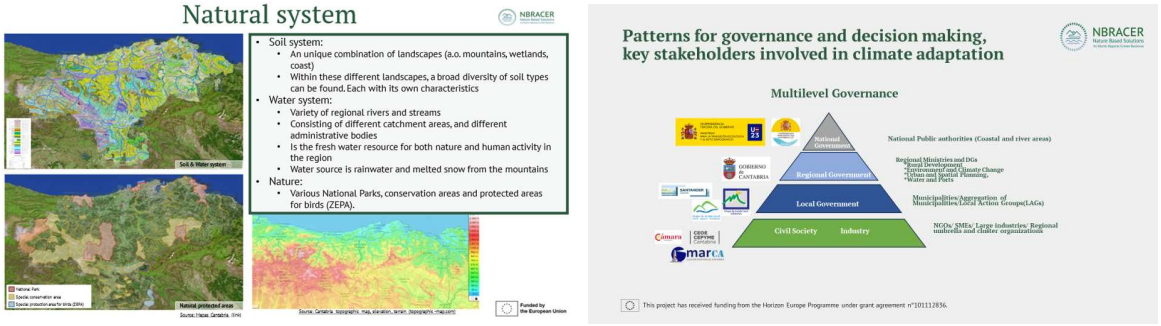

Figure 9: Slides from baseline presentation Cantabria.

Demonstrating region Porto

The information on Porto has been provided by the Porto municipality, a team working on large projects on climate change. This team is supported by the University of Porto, Landscape design department, which has a lot of knowledge on the current local systems, as well on the future directions and design. The Regional Workshop was mainly held in Portuguese. The introductions from the Baseline have been presented by Climate KIC (Figure 10). A Wageningen researcher was present for questions and discussion. Main point of discussion was the elevation of the city, which is crucial aspect in designing solutions for climate adaptation. Other main aspects come from the social system: the integrated planning approach and the involvement of citizens.

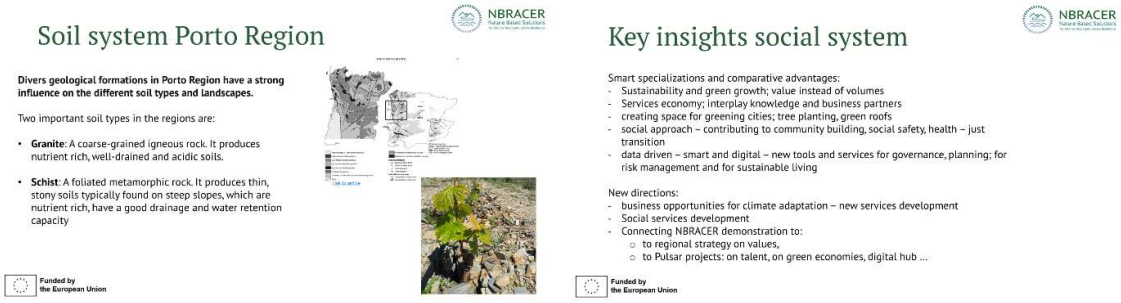

Figure 10: Slides from baseline presentation Porto.

Replicating Region Friesland

The Friesland replicating region has managed to gather most of the regional baseline information by themselves. The template has been delivered as an almost complete report. Friesland has the capacity to source from knowledge institute for the inventory. Wageningen Research has reflected

on the report and has supported the preparations of the Regional workshop (Figure 11). Although Friesland is a Replicating region, there is already much experience with applying NbS to cope with the effects of climate change, on water system and mainly in rural landscape. The interest is to learn how to integrate and upscale the projects and the solutions. Another relevant element from the social system is to strengthen the role of society ("Mienskip").

Figure 11: Slides from baseline presentation Friesland.

Replicating Region East-Flanders

East-Flanders has a small focus area in the municipalities of Ronse, Maarkedal and Kluisbergen. The coordinator of this region has provided already much relevant regional information at the template. Additional information search was mainly focusing on describing the social system. At the regional workshop, the Flemish knowledge partner Vito has presented the Baseline (Figure 12). Next to the risks of flooding and drought in the rural area, there was also much interest in Urban challenges and in vulnerable groups.

Figure 12: Slides from baseline presentation East Flanders.

Replicating Region Cávado

For the collection of baseline information, the Replicating Region of Cávado is supported by a knowledge partner, the University of Lisbon. The introductions from the Baseline have been presented during the regional workshop (Figure 13). As part of Portugal Norte, Cávado is a small region, determined and characterized by the catchment of the Cávado river. The river is connecting cities and landscapes. NbS projects are also planned and designed along the river.

The region has a strong identity and coordination and collaboration at the regional level is taking place.

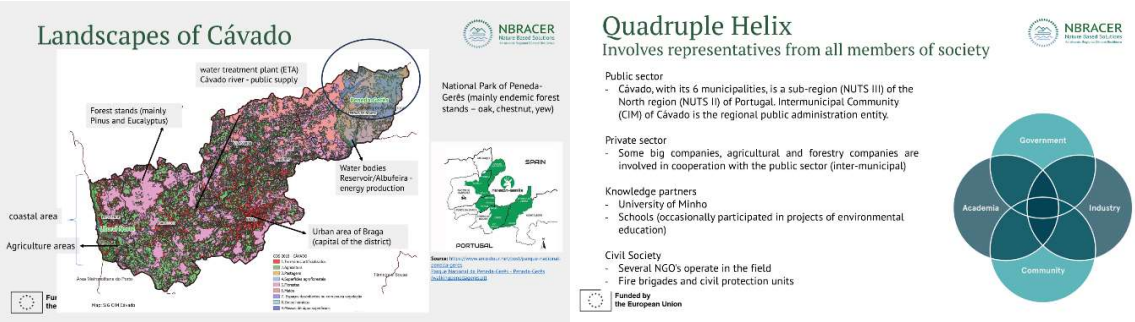

Figure 13: Slides from baseline presentation Cavado.

5.2 The Experiences and Findings

Regions differ from each other in readiness, in volume, in landscape, in governance and in culture. This means that NBRACER partners need to align the tasks and activities as optimally as possible with all of the regions. Also the making if the baselines and the way the baselines are presented and utilized in the regions worked out differently in the various NBRACER regions. Below are some reflections on this process from Wageningen Research as partner, responsible for baseline reports.

- Support of regional knowledge partners in collecting regional baseline information is key; interplay between the regional coordinator, knowledge partner and public sector representative is relevant. Good interplay in France, much information available, broad descriptions and good descriptions.
- Data on the natural system is well available at the regional level. Foremost at NUTS2 (nomenclature of territorial units for statistics) (Nouvelle Aquitaine, West Flanders, Cantabria, Friesland). Also a large city as Porto has much information available.
- Some countries have a Climate Portal, with datasets and maps available (NL and Belgium).
- Risk Assessments have already taken place in all of the regions.
- Social system is more difficult to map. As most of the partners belong to the Climate Community, with a focus on environment, they are not used to mapping socio-economic information and information on policies and strategies.
- Baseline method had to be developed at the beginning of the process. It is a new method, suited for the regional transformative and systemic approach of the Mission. We needed to make these concepts operational, and the NBRACER consortium partners needed to find out if information was available, and if regions were able to collect the information.
- The TAJ was not developed at the beginning of the Baseline trajectory. But the Baseline fits well in this approach, as starting point for the Journey, focusing on gathering and sharing relevant information from a systemic approach as part of ''preparing the ground''.
- Use of Baselines in Regional workshops has varied between the regions. The set up of the regional workshops were different. It is important to take time for preparing the ground,

to share the information, but also to complete the regional baseline commonly, which has not happened in all regions. Some regions struggled to connect and align the NBRACER project with current regional processes, timing, state of development and atmosphere. At least, this took time to find out the best fit, which has hampered the construction and utilization of the Baseline in most of the regions, as a common starting point.

6 Reflections and recommendations

6.1 Reflections

For the reflection on the current baselines and for the creation of future baselines as an activity for *preparing the ground,* we have organized a common feedback session at the NBRACER Online General Assembly, to draw a number of lessons.

The reflection has been set up as a MIRO board (Figure 14), where all NBRACER consortium members were asked to participate. Participants commented on:

i) The process,
ii) The value of the baselines
iii) Lessons learned and recommendations.

Figure 14: The MIRO Board template.

A qualitative analysis of these provides the following insights:

Regions have found the baselines useful for three main reasons:

- Centralized information – The baselines serve as an overview document that consolidates key regional data, making information more accessible and structured.
- New insights about the region – The analysis and reflection process, both in the document and during workshops, provided regions with valuable new insights, particularly on NbS and KCS.
- Unique approach – Some regions particularly appreciated the baseline's methodology, as it included aspects that are not commonly addressed in similar baseline studies.

Looking back at the process, regions encountered several challenges:

- Defining the appropriate scale and level of detail – Striking a balance between comprehensiveness and usability in the baseline reports proved to be complex.
- Changing regional contexts – In some cases, shifts in focus areas required updates or even a complete revision of the baseline.
- Unclear added value – Some regions struggled to see the unique contribution of the baseline, as much of the information was already available.

By reflecting, the regions indicated that the baseline was useful in the following steps of the NBRACER approach:

1. **Regional workshops** – Used for joint in-depth understanding, identifying regional needs, and setting priorities.
2. **Comparative analysis** – Enables comparisons between regions to identify synergies and shared challenges.
3. **Communication and stakeholder engagement** – The baseline supports regional communication and collaboration efforts and to understand the different perspectives of stakeholders.
    - The current document is considered too long. Alternative formats, such as factsheets or presentations, brochures, visuals, and a concise two-page infographic could improve accessibility, particularly for newcomers.
4. **Integration into WP2, WP3, and WP4 co-design sessions** – Suggestion as a next step for using the baseline information.
5. **Monitoring and strategy development** – to inform the development of monitoring strategies and framework

Over time, regular updates and the addition of missing information would be beneficial, including:

- Support in defining scale and level of detail – Establishing a maximum appropriate size to ensure clarity and usability.
- Comprehensive overview of existing NbS – Enhancing the baseline with more detailed information on NbS.
- Continuous updates and integration – Incorporating new insights from workshops and ongoing developments to keep the baseline relevant and up to date.

Reflections on the Baseline development process, the feedback was to:

- Provide clarity on the goal and application within NBRACER approach from the beginning, to help regions better understand its value and use
- More opportunities for feedback and collaborative effort for regional prioritization
- Replicating regions expressed the need for more guidance and resources to develop their own baselines effectively.

6.2 Recommendations

The predominant feedback from the NBRACER consortium was that the baselines were used to a limited extent so far. The baselines have been presented in the first regional workshops. However, the feedback makes clear that the baselines have not been used much. This was due to either i) them being too lengthy and inaccessible, ii) them not being serving a clear goal, iii) unclarity about the use of the baseline and the expectations from regional involvement, iv) the English format as opposed to local language.

These comments by the NBRACER consortium suggest that regions in the beginning of the NBRACER project or at the TAJ were not ready to establish and use the baselines for their regional co-design process. It is important not to relate the baseline only to the NBRACER project, but focus on using the baseline to involve partners in the regional transformative and systemic approaches, beyond NBRACER. Additionally, the format of the baselines, or the way in which the

findings are presented, should be reconsidered. Many reflected that a visual representation of the regional narrative, and their aspects, would help in its usefulness and dissemination.

> *Recommendation 1: Define a clear process of regional involvement, usefulness and embeddedness in the creation of the baseline.*
>
> *Recommendation 2: Consider a briefer (visual) version of the baseline for regional dissemination.*

The creation of the baselines means that creators gain valuable insights into a region, gaining a preliminary grasp of the environmental and socio-economic aspects central to a region. Placing these aspects alongside each other gives the creator an integrated perspective of a region. Input from the feedback session also exposed the limited understanding of the baselines by multiple regions and partners. It was unclear what the baseline was and what use it could have had.

The most useful part was for most the social systems overview, as "this is often less present in other existing baselines", as one evaluator reflected. The broader picture was appreciated, in this respect.

Nevertheless, the creation of these baselines has mostly been seen as input from remote experts, external to the regions. In fact, the contributors were mainly regional knowledge partners and Wageningen Research as responsible NBRACER partner for creating the Baselines. So, the making of the baseline was not envisioned as a co-created process, it has mostly been a knowledge partner that has built a broad overview.

> *Creation Recommendation 3: For the future creation of baselines, the involvement of regional partners (both social and environmental focused) should be enhanced.*

Other than the involvement of experts, one may also consider the involvement of the regional actors in the TAJ in the creation of the baseline. Meaning, the definition of what is important in the region, regarding the environmental and social conditions, is a debate that should be head as an ongoing and dynamic activity. This might more constructively to creating a *regional common ground*, rather than this common ground being built by mostly external and internal knowledge partners.

On the Natural Systems analysis was perceived as too broad for some of the regions. This data is often available at Nuts 2 level, but missing in smaller areas. Analysing and connecting complex data on morphology, soil, water, climate, and nature requires specific expertise. It is essential to have experts who can handle and interpret this data accurately. With co-creation of regional experts, a better common picture can potentially be generated.

> *Creation Recommendation 4: Involve a broader range of regional adaptation actors in defining what is environmentally and socially important in the region.*
>
> *Creation Recommendation 5: Involve (regional) experts that are specialised in analysing complex data on biophysical aspects, as well as complex socio-political aspects in the region.*

7 Conclusion on Regional Baselines

With the EU Mission Adaptation to Climate Change, a new approach on climate adaptation has been developed, focusing on implementation of solutions, by demonstrating NbS in regional practice, with network partners. The Mission has an integrated approach, with attention to the relation between the natural and the social system. As part of this new framework, the concept of KCS has been introduced; NbS should be helpful to prevent society from being affected by climate change and hazards. NBRACER regions and partners collaboratively work on the regional demonstrators. Partners are commonly searching for ways to optimally and collaboratively implement the mission in regional practice. This has led to the operationalization of the NBRACER approach, along the first year of the implementation of the project. NBRACER is following the TAJ, which is inspired by the Regional Resilience Journey, from Pathways2Resilience.

The concept of regional baselines proves to fit very well within the TAJ, as a mean to ''prepare the ground" within a region for starting the Journey. Among the knowledge partners, but foremost the regional partners, many are not familiar with the new frameworks, concepts and approaches, and needed to understand and discover what this means within the NBRACER approach. At the start, the concept of the regional baseline to start the processes in NBRACER regions was not a common method. Within the new EU frameworks and taking into account the regional approach, we needed to develop the baseline approach, the structure, the content and the way of working.

The integrated and systemic approach was important, to create a broad picture of the regional characteristics, qualities and challenges, both from the aspects of the natural and the social system. Most of the information on the natural system at the level of the regions could easily be made available by our regional (knowledge) partners. When we were looking for more detailed information at a more sub-regional or local level, mostly data was not available. For most of the aspects on the social system, it appeared to be much more complex and unusual to gather the relevant information. It became clear that the research and policy community on Climate Adaptation is not connected to the community of regional development and socio-economic aspects of the region, which made it difficult to find the relevant information in the regions, but also to understand the reason for collecting this kind of information. The concept of KCS, very crucial in regional journey towards resilience, was new to almost all partners, which made it difficult to make this concept operational, to find relevant basic data and to actually work with this concept in a manner of co-design.

All the regional baseline reports have been produced, and they meet the objective to collect broadly relevant regional information, as a starting point for the regional transformation process. The report has been distributed among regional coordinators and regional knowledge partners but has not been widely spread and has not intensively been discussed within the regions. In most of the Regional workshops, the main findings have been presented at the start, but discussion and completing the baselines was missing, due to limited time within those workshops, but also due to the habit to focus on the projects and the solutions. Also, after the regional workshops, the use of Baseline reports has been limited. As the feedback session learned that the common finding of the concept and the objective of the regional baselines is very positive, some relevant recommendations have been formulated. Important aspect is to optimize the collecting,

describing, presenting and using the regional baselines in co-design processes with regional partners. A further important recommendation is to make the basic regional information more accessible by using visuals and sharing these actively within the region. Another direction is to emphasize the connection of the regional baseline with the other NBRACER work packages, and the future use of the regional baseline as a living document to be completed and actualized, and to be wider shared and discussed, during the next steps of the TAJ in the regions.

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Annex

Annex 1: Template regional baseline report

NBRACER task 1.1.: Constructing a baseline

Aim of the baseline

The goal of the baseline is to collect and share the regional information and to discuss the current situation among partners in the regions involved in NBRACER. By creating a baseline first insights on the current physical and social-economic context will be developed, relevant to deal with climate change, to plan and implement Nature Based Solutions (NBS) and to start the Transformative Adaptation Journey in each Demonstration region towards a climate resilient society.

Content of the baseline

The baseline comprises a collection of general regional information both qualitative and quantitative data. The baseline adopts a systemic approach to comprehend the intricate relationship between the natural system and the human/social system . Within this framework, three key components are delineated: the natural system, the social system, and the connection between these two systems. Through this systemic approach, a clearer understanding of resilience-building mechanisms and pathways can be attained.

The baseline will give direction to region's specializations, unique characteristics, as well as its strengths and weaknesses concerning Nature-Based Solutions (NBS). The baseline will facilitate a common understanding, to support the joint sense-making for future visions and pathways.

Collecting baseline information

As regional partners, you have an intimate knowledge of your region. That's why we're asking you to share your available information through this document. Please consider including maps, data, reports (preferably in English), and any other relevant materials. We are not aiming for deep analyses but we focusing on a broad and general inventory. This means that short descriptions will be sufficient for the baseline, as a starting point of the regional transformative adaptation journey within the regional demonstators of the NBRACER project.

Here's how this document works: You'll find the four parts and related elements of the baseline outlined here. We're asking you to share what you consider important information for each category. Since this is about creating an initial description of the region to start the NBRACER Transformative Adaptation Journey, it does not need to be overly specific and extended.

This document is made interactive and you can easily add text, images, links to maps or other data, newspaper articles (such as those highlighting climate effects you're experiencing), photos, links to videos, and anything else you believe would be useful for establishing a baseline of the region for NBRACER.

Creating the baseline

We will develop an initial version of the baseline using both the information shared by you and which we have already collected ourselves. This preliminary version will be presented during the regional workshop, in which we will identify together the elements that require addition, removal, or prioritization to ensure the baseline matches with your view and knowledge on the region. It is not our goal to achieve

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completeness immediately. Instead, consider it as a foundational document that will evolve throughout the NBRACER project.

Next steps

Wageningen Research will collect and bring the information together in order to develop the regional baselines. We would like to receive the information one month prior to the regional workshop. If you wish to discuss or to clarify this request, we are open to set up a Teams meeting.

When the data cannot be included easily in this format or the quality of maps/figures will be less, please send this information directly (including question number) to marlies.vanree@wur.nl or add it at the SharePoint if accessible for you (WP1 - Regional journeys to resilience).

Thank you for providing the information. Your cooperation is greatly appreciated!

Region: **Choose a region.**

Part A. General information

1. Map of the region

2. Population (please add available maps and graphical data)
    a. Total population: Click here to enter text.
    b. Current demography: Click here to enter text.
    c. Demographic trends: Click here to enter text.

3. Surface area of the region(km^2): Click here to enter text.
4. Surface area of the focus area within NBRACER (if applicable): Click here to enter text.
5. Involved regional partners within NBRACER project: Click here to enter text.
6. What is the regional purpose for implementing/upscaling NBRACER project
   Click here to enter text.
7. Other relevant and available information and data
   Click here to enter text.

Part B. The Social System

8. What are the most important regional policies, visions, action plans and strategies:
    - On climate change (Mitigation and adaptation)
      Click here to enter text.
    - On nature based solutions
      Click here to enter text.
    - Other relevant policy fields which considered as relevant for the regional baseline:

      ☐ spatial policy ☐ regional economic development ☐ biodiversity and nature

      ☐ water ☐ circular bio-economy…

      Agricultural transition
9. How are decision-making power divided between the different governmental levels (please try to explain from local – regional – national levels):

Click here to enter text.

- What is taking place within other domains:

  ☐ Knowledge: research and innovation programs: Click here to enter text.

  ☐ Private sector programs: Click here to enter text.

  ☐ Community programs and NGO's: Click here to enter text.

- How are initiatives mostly arranged?

  ☒ Top down vs ☐ Bottom up

  ☒ Public vs ☐ Private

- How are the different quadruple helix sectors involvement in climate change topics and implementing nature based solutions

  ☐ Public sector: Specify

  ☐ Private sector: Specify

  ☐ Knowledge domain: Specify

  ☐ Civil Society: Specify

  ☐ Intermediate organization: Specify

  - Connectedness of the domains:
    Click here to enter text.

10. What are the main economic activities in the region?
    Click here to enter text.

11. What which financial resources are available for climate adaptation:
    Click here to enter text.

12. Can you elaborate on the following society aspects?
    - Cultural aspects, values and identity in relation to climate change and nature - information about the role of landscape in people's life:
      Click here to enter text.
    - Identified vulnerable groups with regards to climate change (social justice):
      Click here to enter text.
    - Civil society engagement, including identification of hard to reach population groups:
      Click here to enter text.
    - Behavioural change
      Click here to enter text.

13. Other relevant and available information and data:

    Click here to enter text.

Part C. The Natural System

14. Soil map of the region (please add links if available)

Click here to enter text.

15. Landscape map of the region (please add links if available)

Click here to enter text.

16. Short description of rural landscape type in the region (if applicable)

    Click here to enter text.

17. Short description of coastal and marine landscape type in the region (if applicable)

    Click here to enter text.

18. Short description of urban landscape type in the region (if applicable)

    Click here to enter text.

19. Other valuable available data like maps/data on nature/blue infrastructure/land use functions/green spaces in the city.

    Click here to enter text.

20. The interrelationships between urban, rural and coastal landscapes in the region
    - Morphology: Click here to enter text.
    - Hydrology: Click here to enter text.
    - Biodiversity: Click here to enter text.
    - Connectedness of the landscapes: ☐ separated landscapes vs ☐ mixed landscapes

      Click here to enter text.
    - Main influences that are changing the landscape:

      Click here to enter text.
    - Which climate change effects does the region face, in short (2030)- and long-term (2050-), depending on the regional time horizon used?

      ☐ Flooding (sea level rise, fluvial, heavy rainfall, seasonal changes)

      Click here to enter text.

- ☐ Heat Click here to enter text.
- ☐ Drought Click here to enter text.
- ☐ Salinization Click here to enter text.
- ☐ Wildfires Click here to enter text.
- ☐ Erosion Click here to enter text.
- ☐ Multi-hazard: Specify

21. Other relevant and available information and data on the natural system
    Click here to enter text.

Part D. Connection between the Natural and Social System

22. Is there a climate atlas/portal focusing on climate effects or climate risks (please add link if assessable):
    Click here to enter text.

23. Can you elaborate on the impact of climate change on following the Key Community Systems

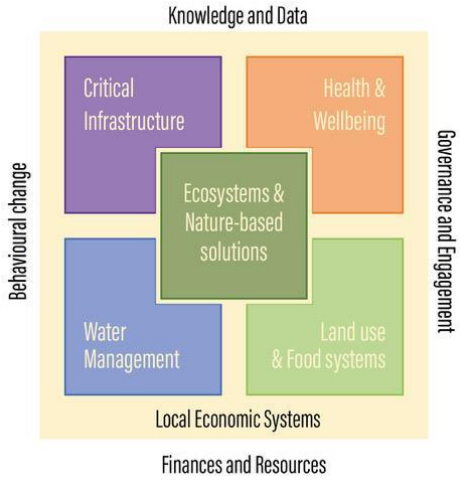
    ☐ Health system: Specify

    ☐ Critical infrastructure: Specify

    ☐ Land use/food systems: Specify

    ☐ Water management: Specify

    ☐ Local economic system: Specify



24. Key vulnerabilities and climate risks
    a. Climate change effects
       Click here to enter text.
    b. Risk Assessment
       Click here to enter text.
    c. Vulnerability assessment
       Click here to enter text.
    d. Regional resilience
       Click here to enter text.

25. Climate change and awareness
    - The regions' awareness and understanding of climate change and nature based solutions:
      Click here to enter text.
    - The regions' risk perceptions and risk acceptance:
      Click here to enter text.

26. Readiness and resiliency
    - On regional resilience: Click here to enter text.
    - On readiness level for NBS: Click here to enter text.
    - On readiness for systemic approach: Click here to enter text.

27. Other relevant and available information and data

Click here to enter text.

Annex 2: Baseline Central Denmark

NBRACER
Nature Based Solutions
for Atlantic Regional Climate Resilience

Regional Baseline Report

Central Denmark

Ingrid Coninx, Remco Kranendonk, Marlies van Ree, Yawei Wang
Wageningen Environmental Research

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Disclaimer

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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 Mission on Adaptation to Climate Change by addressing this challenge with an innovative and practical approach to accelerating the transformation towards climate adaptation. Transformation adaptation 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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1 A Regional baseline: aim, concepts and process

1.1 Aim of the Regional Baseline

The aim of this regional baseline is to bring together information about the region that is crucial for their journey to enhance the climate resilience of society. NBRACER aims to work with a systems transformation approach via Nature Based Solutions. This requires a joint understanding of the regions' natural system, social system and how these two are interrelated. This regional baseline provides the required information to discuss and to co-develop this joint understanding of the region among partners in the regions involved in NBRACER. Furthermore, the baseline will be helpful to better assess the climate change impacts and the role that Nature Based Solutions might play in the regional systemic transformation. This information will therefore also be supportive in the design, planning and implementation of Nature Based Solutions (NBS) that fit with the typical characteristics of this region. The baseline will give direction to region's specializations, unique characteristics, as well as its strengths and weaknesses concerning Nature-Based Solutions (NBS). And last but not least, the use of the baseline will contribute to facilitating a joint commitment among stakeholders to start the Transformative Adaptation Journey – preparing the ground - and is expected to be used in joint sense-making for future visions and pathways.

1.2 Key concepts

Climate change can be approached in different ways. Therefore, it is important to describe the conceptual approaches that are underlying the NBRACER project and the analysis of information that has been collected for this baseline report. While many studies have been using an impact or risk-based approach, NBRACER is focussing on a systems-based approach to foster resilience. Key concepts related to this approach are:

- Systemic approach and key community systems
- The concept of regional transformation adaptation journey
- The transformational governance; concepts of collaboration and inclusion

1.2.1 Systemic approach

The baseline adopts a systemic approach to comprehend the challenges that climate change poses on the region. The systemic approach is focussed to better understand the intricate relationship between the natural system and the social system. This approach starts from the Sustainable Development Goal's wedding cake that illustrates how economies and societies are connected with the natural system and in order to have a well-functioning economy and society, they should be well embedded in the underlying natural system.

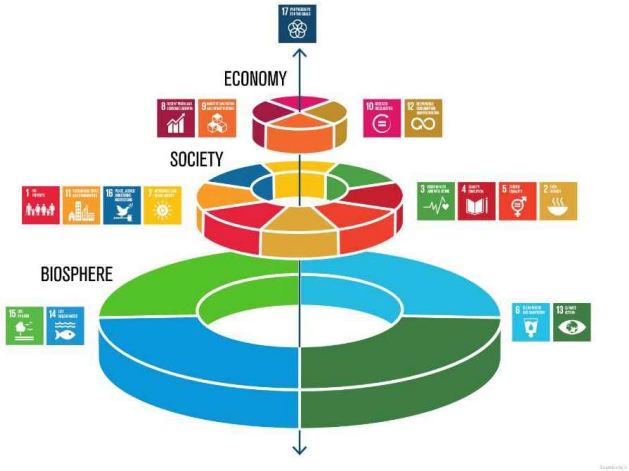

Figure 1: Wedding Cake of sustainable development goals (SDG), United Nations

In the baseline, we aim to analyse the different parts of the natural and social systems and their connection. This will help to move away from the environmental or sectoral approach only, that is often used in climate change assessments that considers nature separate from society and economy. Instead, it promotes a more systemic approach that explicitly focuses on the interrelationship between natural and social systems. Nature-based solutions inherently have the potential to strengthen this connection sustainably by leveraging the natural system's capabilities to address societal issues.

Within this approach, three key components are delineated: the natural system, the social system, and the connection between these two systems that includes the governance that is in place to ensure natural and human systems are in balance. Approaching climate change in a systemic way enhance a better understanding on the systems issues that lead to climate change impacts and provide a better understanding on how systems could change in order to regain a balance between the natural and social systems given the context of the climate changes.

Related to this systemic approach are the key community systems that play a dominant role in the European Mission on Adaptation (European Commission, 2021). Key community systems are systems that meet basic needs for society but might be impacted by climate change.

Furthermore, the baseline also summarize the available information on climate change risks and assess the related vulnerabilities of the key community systems due to climate change. To safeguard our wellbeing, it would be needed to assess the needs for transformation to ensure that the key community systems keep on meeting basic needs. The EU distinct 5 Key Community Systems: the land use and food system, water management system, critical infrastructure system, the health and wellbeing system and the local economic system. The Mission Climate Adaptation is focussing on using the ecosystems and nature-based solutions in order to protect the key community systems to the negative impacts of climate change. , The ecosystem is crucial for our wellbeing and ensure that we are ecologically connected, that nature is restored and that ecosystems services are delivered.

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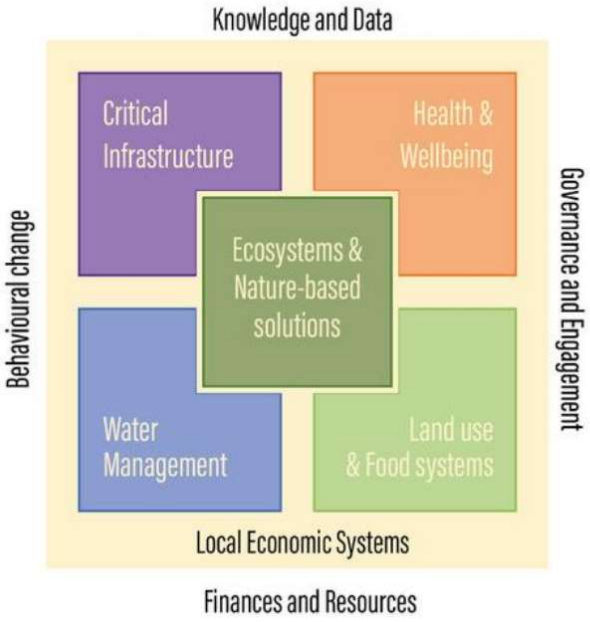

Figure 2: Key Community Systems (EU Mission of Climate Adaptation)

1.2.2 Transformative Adaptation Journey

As NBRACER aims for systemic transformation at the regional level, we are relying on the Transformative Adaptation Journey (also used in Pathways2Resilience) in order to bring forward the regional transformation. This approach is originally based on the adaptation policy cycle but is extended with elements that would enhance the collaboration between public, private, knowledge and societal partners.

The first phase of the Transformative Adaptation Journey - *preparing the ground* – is focusing on understanding what's already being done in the broader policy, social, environmental, and economic contexts, understanding who are the key actors and institutions needed to involve, understanding the socio-economic context and available resources, and providing evidence to determine regional priorities and opportunities for sustainable, climate-resilient regional development. Also climate risks and opportunities for prosperity need to be assessed. At the end of this phase, regions will have a comprehensive baseline covering, among others, risk assessments, adaptive capacity needs, a stakeholder map and a monitoring framework that will act as a solid foundation for the journey. (Source Climate KIC, DesirMED).

The next step in the regional adaptation journey involves co-developing a *shared vision* with stakeholders. Active engagement is essential for creating commitment and ownership of the process and vision. This co-created vision will be a tool for mobilizing change and holding regional stakeholders accountable. It must be holistic, combining scientific insights with community priorities to foster a sustainable and equitable future. Public-private partnerships will be key to mobilizing resources and driving large-scale innovation. Ultimately, the vision must be dynamic, evolving with climate changes and lessons learned, and calls for courage,

collaboration, and commitment from all sectors to protect our planet for future generations. (DesirMED)

Next step is developing adaptation pathways for climate adaptation and resilience gather interventions across multiple levers of change in a portfolio of actions, each of them contributing to progress towards the desired pathway, that will coincide with action & investments plans. While implementing the plans, it is aimed to closely monitor progress on the systemic change and to evaluate and learn and adjust actions if needed. In this way, building resilience via transformation becomes an iterative process, a journey, where all relevant regional stakeholders take part.

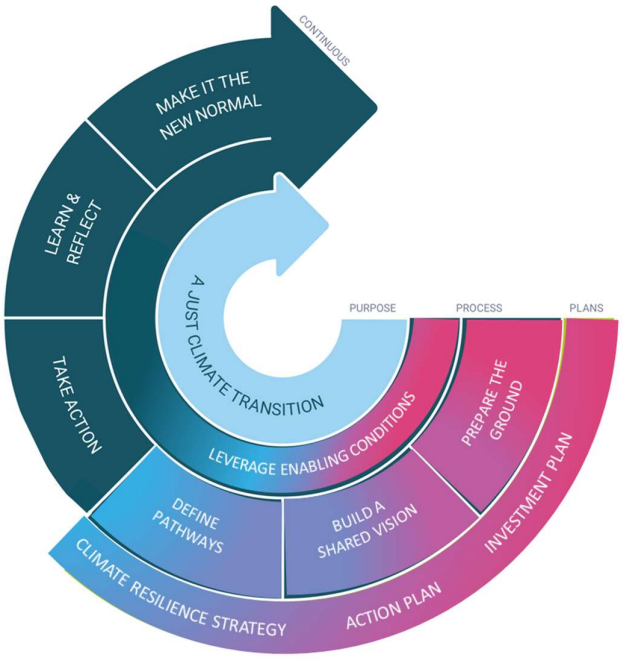

Figure 3: Transformative Adapation Journey (Climate KIC, P2R)

1.2.3 Collaborative and inclusive approach

The European Mission on Adaptation acknowledge the need to involve organisations beyond the conventional public actors, when it comes to building resilience. It is crucial that private partners, knowledge partners and society (quadruple helix) are involved in the regional transformation adaptation journey. This means that these partners need to be mobilized and engaged in the various phases of the transformational process, and start with collaborating on directions and solutions to cope with climate change, and to create dynamics and initiatives within the specific regional context (Smart Specialization).

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The European Strategy on Climate Adaptation (2021) also promotes the principle of just resilience, indicating that adaptation processes have to be inclusive in order to avoid the risk that adaptation measures put an uneven burden on some groups and that marginalised groups are not well included in the planning and decision-making processes. Therefore, it is crucial to better understand who in the region might be unequally affected due to climate change and to ensure that they are well engaged in the development and implementation of adaptation measures to ensure that these measures meet their needs. Generally spoken, it is assumed that elderly, children, immigrants, single parents and poor people are more severely affected by climate change (Breil, 2021). However, it would be needed to explore vulnerable groups in the regional context and identify groups that are now already feel that they are left behind.

1.3 Process of constructing the Regional Baseline

To create the regional baseline, we first defined and listed the required information topics to get a better understanding of the systems characteristics. As mentioned earlier, the baseline examines both the natural and social systems, with a focus on their interconnections and the key community services. For each component, we identified the specific information needed to gain the desired insights for the baseline. More detailed information about this systemic approach and its individual components will be presented in the upcoming chapter.

To gather this information, we distributed a document to regional NBRACER partners based on the list of required information topics. The region, with its valuable insights into local conditions, significantly enriched our understanding of vulnerabilities, challenges, and opportunities. This collaborative knowledge-sharing formed the foundation of our regional baseline.

Additionally, this information has been supplemented with relevant online sources. We thoroughly reviewed existing reports, data, and materials to enhance the insights shared by the regions. Our goal was to create an initial overview of the region's current state—a snapshot that captures its unique characteristics, risks, and adaptive potential.

The baseline serves as a starting point. During the regional workshop, we collected additional information and incorporated it into the baseline as needed. Our aim is to align with your perspective and regional expertise, ensuring that the baseline evolves dynamically throughout the NBRACER project.

2 Situating Central Denmark

Denmark is a Scandinavian country, located in Northern Europe. As Central Denmark was initially the focus of NBRACER, the regional partners decided to focus on the 15 municipalities along the North Sea/ Atlantic coast of the Danish mainland, Jutland (see Figure 4). Thisted and Morsø are part of Region North Denmark. Skive, Struer, Lemvig, Holstebro, Herning, Ringkøbing-Skjern and Ikast-Brande are part of Region Central Denmark, whilst Billund, Varde, Esbjerg, Vejen, Fanø and Tønder are part of Region Southern Denmark. Surface area of the region(km2) 508.17 km2 (Nørre Nissum).

This focal area poses us with a great challenge in data collection, as most of the data in Denmark is collected for the municipality level or the regional level. So regarding the data collection to better understand the characteristics of the region, we have focussed the analysis mainly on Central Denmark. This will therefore also include information on the Eastern part of Central Denmark, which is not part of the biogeographical region of the Atlantics. Beside the data we have collected also other types of information of Central Denmark and the coastal zone.

Central Denmark Region, also known as Region Midtjylland, is one of Denmark's five administrative regions and is located in the central part of the Jutland Peninsula. The East and West are surrounded by coast, of which the Western coast is part of the so-called North-Atlantic Region (EEA, 2011). Rivers are running from East to West.

Central Denmark is a flat region almost entirely at sea-level but it also possesses the highest point of Denmark at just 178 m above the sea level. The region accounts for around 30% of Denmark's land area and one-quarter of the country's population. With 2,500 km of coast and 10,000 km of streams, the region has water everywhere. The Danish region has successfully worked since 2010 for bridging domains with the aim of increasing climate change adaptation (CCA) action, including capacity building for local officials.

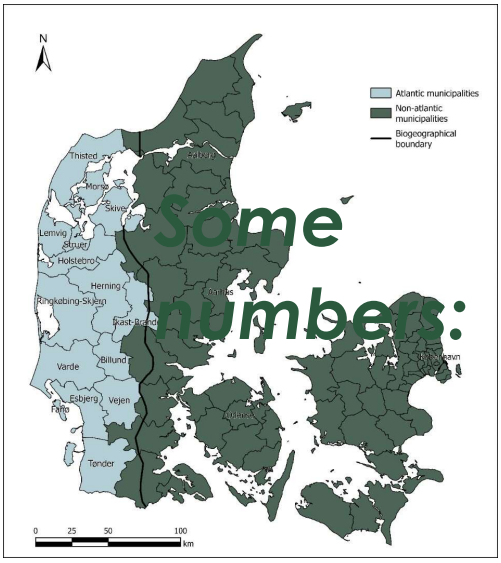

Figure 4: NBRACER Region (Central) Denmark

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2.1 The Coastal Landscape

The mainland of Denmark is a low-lying peninsula that juts out 300 km into the North Sea from northern Germany, and the North Sea coast is a landscape of estuaries, inlets (fjords), low cliffs, dunes and long sandy beaches. In 2004 the Ministry of Environment designated 99 National Coastal Landscapes (NCL), which represent the wide variety of coastal landscape in Denmark. 5 of these national coastal landscapes are located in Geopark West Jutland and form part of designated geosites. Besides the five National Coastal Landscapes the total of 218 km coastal line represents examples of almost all the various types of Danish coastal landscapes and offers many fine experiences. The map below shows the different coastal landscapes based on their soil type.

2.2 The Urban Landscape

In between this agricultural land and nature areas,[1] towns and cities can be found in Central Denmark.

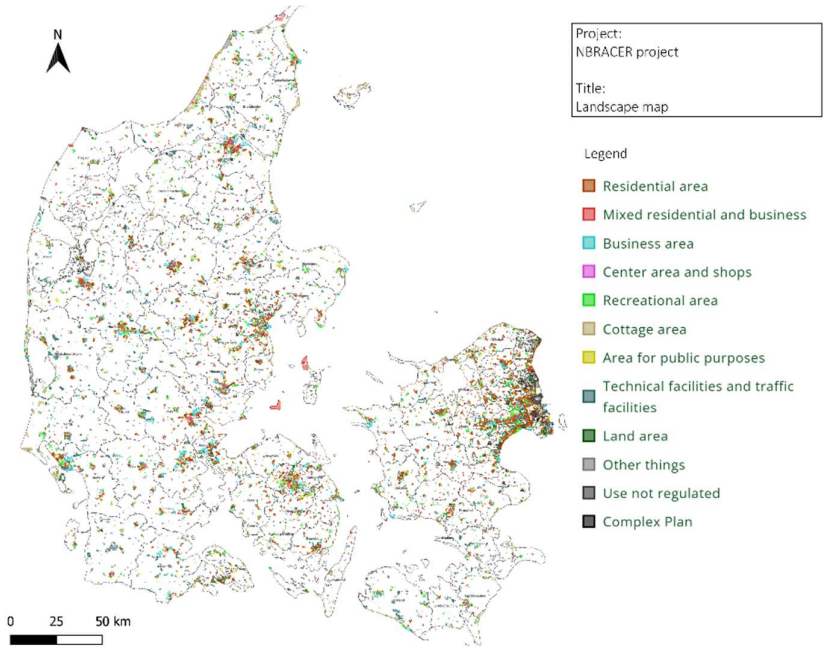

Figure 5: Landscape Map: Urban areas

Major cities in Central Denmark are:

- Aarhus: The largest city in Central Denmark, Aarhus is a major cultural, economic, and educational hub, known for its vibrant cultural scene and modern architecture.
- Aalborg (Northern Denmark): A key industrial and university city with a thriving port, often associated with Central Denmark due to its proximity.
- Herning: A significant trade fair and conference centre with a strong industrial base and modern amenities.

[1] RESIST | Central Denmark (resist-project.eu)

- Randers: One of Denmark's oldest towns, known for its medieval centre and the Randers Rainforest, a popular cultural attraction.
- Viborg: A historically significant city with a well-preserved medieval cathedral and a rich religious and political past.
- Silkeborg: A picturesque town surrounded by lakes and forests, renowned for outdoor activities and cultural events.
- Horsens: A city with an industrial past, now a cultural hub famous for festivals and historical sites like the old state prison museum.
- Holstebro: Known for its vibrant arts scene, focusing on theatre, dance, and visual arts, and an important commercial centre.

These cities play key roles in the economic, cultural, and social life of Central Denmark, each contributing uniquely to the region's overall character. In between these cities are towns located that are local centres for commerce, industry, agriculture and tourism. They play an important role to provide services and amenities to the surrounding rural areas. Central Denmark has several towns that are known for their shops and markets. They play an important commercial role in the region, as for instance Skanderborg. Other towns are a basis for people that are working in the industry, as for instance Struer where an important employer for the region, Bang & Olufsen, is located, a manufacturing company for electronics. Typically agricultural towns are **Lemvig** and Ringkøbing which are serving the surrounding farming communities. These towns play a role in agricultural trade, processing and supply distribution.

These towns are often surrounded by farmland and are closely connected to Denmark's agricultural sector, providing necessary services and infrastructure for farming activities. Some tourists attract many tourists, due to their historical significance or location close to nature or coastal areas like Ebeltoft and Fregatten Jylland. These towns have a significant amount of accommodation, restaurants and activities to cater the tourists. Some towns are just commuter towns, located near large cities. These towns provide a quieter, suburban lifestyle with easy access to urban job markets. They often feature residential developments, schools, and local amenities, catering to families and professionals. Port towns like Esbjerg are important for their trade, fishing and transportation. They are gateways to others regions in Europe.

There is a tendency of people moving from rural areas to cities, what has been recently questioned by research in Denmark (Nørgaard, H., Andersen, H. T., Lange, E. S., & Ruud, M. S., 2023). Based on data from Statistics Denmark, it was revealed that people are moving from rural areas and townships of less than 200 citizens. However, not only to the biggest cities in Denmark, but to a high degree cities off 30.000 cities and upwards, and towns with between 1000 and 29,999 citizens. Cities and towns in the focal area of the NBRACER project in Denmark, are therefore, subject to growth, at least to some degree in the future, whilst rural townships of less than 200 citizens are expected to decrease with respect to number of citizens, as they have since 1901 (57.2 % in 1901 and 11.8% in 2022).

2.3 The Rural Landscape

The land use in Central Denmark is typical for rural area. Land for agricultural and aquacultural use dominates the landscape, combines with land used for nature and forests. This is also shown in figure 13 that makes clear that the land cover distribution in Central Denmark is

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largely comparable to all of Denmark distribution, although there are proportionally more forests. Agriculture is the most dominant lad cover type.

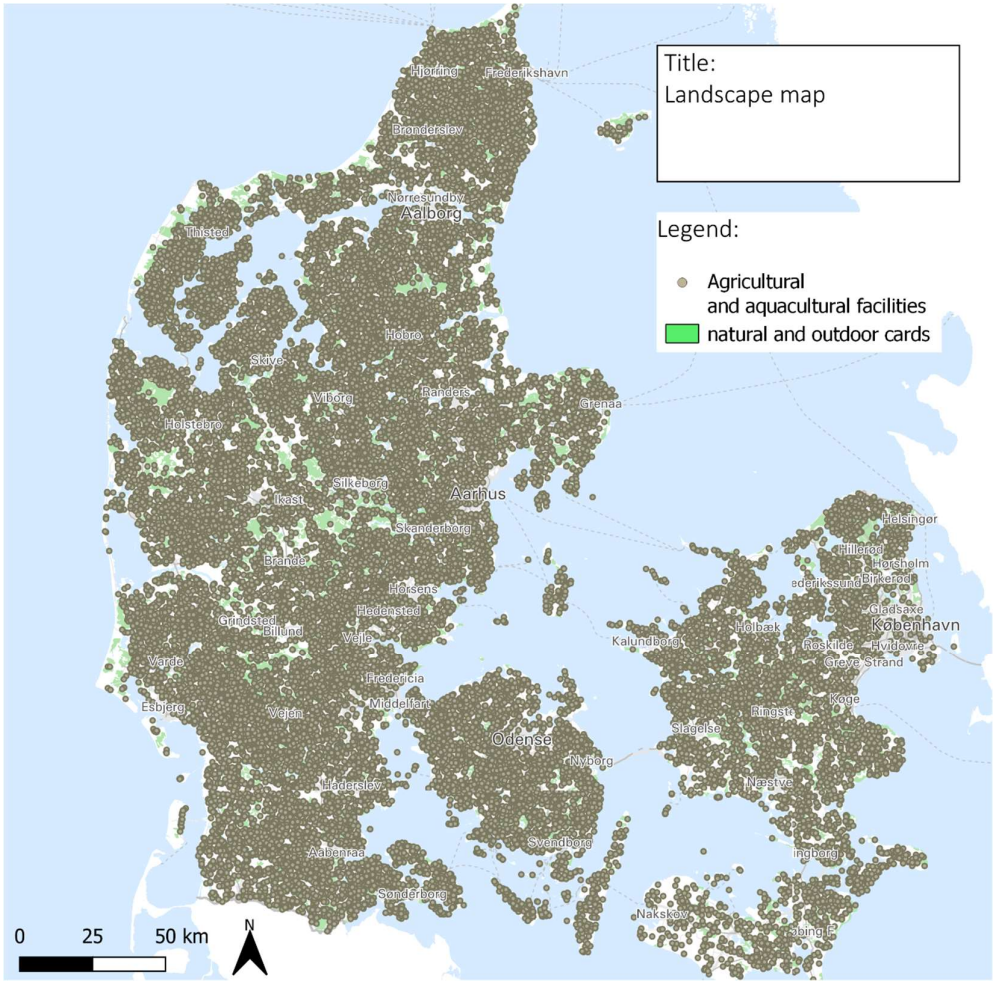

Figure 6: Rural area

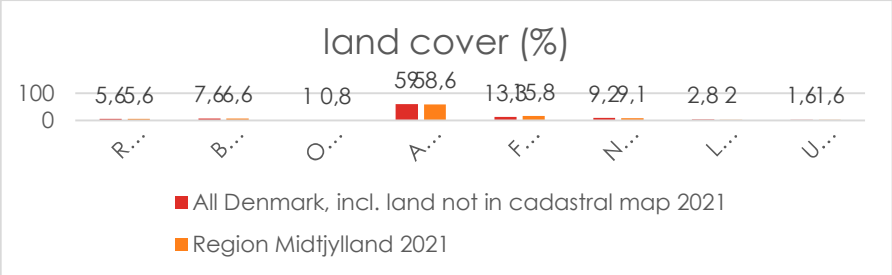

Figure 7: Land cover

Since 2011, some changes in land cover have taken place, where the trends are the same for Denmark compared to Central Denmark[2]. Nature and build-up areas have increased, while agricultural areas have decreased, proportionally.

[2] https://www.statbank.dk/20291

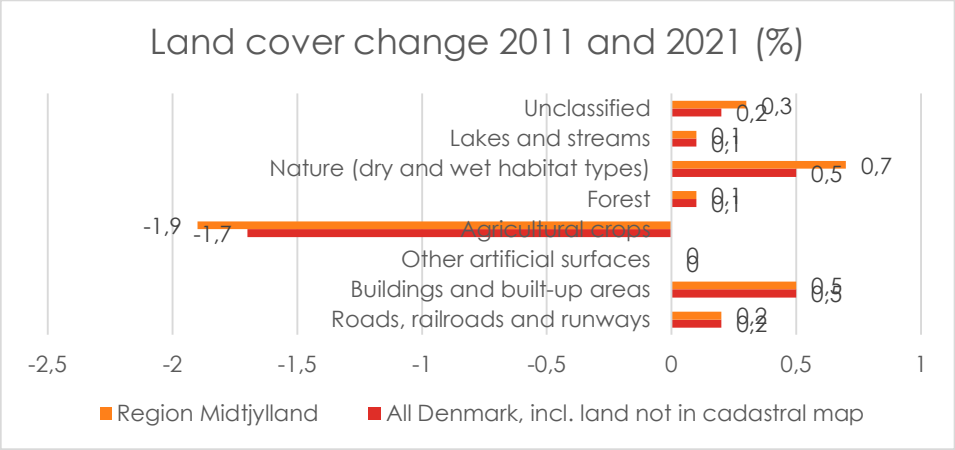

Figure 8: Land cover change

Next to agriculture, Central Denmark is also the main Forestry region of Denmark.

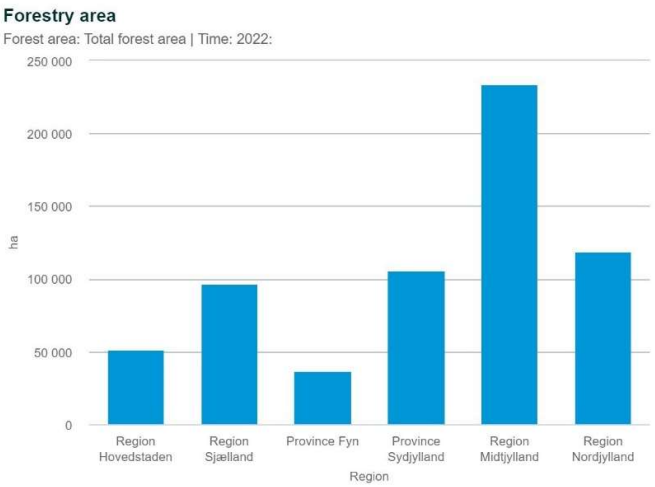

Figure 9: Forestry

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3 The Natural System

3.1 The landscape system

The landscape of Central Denmark is known for its flat geography, in combination with rolling hills, numerous lakes and open plains. The contemporary topography/landscape in Central Denmark owes much of its formation to glacial activity during the last two Ice Ages. Specifically, during the most recent ice age, the glacial cover extended solely to the northern and eastern regions of Jutland, effectively dividing the country into distinct halves. Glacial advances and retreats have reshaped the landscape in the way we know it today. In figure5, the schematic black line gives an impression to where the ice sheet has reached. It is still noticeable in the landscape today as a ridge and has been the result of glaciers advancement that has pushed large amounts of debris. The East is known for its lakes and forests while the West is characterised by flat landscape with open plains. These plains emerged during glacier retreat which have been formed by meltwater that carried and deposited sediments. These plains are typically flat or gently sloping and are composed of sand and gravel. In the Western part, meltwater beneath the glaciers has carved out deep valleys, which were filled with sediment once the ice retreated. Some lakes and river valleys are the results of this landscape process. Lakes and ponds were formed as the result of large blocks of ice that broke off during glaciers retreating. They melted and formed depressions, known as kettle holes. Especially the Silkeborg area that is known for its lakes is the result of this process. Eskers and kames are also still to be recognised in the Danish landscape. As the ice melted, meltwater streams within and beneath the glaciers deposited sand and gravel in narrow, sinuous ridges called eskers. Kames, on the other hand, are irregularly shaped hills formed from sediments deposited by meltwater in ice-walled depressions. Denmark is still experiencing isostatic rebound. This is the process that took place after the glaciers retreated. Land that had been compressed under the immense weight of the ice began to slowly rise, which is now known as the process of isostatic rebound. This uplift is still ongoing in some parts of Denmark, though at a much slower rate, and it has influenced the drainage patterns and the development of rivers and lakes in the region.

3.2 Soil system

The soil system is closely connected to the process of the landscape formation, as described above. As indicated by the soil map, Central West Denmark exhibits a diverse range of soil types. Notably, a distinct division can be seen on whether the ice sheet reached to that part of the country or not. This also results in a broad variety in nutrient availability and acidity of soils across the different regions.

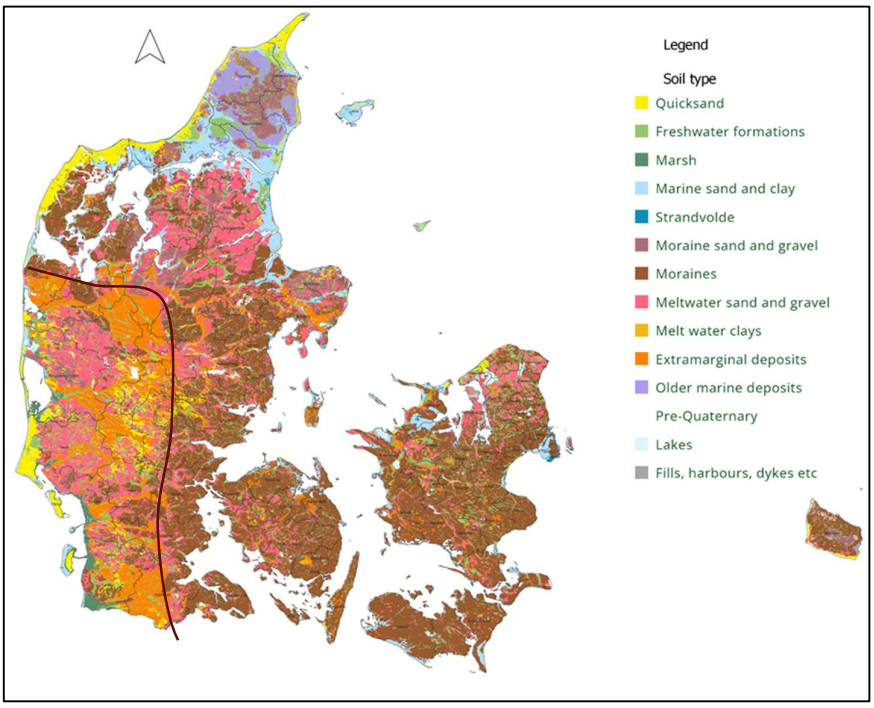

Figure 10 Map soil type

The northern and eastern parts of the mainland are dominated by moraine deposits (till). Moraine soils consist of a mix of clay, sand, and gravel. They tend to be relatively rich in nutrients due to their clay content. The southwest is dominated by plains and valleys of sandy nutrient poor meltwater deposits and local “islands” of older glacial till. Due to the nutrient poor nature of the relatively coarse meltwater deposits in the southwest the soils here are naturally poor and relatively acidic (podzols). The parts that are dominated by the more clayey moraine deposits are relatively nutrient rich and is therefore suitable for agricultural activities, amongst others.

3.3 Water system

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In the Central West Denmark region, the water system consists of different water bodies[3]. First, there are the North Sea and Wadden Sea, both critical maritime ecosystems that support food production and economic activities. Additionally, the region features various rivers and streams flowing inland. While major rivers from high mountain areas are absent, these local and regional water systems still play a crucial role in draining precipitation and transporting sediment from inland to the coast. The water is also used for human activities. Coastal marshes and mudflats are also present, serving essential functions within the ecosystem and providing protection against coastal erosion. Lastly, existing groundwater resources are significant for both human water supply, including drink water supply and natural processes. The functioning of these water bodies is largely affected by the seasonal precipitation patterns that are known to Denmark.[4]

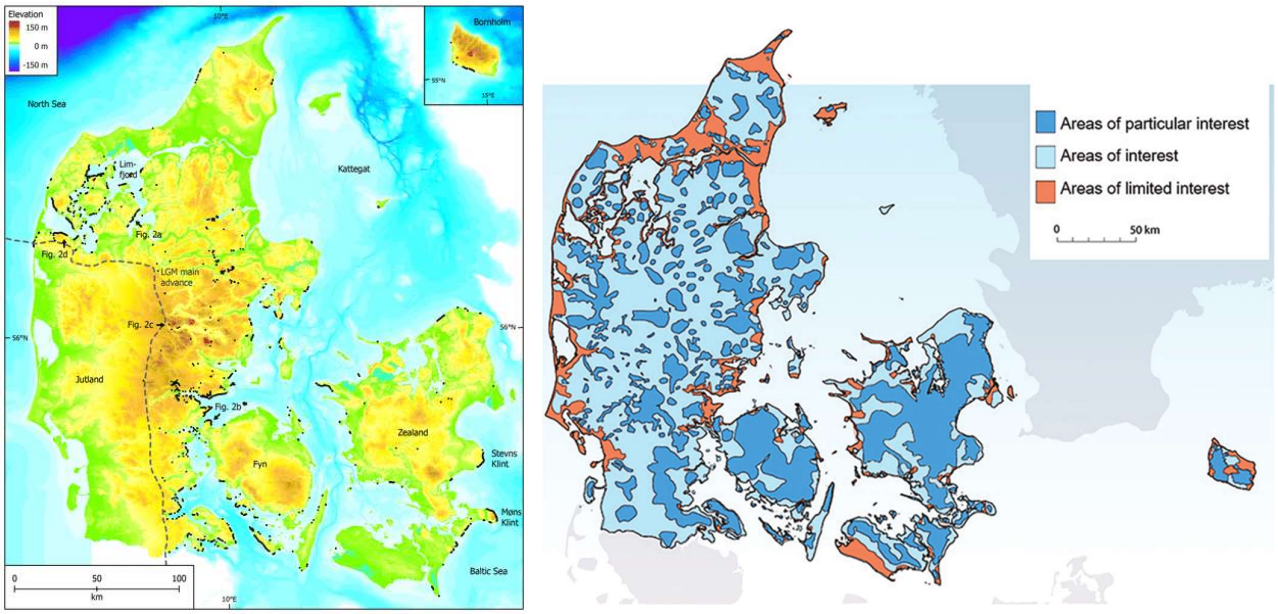

Figure 11 Water system maps

3.4 The nature system

Central Denmark has various natural landscapes. Among them are forests, which are predominantly populated by both deciduous and coniferous trees, providing essential habitats for a wide variety of wildlife. Additionally, the region features open land, encompassing both agricultural and non-agricultural landscapes. In certain areas, these open spaces are connected by networks of hedgerows. Furthermore, wetlands are prevalent in this area, including bogs, marshes, and coastal lagoons. These wetland ecosystems are rich in biodiversity and play a critical role in water purification and flood control. The North Sea and Wadden Sea coastlines are home to a multitude of species and are vital for bird migration and marine life. The interplay between natural landscapes and human activity significantly shapes the environment in this region.

[3] Mollerup, Finn & Vejergang, Carsten & Vægter, Bo & Esbjørn, Anne. (2018). HACCP in drinking water systems. 10.2166/9781780408699_0245.
[4] Source Luetzenburg, G., Svennevig, K., Bjørk, A. A., Keiding, M., and Kroon, A.: A national landslide inventory for Denmark, Earth Syst. Sci. Data, 14, 3157–3165, https://doi.org/10.5194/essd-14-3157-2022, 2022

Central Denmark also hosts several national parks and protected areas dedicated to preserving its natural heritage and biodiversity. These parks include:

- **Mols Bjerge National Park:** Known for its diverse landscape of hills, heathland, forests, and coastal areas, this park supports a wide array of wildlife and offers numerous recreational opportunities.
- **Thy National Park:** Situated along the North Sea coast, this park features extensive dune landscapes, heathland, and forests, providing crucial habitats for many rare and endangered species.
- **Wadden Sea National Park**: A UNESCO World Heritage site, this park is part of the largest unbroken system of intertidal sand and mud flats globally. It supports a rich biodiversity, including migratory birds and marine life.

These parks play an important role in conserving the region's natural habitats and species.

3.5 Dynamics in the natural system

Temperature changes and precipitation changes largely influence the dynamics in the natural system in Central Denmark, which are affecting vegetation growth, soil dynamics and the changes in water bodies.

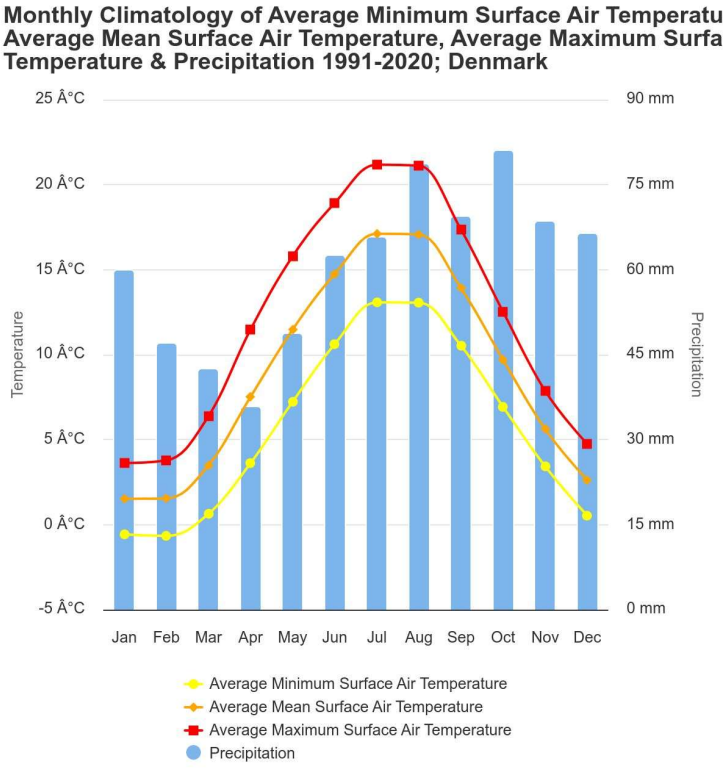

Figure 12 Surface temperature; (Source: World Bank Climate Change Knowledge Portal)[5]

[5] Denmark - Climatology | Climate Change Knowledge Portal (worldbank.org)

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During the winter, processes of freezing and thawing results in physical weathering as frozen water in soils and rocks expand. It can even result in pushing soils and rocks upward, affecting the landscape. During this winter period, large amounts of precipitation that, depending on the temperature, can be in the form of snow, will be accumulated. Melting of this snow may result in increased runoff, contributing to soil erosion and potentially to riverine flooding.

Temperatures are going up in spring, which is in the period of March-May. This results in plants starting to grow. Depending on the availability of snowmelt, some low-lying areas may get flooded and sediment might get transported downstream due to increased water flow, which may even reshape riverbanks and floodplains. After these higher rates of soil erosion due to water and wind in early springs follows a rather stable period that helps to reduce erson risk and support the establishment of full vegetation cover.

In summer, temperatures are further increasing and evapotranspiration is at its peak, leading to drying of soils, mainly in sandy soils and soils with poor water retention. Summer also may go hand in hand with some intense thunderstorms that may result in localized flooding and soil erosion. Autumn is known for decreasing temperatures, leading to vegetation to die. This process is very important to enrich the soil with nutrients, promoting its structure and fertility. Meanwhile, rainfall increases and in case soils are already saturated, this may result in surface runoff and river flooding.

Understanding these seasonal processes is crucial for managing climate change risks, which is expected to result in more frequent and more intense extreme weather events.

4 Social System

4.1 Demographics

Population

Denmark currently has a population of about 5.9 million people, with approximately 652,700 residing near the coastline. Of this population, 1.3 million live in the NBRACER region of Central Denmark, which covers an area of about 13,000 km². This results in a population density of roughly 101 people per km², classifying Central Denmark as a rural area—a status it is expected to maintain in the coming decades[6]. This population density is lower than the national average, which currently stands at 137 people per km². In contrast, population densities are significantly higher in the Capital Region of Denmark and in Region Zealand.

Projections indicate that Denmark's population will reach 6 million by 2028, 6.1 million by 2050, and 6.2 million by 2070. These projections reflect an anticipated decline in annual growth, primarily due to a predicted low fertility rate (Statistics Denmark).

The residential areas vary in Denmark from municipality to municipality. In the west coast of Denmark, the growth in the residential areas from 2011 to 2021 is about minus 2.5 % to 10 %. For example, Holstebro municipality which is also part of the selected region has a growth with approximately 7.6 to 10 % (Figure below)

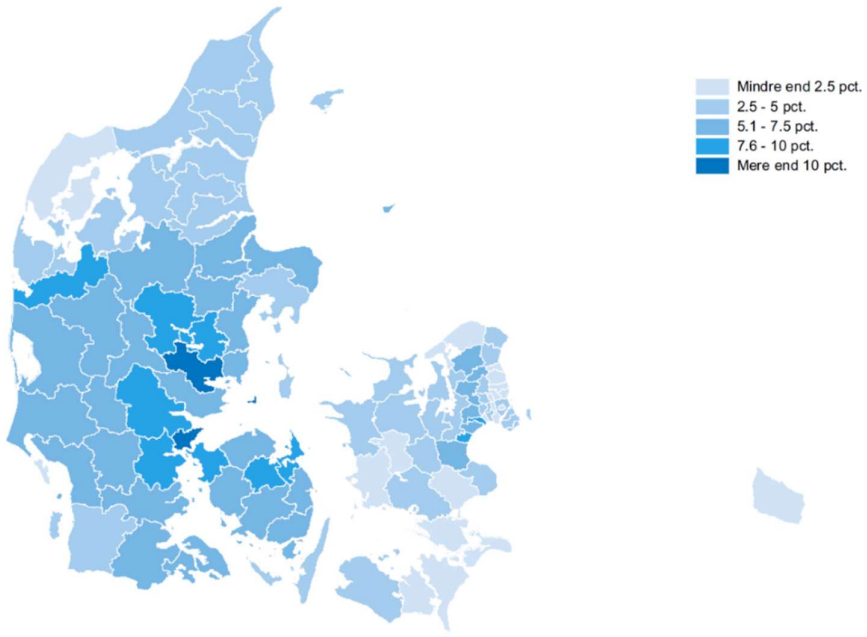

Figure 13: population growth

6 https://projects.mcrit.com/foresightlibrary/attachments/The%20growth%20of%20the%20working%20age%20population%20differences%20between%20rural%20and%20urban%20regions%20across%20Europe.pdf

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Age

The following figures illustrate the age distribution within the population, showing a relatively balanced demographic spread. However, the dependency ratio is expected to increase as the population ages, with a significant rise in the proportion of individuals aged 80 and older—projected to comprise about 10% of the total population from 2047 onwards. The life expectancy at birth in this region is 81.8 years across all genders (Eurostat, 2022). The age distribution in Central Denmark reflects a somewhat younger population compared to the national average, with a higher proportion of individuals in the 0 to 29 age groups (Statistics Denmark).

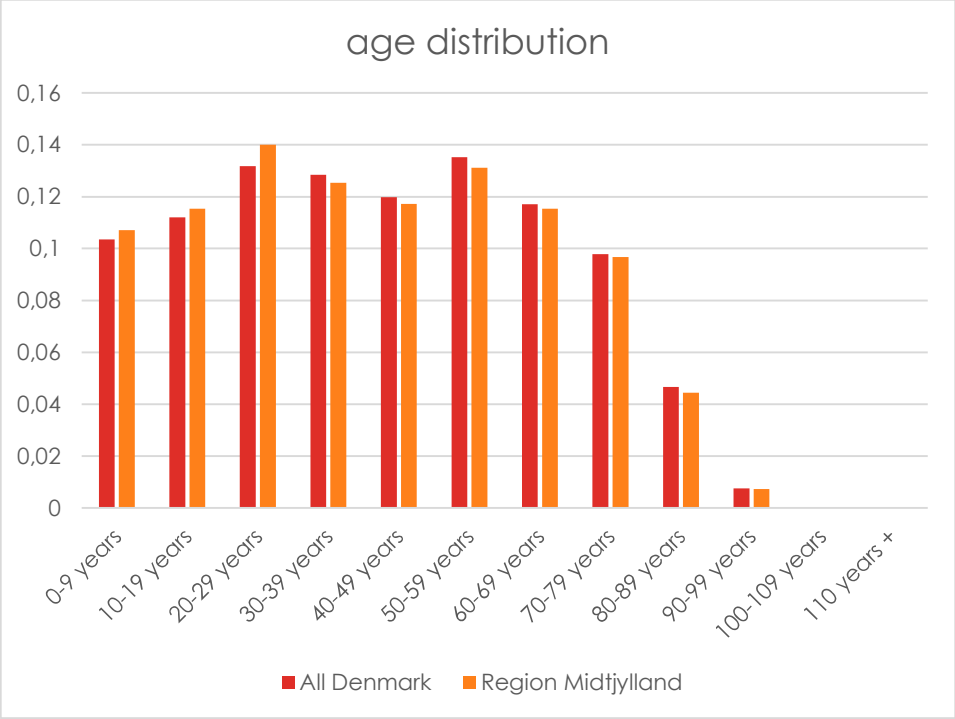

Figure 14: population – age distribution

Household composition

Most households exist out of married couple. This is a type of household that is more common in Region Central Denmark compared to in the whole of Denmark. There is also a rather large proportion of single women, in particular 25%. Of these single women, 19% of them are having 1 or more children, compared to single men of which only 6% has 1 or more children.

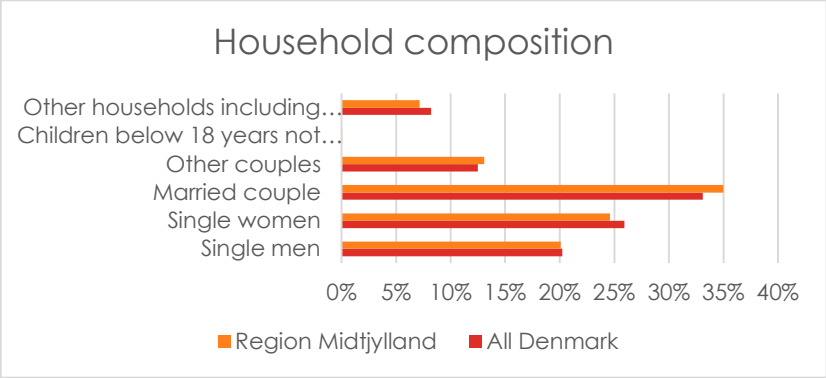

Figure 15: Households

Gender

In Central Denmark, the gender division is almost in balance, with slightly more women living in this region. (about 682489 men and 684962 women) (Statistics Denmark, 2024). This gender division is in line with the national gender division (Statistics Denmark, 2024).

Nationality

Most people living in Denmark have Danish origin, about 84%. 15.9% are immigrants or have non-Danish parents. The past few years were known by a significant increase of new people coming to live in Denmark, mainly due to Ukraine refugees. The largest proportion of immigrants are coming to Denmark to work (mainly Romanian and Polish people) and to study.

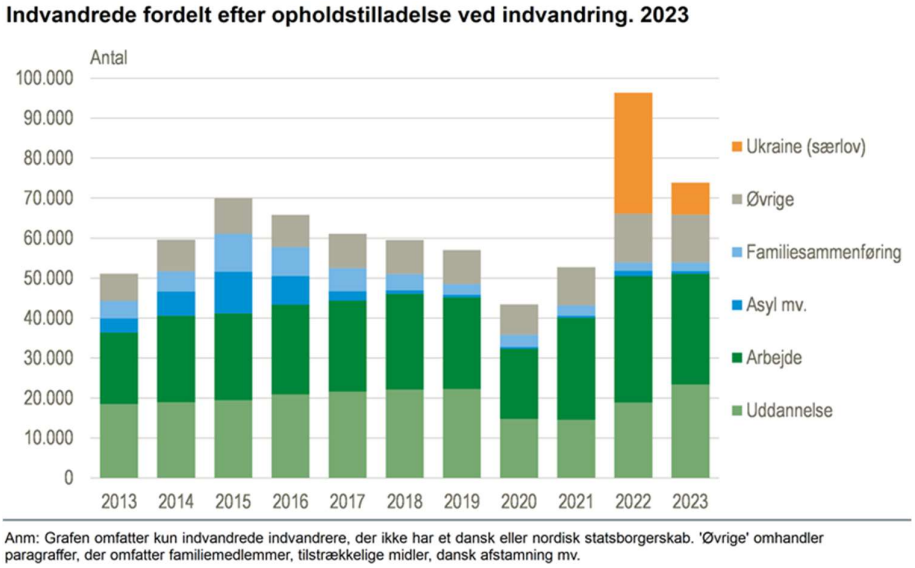

Figure 16: migration

Income, poverty and unemployment

Average disposable income for people is 230 649 DKK in 2022, which is slightly lower than the average for the whole of Denmark (236.222 DKK)[7]. 3.7% of people in Denmark have less than

[7] StatBank Denmark

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50% of the median income and are at risk of poverty. The relative poverty is highest among people age 20 – 34 years. Approx. 3.7% of children in the region of Central Denmark lives in households that receive financial aid, with Varde and Esbjerg municipalities being the ones with most children receiving aid (4.7%) and Fanø having the lowest number of support-receiving children (1.3%). In terms of vulnerable adult people in the Danish society, defined by the Ministry of Social Affairs, Housing and Senior Citizens as: "People over the age of 18, with social problems or in risk of getting such. These can entail: homelessness, addiction, psychological conditions, and prostitution or violence within close relationships. In Denmark, it is the municipalities' responsibility to aid and support vulnerable people.

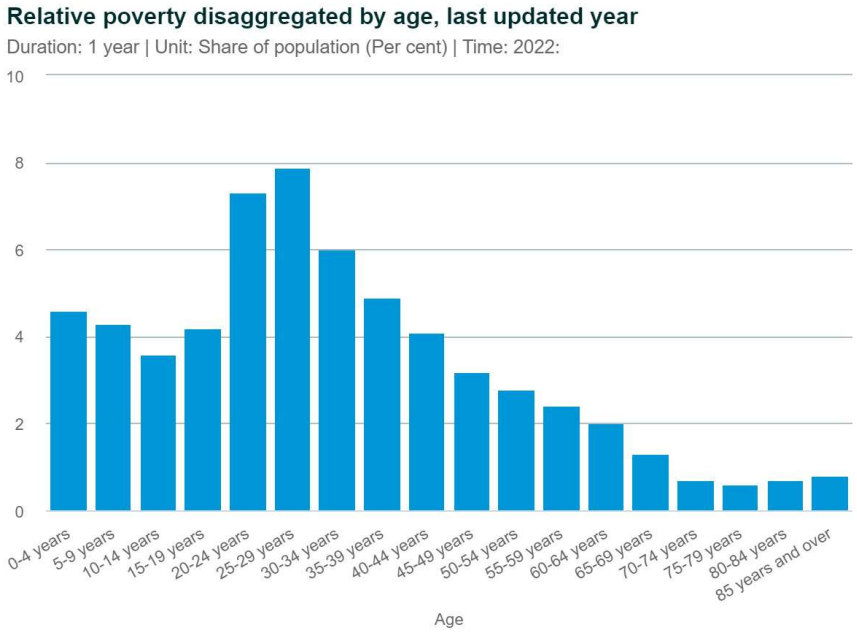

Figure 17: Poverty

Central Denmark has an unemployment rate of 4.1%[8], which is lower than the national unemployment rate that is around 5.1% (Eurostat June 2023).

People with disabilities

Handicap/ Disability is not registered in Denmark. However, The Danish Handicap Organisation estimates that approx. 30% of the population has some form of disability[9]. Numbers from VIVE, furthermore specifies that 120,164 people in Denmark lives with substantial psychologic disabilities, whilst 313,155 people live with major physical conditions.

Housing

[8] https://www.dst.dk/en/Statistik/emner/arbejde-og-indkomst/indkomst-og-loen/indkomstulighed
[9] https://www.sm.dk/arbejdsomraader/udsatte-voksne; https://www.dst.dk/da/Statistik/emner/sociale-forhold/social-stoette/sociale-ydelser-til-aeldre https://handicap.dk/politik/analyse-fakta-om-handicap/fakta-om-handicap https://www.vive.dk/media/pure/16726/6185728

Central Denmark counts for 642 062 dwellings with registered population. Considering house ownership, the data indicates that house owners mainly live in detached houses and farm houses, while tenants mainly live in multi-dwelling houses or terraced, linked or semi-detached houses.

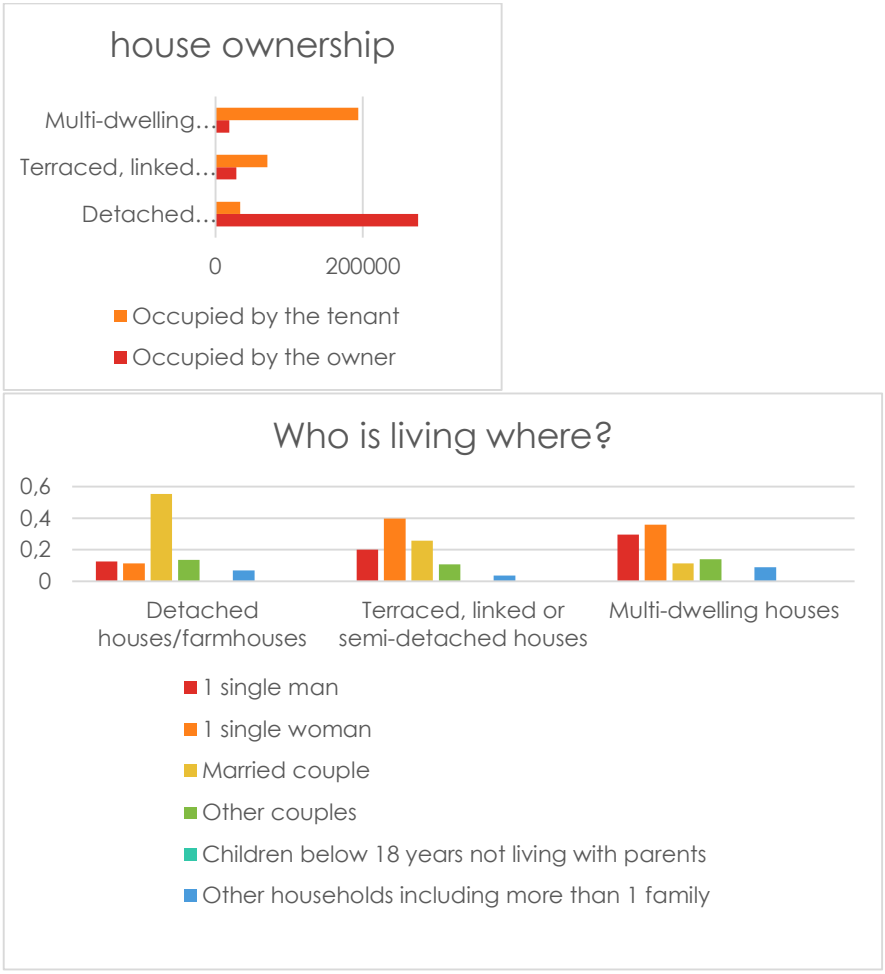

Figure 18: Housing

Detached houses/farm houses are mainly occupied by married couples, while single women mainly live in terraced, linked or semi-detached houses and multi-dwelling houses are often occupied by single men or women.

The existing stock of housing is rather old in Central Denmark, with a quite significant proportion of detached houses/farmer houses being built in the past century.

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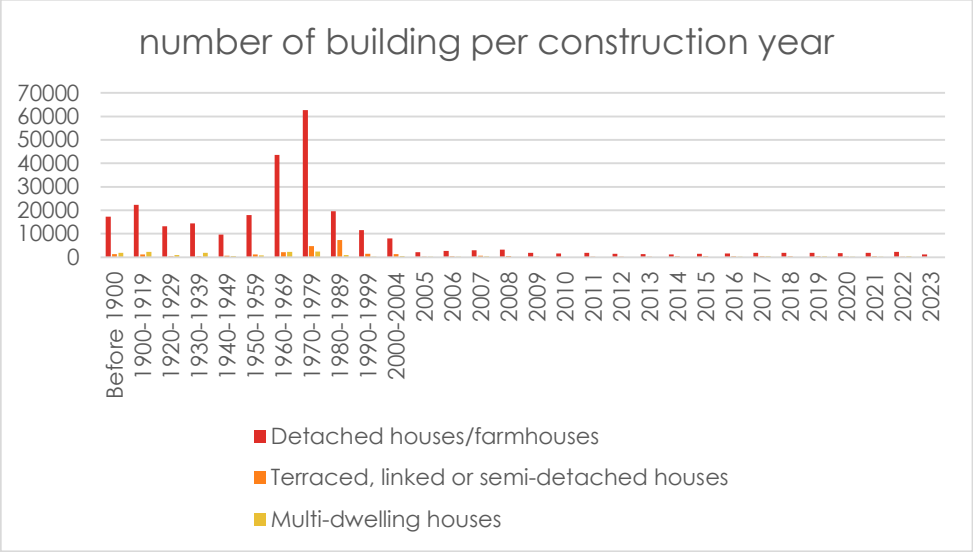

Figure 19: construction of buildings

Nevertheless, many of the houses are well insulated. Danish houses are made of decent materials, like brick and wood and light is an important element in the design.

4.2 Policies

Climate adaptation policies

Climate change adaptation, including the planning and implementation of measures, is primarily the responsibility of municipalities in Denmark, as outlined in various laws and executive orders. Climate adaptation is often associated with water management in Denmark[10] and has come into emergency around 2008, when the government had published the national strategy for adaptation. The first generation of local adaptation plans stems from the period of 2013 – 2015. There are now 97 local adaptation plans. DK2020 and Climate Alliance are two projects that are currently supporting local authorities to update and renew their plans. In 2023, the national government has taken responsibility to speed up climate adaptation by proposing a first climate adaptation action plan, that focussed on a number of issues.

Nature conservation

The Danish Environmental Protection Agency, overseen by the Ministry of Environment and Food, playing a crucial role in policy formulation and regulation enforcement for ecosystems.

Locally, municipalities are responsible for implementing intervention programs based on National Biodiversity Strategy and Action Plans (NBSAPs), aligning local conservation efforts with broader ecological management strategies, and developing and implementing Municipal Biodiversity Management Plans (MBMPs). Municipalities also directly manage protected areas and conservation projects, often in collaboration with local stakeholders and NGOs. The Danish

[10] Adaptation approaches in Danish municipalities climate action plans (realdania.org)

Society for Nature Conservation (Danmarks Naturfredningsforening) represents conservation interests nationwide.

Conservation of nature is organized via the Nature Conservation Act that came into establishment in 1917. Since, the Act has been amended several times. It is the Nature Agency who is in charge of the implementation of this Act. Denmark has designated about 250 Natura 2000 sites. The Danish Environment Protection Agency is in charge of monitoring the policy programs (via NOVANA).

Ground water resources management

Denmark heavily relies on groundwater resources for its water supply. The management of these resources primarily occurs at the local level. Nationally, water management involves policy formulation and regulation enforcement. The Danish Environmental Protection Agency, overseen by the Ministry of Environment and Food, plays a crucial role in this process. They protect the groundwater, regulate wells and boreholes and ensure that the drinking water meets the quality requirements.

The municipalities have authority regarding water supply and are in charge of approving their local water utilities' control programs, supervise whether the water supply meets the requirements for drinking water quality and inspect the local water utilities' technical facilities[11]. Danish drinking water providers have one of the lowest water-loss rates in the world.

Coastal and river flood management

Coastal flood management is to a large extent influenced by the EU Floods Directive which has been consolidated into the Danish Flood Risk Act. This responsibility is located at the national level (Danish Coastal Authority, part of the Danish Nature Agency and guides the Danish Ministry of Environment) who is in charge for identifying flood risk areas, mapping flood hazards and risks. The Danish Coastal Authority develops methods and tools for the public, authorities, and others for their work with climate change. However, it is the municipalities who are in charge of the risk management plans. 27 municipalities in Denmark are in charge of making such risk management plans.

At the municipal level, responsibilities include implementing intervention programs based on River Basin Management Plans (RBMPs), aligning local action plans with broader water management strategies, and developing and implementing Municipal Flood Risk Management Plans (FRMPs).

Coastal protection takes place at the municipal level, where local authorities can request owners of real estate property to contribute to paying coastal protection measures, as stated in the Coastal Protection Act.

Rainwater and waste water management

At the national level, the Danish Ministry of Environment and the Danish Environmental Protection Agency are in charge of legislation on waste water. They supervise the discharges

[11] Drinking water - The Danish Enviromental Protection Agency (mst.dk)

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and monitor the compliances. The national level is also in charge of managing operational accidents of treatment plans and rain-fed outlets as well as pumping stations where waste water is directly discharged into the environment. The municipalities directly own and supervise water supply and wastewater treatment companies. They also manage accidents at pumping stations where waste water overflows the surrounding areas. The Danish Water and Waste Water Association (DANVA) represents utilities nationwide. The waste water utilities are responsible for establishment, operation and maintenance of the public sewage systems up to the individual property lines. They are also responsible for treatment of the waste water from the public sewer, as well as treatment and discharge of rainwater in case a separated sewer system has been established[12].

VCS Denmark – known in Danish as VandCenter Syd – is the third largest water and wastewater utility in Denmark, and its history as an enterprise dates back more than 160 years. VCS Denmark's main operational activities include catchment management, treatment and distribution of potable water, and transport, treatment and disposal of wastewater. In recent years its activities have increasingly incorporated climate adaptation. VCS Denmark contributes to the protection and improvement of the aquatic environment and the development of green urban living. In all activities, consideration for the environment is a key factor.

4.3 Responsibilities

National Government

The central government's main role is to create an appropriate framework for local climate change adaptation by adapting laws, regulations, and strategies, ensuring coordination, and providing information. Climate adaptation is highly complex because it relates to different legislative areas and this holistic approach across legislation is still missing (Basse, 2022). The key elements of the national regulatory framework include the Planning Act, the Floods Act, the Act on Watercourses, the Water Supply Act, and the Waste Water Executive Order under the Environment Act. At national level, it is mainly the Danish Nature Agency, now the Danish Environment Protection Agency who is in charge of climate adaptation coordination. In October 2023 Danish Government established its first Climate adaption plan, indicating that there will be higher governmental involvement in the climate adaptation strategies in local areas in the future.

The Danish government has identified key focus areas for climate adaptation on its website and allocated funding accordingly. For 2024, DKK 150 million has been allocated to coastal protection in specific areas, with a proposed allocation of DKK 1 billion for coastal protection along the entire North Sea/Atlantic coast in Jutland.

In 2023, the Danish Environmental Protection Agency allocated DKK 7.5 million for the development of Environmental Technology Verification and research projects, and DKK 57 million for development, testing, and demonstration projects. Additionally, DKK 57 million was earmarked for lighthouse/beacon projects.

[12] Waste water - The Danish Enviromental Protection Agency (mst.dk)

The Innovation Foundation in Denmark provided DKK 1.6 billion for research into future green solutions, digitalization, technology, life sciences, and health. Furthermore, the Ministry of Food, Agriculture, and Fisheries allocated DKK 189.3 million for Green Development and Demonstration Programs in 2023. The Department of Higher Education and Science also allotted DKK 1.8 million for their CLEAN knowledge projects in the same year.

Rural development

Rural development in Denmark is a national responsibility, more specific the Danish Ministry of Food, Agriculture and Fisheries. The Rural Development program[13] is funded by the European EAFRD and added with national contributions. The focus is on increasing competitiveness, enhancing ecosystem management, contributing to resource efficiency and climate change and fostering social inclusion and local development.

Region Central Denmark

Region Central Denmark has no formal responsibility for Climate adaptation, but has a role in the Climate Alliance. The region is a well-established institution, with their regional quadruple helix networks and services, which may also be relevant for strategies and governance for climate adaptation. Although regions do not have formal responsibility for climate adaptation, they are responsible for a number of tasks that relate to climate change and nature based solutions like handling risks from soil and groundwater pollution (mapping, investigation and sanitation); mapping raw materials and permitting extraction of raw materials; hospitals and health care, public transport between municipalities and across major cities, the green transition; operation of institutions for vulnerable people; education, rural-urban collaboration and cross border collaboration.

Due to the need for regional collaboration, some forms of institutions are emerging, although they are different between regions: Central Denmark has set up a Board for Climate Adaptation. Such a board is not available in Northern Denmark.

The region is the basis for EU Structural funding and Interreg projects (as: Coast to Coast). At regional level connections are made with other policy sectors: economic development and health.

Municipalities

Development of the region and spatial planning processes determines how the human system evolves and is adjusted to the natural system. In 2018, new regulation in the Danish Planning Act were introduced. The amendment gave municipalities now the power to prevent damage from flooding and erosion through spatial planning. The objective is to prevent flooding and erosion when planning for new urban areas, urban densification of existing city, technical facilities or changed to land use and so on. Besides mapping areas in danger of flooding and erosion, it is now compulsory to assess the need for mitigation or remedial measures and to weigh the consequences against other concerns. However, this does not obligate municipalities to set requirements in case local government does not favor climate adaptation. In 2022, climate considerations are included in the Planning Act, which indicates that municipalities can

[13] ec.europa.eu/enrd/sites/default/files/dk_rdp_qnt_summary_v1_2.pdf

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impose strict requirements when approving building permissions. The final guidelines on the planning act were published in 2022 and can be found here: https://www.klimatilpasning[...]emmelse-og-erosion-2022.pdf

All municipalities in Denmark now have local adaptation plans[14], developed with input from stakeholders such as civil society, utilities, and the public sector. The plans mainly focus on erosion and flooding (from sea, rain and groundwater). However, there are significant differences in the quality and scope of these local plans. Two key principles are returning everywhere: no building construction in rivers beds and land owners have responsibilities for protection and adaption to floodings.

The primary challenge remains the implementation of these plans, which is often hindered by limited capacities and insufficient financial resources. Nonetheless, several funding opportunities for climate adaptation are available.

Capacity enhancement

To enhance capacity at local level, DK2020 project has to mentioned. DK2020 project was funded by Realdania, a philanthropic organization funded by the real estate and banking sectors. The project supports voluntary municipal climate action plans, fostering dialogue and cooperation across Denmark. The DK2020 project has provided technical assistance to Danish municipalities in developing climate action plans that align with the C40 Climate Action Planning Framework (CAPF). These plans aim to make municipalities climate neutral and resilient by 2050. Staff from Local Government Denmark (KL), the five Danish regions, and local operators offered guidance throughout the process.

Stakeholder engagement

Municipalities use various approaches to engage both internal and external stakeholders, such as hearings, citizen meetings, informational materials, workshops, digital platforms, apps, and climate ambassadors. Internally, they involve specific departments like those responsible for technical and environmental works, planning, and emergency response. While a majority of municipalities refer to their development plans, wastewater management plans, emergency response plans, and previous climate adaptation plans, fewer municipalities reference other sector plans or align with broader local government policy agendas. To effectively address climate change, municipalities should integrate climate adaptation across all agendas, moving away from the silo mentality that often characterizes local governance.

Externally, municipalities collaborate with utility companies, citizens, neighbouring municipalities, and community councils. Notably, one-third of the plans include neighbouring municipalities in the planning process. Local governments base their decisions on dialogue within various councils established in the municipalities. This dialogue is often supported by citizen participation and feedback from local communities, homeowners' associations, and stakeholders from local businesses. However, as decision-making is part of the democratic process, most decisions are subject to a voting process before approval and execution. This

[14] Adaptation approaches in Danish municipalities climate action plans (realdania.org)

process has occasionally led decision-makers to prioritize local political mandates over regional, national, or international interests.

4.4 Regional Development

Denmark has regional development processes that are based on the smart specializations of a region and the missions that should be tackled. Cluster organizations and so called valleys are in establishment. These regional development processes are the basis to apply for EU Structural funding and Interreg funds as the Coast to Coast project. The policy of implementing NBS as a sustainable tool for reducing the negative effect of climate change is considered as a way to creating a new residential, business area, or recreational space for citizens and tourists and contribute to create more jobs.

Within the Central Denmark region, some new organizations, networks and initiatives have been taken on collaborating in finding solutions, opportunities and innovations for the regional development based on the local characteristics and dealing with the challenges of climate change.

Klimatorium

– A Beacon where Climate Threats are Turned into Business Opportunities -

The Klimatorium is a recent established quadruple helix collaboration between public and private sector, knowledge partners and civil society, that aims to deal with the climate change challenges in the region. It is located in Lemvig and founded in 2019. These organisations meet at the Klimatorium to develop solutions for the following topics: Coastal Climate Challenges, Green Energy, Circular Economy, Water and the Environment. Solutions that can be used and disseminated locally, regionally, nationally and internationally. The approach that Klimatorium is mission driven, based on the smart specialization in the region and in collaboration between the different groups in society. The aim is to push Central Denmark further in its way to find solutions. It is a membership organization that has developed a research and education agenda, designs projects, tests and demonstrates solutions and exchange knowledge via exhibitions and meetings.

The impact on the environment from the climate changes is very distinct in this part of Denmark. Towns and villages along Limfjorden are vulnerable to storms and rising waters. Along the west coast, saltwater intrusion in the fresh groundwater threatens the supply of potable water. Higher temperatures, as a result of the climate changes, affect the vulnerable aquatic environment in Limfjorden. Therefore, the local utility companies and other public enterprises are challenged, especially by climate changes and their consequences.

The Klimatorium will be the center in interactions between the public sector, universities and other educational or research institutions, citizens and the business community. The solutions to the climate challenges are created in collaboration between the parties with a strong focus on generic business development.

A particular ambition is to develop the segment “climate change tourism”. This part of Jutland is already a well-known holiday destination for Danes and tourists from other nations. By focusing

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on climate action as a tourist attraction, the aim is to attract climate tourists, thus spreading awareness of the Danish response to the effects of climate changes.

Aalborg University (AAU) is partnering Central Denmark regio as a partner in Klimatorium. Students can contribute to climate change topics and raise awareness through contributing to workshops and seminars. Students and researchers/ expertise can conduct research to develop innovative and environmentally friendly solutions. Student from AUU engaged and working on the project – description of NBS designs for collection or storage of rainwater/wastewater to protect Sewage systems during heavy rainfall or flooding

Water Valley

National unifying initiative driving the development and innovation of solutions for the water industry. We bring the best minds in the water industry together fostering open and creative thinking across segments, professions, and traditional mental barriers. Water Valley Denmark is an alliance encompassing Danish and international players, stretching from sciences and research institutes to startups and global supply companies. Focus on developing new technologies for dealing with water Water vision Vandvisionen 2025; Denmark wishes to double the export of water technology and create 4,000 new jobs within the industry.

Water Valley aims to apply an innovative approach to project work, combined industry effort and knowledge sharing, to solve some of the world's fundamental water challenges. In doing so we aspire to enhance the quality of life for people worldwide.

- Water Valley Denmark will create a platform and epicenter for developing groundbreaking water technology that will enable water consumption to become more resource efficient, cost effective and quality assured.
- Research & Development: Increased focus on innovation collaboration and research in water technology, such as: PhD School, Lab Facilities
- Startup & Incubation: Strengthening startup environment and ecosystem through incubation and accelerator programs, such as: Experimental Water Lab, Water Accelerator
- Innovation & Large-scale Projects: Build large-scale test and demonstration facilities. Create improved access to water data and establish better opportunities for developing new digital business models
- Global exposure and Collaboration: Focus on establishing the Lighthouse Water Tech which will strengthen Denmark's exports, such as: Building a network of water living labs – including The Spring, Develop a digital knowledge sharing platform

Food Cluster Denmark

Food Cluster Denmark in Central Denmark is a leading agricultural and food innovation hub that plays a significant role in the region's economy and sustainability efforts. Located in the heart of Denmark, this area is known for its advanced agricultural practices, food production, and research initiatives that focus on creating a more sustainable and efficient food system. These institutions work closely with local farmers, food producers, and tech companies to develop new

methods and technologies for improving food production, reducing waste, and enhancing food safety. They also work on methods for sustainable farming practices. In this way, the region has succeeded to remain a major play on the global food market, via the provision of high-quality food products.

4.5 Projects and Initiatives

A growing amount of organizations, networks and initiatives can be found in this region focusing climate adaptation (and nature based solutions). To provide insights on existing examples, several of these initiatives are described below.

Climate Alliance

Climate Alliance is a five-year commitment to aid the municipalities in developing and implementing their CAPs, reducing GHG emissions and enhancing climate resilience throughout Denmark with a target of emissions neutrality by 2050 at the latest. In doing so the local governments engage with the community to inform the plan and identify key social, environmental and economic benefits expected from implementing the plan, and establish ways to ensure an equitable distribution of these benefits among the population. The project is managed by the Danish independent green think tank CONCITO who alongside C40 provide tools and knowledge on climate action planning and ensure a consistent level of quality.

European projects

In the *RESIST project* (resist-project.eu), the Central Denmark Region is implementing innovative solutions focused on sustainable infrastructure to address sea level rise and erosion. These solutions will be demonstrated across five municipalities: Lemvig, Randers, Horsens, Hedensted, and Norddjurs. The project aims to raise awareness and promote integrated planning to enhance resilience against flooding in Central Denmark.

Key activities in the region will include showcasing adaptive building methods and nature-based solutions (NBS) to mitigate flooding risks. To engage the public and increase understanding, the project will utilize extended reality (XR) technology to visualize these solutions and infrastructure projects. The participatory approach in the RESIST project emphasizes collaboration and community involvement in building resilience.

In 2022, Central Denmark was appointed as a *national beacon for climate change adaptation* (CCA) and water technology, supported by REACT-EU grants. Despite this recognition, there remains a need for greater awareness and integrated planning to address the water-related challenges posed by climate change.

Central Denmark has also been recognized as a hub for water solutions in Denmark. The *Coast to Coast Climate Challenge* (C2C CC), a significant climate adaptation project funded by the LIFE program, spans from the West Coast to the East Coast and connects 31 partners across the region. This project includes 24 different climate adaptation initiatives and has fostered a strong network of municipalities, universities, engineers, and SMEs, now known as *Klimatorium*.

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Other relevant and related projects are living labs as part of the lighthouse projects. Klimatorium is participating in 14 of these projects, in which research and entrepreneurs are involved as well.

Three projects within the Atlantic Coast:

1. Thyborøn City and Harbour
Thyborøn, a coastal town, faces significant environmental challenges due to its unique geographical and geological conditions. The town is built on reclaimed wetlands, resulting in a subsoil that is heavily saturated with water and lacking natural drainage capabilities. This situation is exacerbated by the town's location on a narrow isthmus, surrounded by the sea on three sides, which puts additional pressure on the underground and groundwater. After storms, this pressure causes the water levels in the subsoil to rise further, leading to instability. The unstable underground affects the infrastructure, particularly sewage pipes, which are prone to settling or breaking due to the constant motion.

2. The Thyboron Channel and the Western Limfjord
The region surrounding the Thyborøn Channel and the Western Limfjord is particularly susceptible to flooding, especially as climate change exacerbates weather extremes. In response, seven municipalities and various water utilities along the fjord have launched a joint project aimed at safeguarding the cities and surrounding land from future floods. This collaborative effort seeks to implement protective measures that will mitigate the risk of flooding, ensuring the safety and resilience of the communities along the fjord. The project represents a proactive approach to managing the anticipated challenges posed by climate change in this vulnerable area.

3. The River Stora in Holstebro
The River Storå, which runs through the city of Holstebro, poses a significant flood risk. When the water level in the river exceeds a critical threshold, it leads to flooding in the city center, causing considerable disruption and damage. To prevent such occurrences, it is essential to keep the river's water levels below this critical point. Efforts are being made to manage the river's flow and implement flood control measures to protect the city from future flooding events. These initiatives are crucial for ensuring the safety and well-being of Holstebro's residents, as well as safeguarding the economic and cultural assets of the city.

5 Climate change risks

5.1 Regional climate changes

The year 2023 has set new records both nationally and globally, surprising even the experts with its weather patterns. On January 1st, Denmark experienced its highest January temperature ever recorded at 12.6 degrees Celsius. It also became the wettest January on record, transitioning from the sunniest June with drought conditions to the wettest July. The ground is saturated, and the groundwater level is high. This became even more evident after the historic storm surge that hit the country on October 20th, with water levels measuring up to 216 cm. All these events underscore what we already know: there is an urgent need for action! Sense of urgency: just started to arrive after 2023 year with events.

Looking back at the history, it is clear that the climate is already changing in Denmark:

- Average annual temperature has increased by 1.5°C since the 1870s
- Average annual precipitation has increased by 100 mm

These changes have led to coastal erosion, flooding (mainly coastal and pluvial flooding, some extent fluvial), high groundwater levels and some other risks like risk to salinization, heatwaves, and risk to drought but limited to some municipalities.

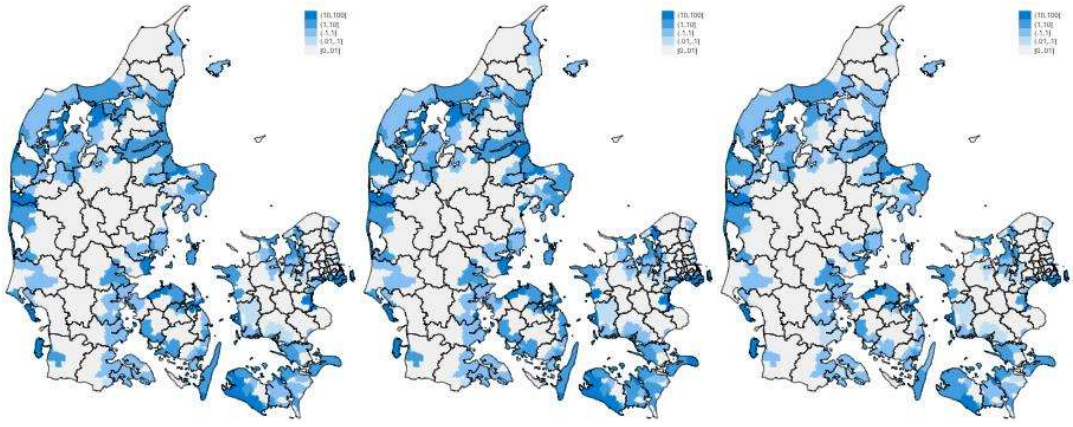
The Danish government has identified the two top climate change risks:

- Sea Level Rise and storm surges - increase up to 1.2 meter by 2100
- Heavy rainfall - (cloudbursts), consequently flood risks, mainly issues in the built environment

Sea level rise and storm surges

The governmental institute Danish Coastal Authority has conducted a risk study covering the whole of Denmark. The study maps the risk from erosion and flooding in 20-, 50- and 100-year horizon and gives general recommendations for action in form of generalized measures. It will be up to local municipalities to decide if they will follow the recommendations.

Climate Atlas Denmark:



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Now 2041 2071

Figure 20: Climate Risks: Sea Level Rise (Source: Denmarks National Bank)

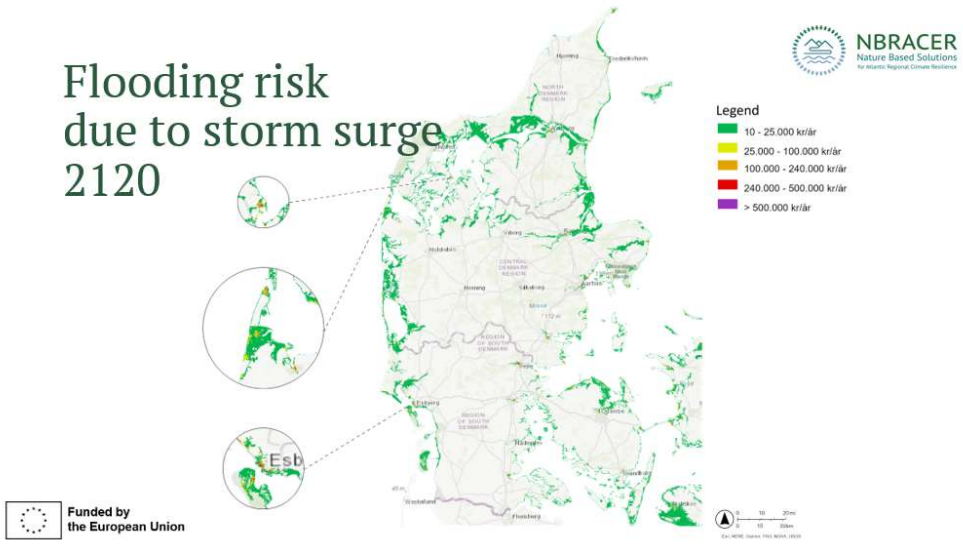

Figure 21: Climate Risk Flooding

Heat

High temperature is not yet considered as a main hazard in the region of Central Denmark. However, one or two municipalities mentioned in their climate adaptation plans about its effect for the midterm. High temperature may damage natural resources in 2050. It may negatively affect some species. However, high temperature is not the main priority.

Climate Change Central Denmark

Storm surges and heavy precipitation are the main challenges of the central region. Another problem of the central region is groundwater level which will be increased until 2050.

The region is facing water challenges from all sides. The rising sea level on the east and west coasts of the region is a pressing challenge. However, water does not stop at the shore. Central Denmark has an intricate network of streams and lakes and is experiencing rising shallow groundwater levels. This situation, linked to increasing cloudburst events, is also causing more floods and soil erosion.

The impact on the environment from the climate changes is very distinct in this part of Denmark. Towns and villages along Limfjorden are vulnerable to storms and rising waters. Along the west coast, saltwater intrusion in the fresh groundwater threatens the supply of potable water. Higher temperatures, as a result of the climate changes, affect the vulnerable aquatic environment in Limfjorden. Therefore, the local utility companies and other public enterprises are challenged, especially by climate changes and their consequences.

Climate Change Region Southern Denmark

The main climate challenges of Southern region is heavy precipitation and high groundwater level. Some parts of the region will also experience storm surges. It is estimated that a 100-year

storm surges in 2050 will potentially damage some parts of south region which will have significant financial damages. Moreover, it is estimated that the high groundwater level in 2050 will cause potential challenges for both public and private properties and critical infrastructures.

Policies in Regions Central and Southern Denmark

- Rainwater more than 10 cm on the surface of private properties should be managed by the owners.
- Properties that are located in open country should purify wastewater through implementation of small purification plants.

Visions and action plans Regions Central and Southern Denmark

- Creating climate adaptation along with recreational values
- Reducing negative impacts of climate change including heavy precipitation by increasing green spaces including forests and NBS such as wetlands, and delay basins.
- Creating climate adaptations that add value to both citizens and business.
- Reduce GHG emissions through implementation of green infrastructure by the year 2050

Climate Change Northern Denmark

North region will experience different climate challenges including storm surges and heavy precipitation. However, the assessment of groundwater is not part of their assessment. It is estimated that an extreme storm surge event

In 2050: Extreme storm surges from the Limfjord and North Sea. Moreover, extreme precipitation is another challenge of north region.

Policies in Region Northern Denmark

- High risk areas to storm surges need to be keep free from buildings
- Rainwater more than 10 cm on the surface need to be handled locally

Visions and action plans in Northern Denmark

- Identifying high risk areas to flooding
- Developing environmentally sound solutions within those areas to increase robustness
- Climate hazard must strengthen the recreational opportunities for citizens.
- Strength biodiversity

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6 Key Community Systems

6.1 Local economic systems

The local economy in Central Denmark is focussed on the following sectors:

- Agriculture, food processing
- Fishery
- Renewable energy and environmental management
- Pharmaceutics and biotech
- Manufacturing

Looking at employment, most people living in Central Denmark are working in public administration, education and health sectors, or in trade and transport sector, followed by manufacturing and other business services.

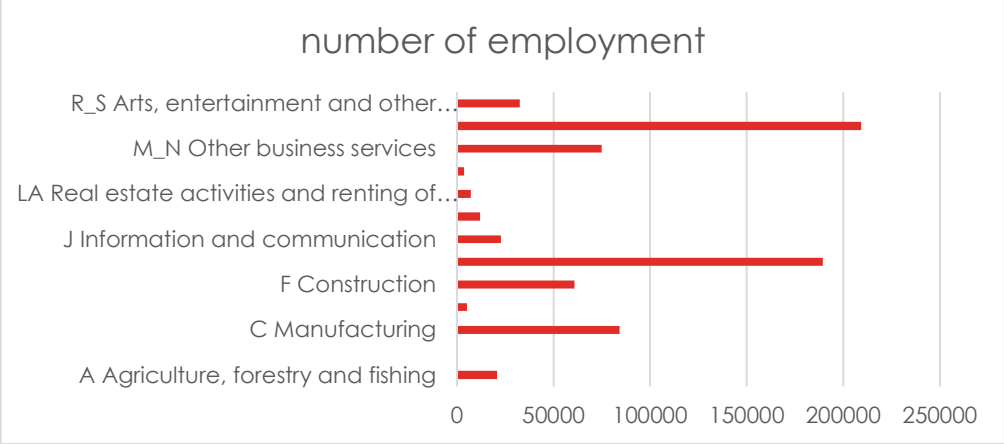

Figure 22: employment

As agriculture is one of the most dominant land cover, it is useful to have a better look at the food system in Central Denmark as well. The food system in Central Denmark is characterized by a blend of traditional agriculture, modern food processing industries, and a growing focus on sustainability. Food production:

- Dairy farming: Central Denmark is known for its strong dairy sector. The region produces a variety of dairy products, including milk, cheese, and butter. Danish dairy farms are highly modernized, focusing on efficiency and sustainability.
- Animal husbandry: Beyond dairy farming, the region also engages in livestock farming, particularly pigs. Denmark is one of the world's largest exporters of pork, with Central Denmark contributing significantly to this output.
- Crops: The fertile lands of Central Denmark support the cultivation of various crops, including cereals (wheat, barley), root vegetables (potatoes, carrots), and other essential grains. These are both consumed locally and exported.

Food processing industry in Central Denmark is known for meat processing. Central Denmark hosts several meat processing plants that prepare and package pork, beef, and poultry for both domestic and international markets. There are also some dairy producers that have advanced processing facilities. These products are recognized for their quality globally. Organic and specialty foods production is a rising trend in Central Denmark, including organic vegetables, free-range meats, and artisanal products. Denmark is a leader in sustainable agriculture, and Central Denmark is no exception. Farmers and food producers in the region are increasingly adopting practices that reduce environmental impact, such as precision farming, organic farming, and the use of renewable energy sources. Central Denmark is also home to innovation hubs and research institutions that focus on food technology, exploring new ways to improve food production, processing, and distribution in a sustainable manner. While large part of the agricultural production is exported, especially dairy and meat products, part of it is distributed and consumed in the region. Central Denmark has a well-established network of local markets where fresh produce, dairy products, and meats are sold directly to consumers, supporting the local economy and ensuring traceability. Furthermore, several major Danish grocery chains operate extensively in Central Denmark, providing residents with access to both local and imported food products. There is also a growing presence of online grocery shopping[15]. The food culture in Central Denmark is deeply rooted in Danish traditions, with a focus on hearty, seasonal dishes. Traditional Danish foods like smørrebrød (open-faced sandwiches), frikadeller (meatballs), and a variety of seafood are staples.

The expected climate changes may result in financial damage in the region, including but not limited to building damage, damages to household goods, damages to businesses. Otherwise climate change will challenge regional partners to find solutions, which is actually already leading to new collaborations within clusters on climate, food and water, working on innovations, which may provide new future perspectives on local economies and environment, and added value, as well for private sector as for public sector.

6.2 Critical infrastructure

6.2.1 Transport system

People living in Denmark can rely on a mix of means of transport, like cars (roads), trains (railways), flights (airports) and boats (sea ports).

The railway network is crucial to connect the hinterland with the main transport network.The road network is extensive. Only 5% of the roads are state roads and 95% are owned by local municipalities. To connect islands with the mainland, there are a number of bridges built as well. Most bridges are free of charge. Ports play an important role in trade, but ports on the West coast struggle with issues like low water depth due to natural erosion. Danish ports also play an important role for the aquacultural sector.[16] For Central Denmark, the north-south and the west-east transport corridors are crucial for the local economy.

[15] Statistics Denmark for data on agriculture and food production. Danish Agriculture & Food Council for insights on food industry practices. Local government resources on sustainability initiatives in the region.

[16] The Danish Transport System, Facts and Figures (trm.dk)

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People in Central Denmark are commuting to work and the graph below illustrates the distance differences for employment types. People living in rural and in commuter communities still have poor access to public transport, with over 60% not having a decent level of public transport service provided to them[17]. These people still mainly rely on their private car for transport. In Central Denmark, 67% of the families possesses at least 1 car.

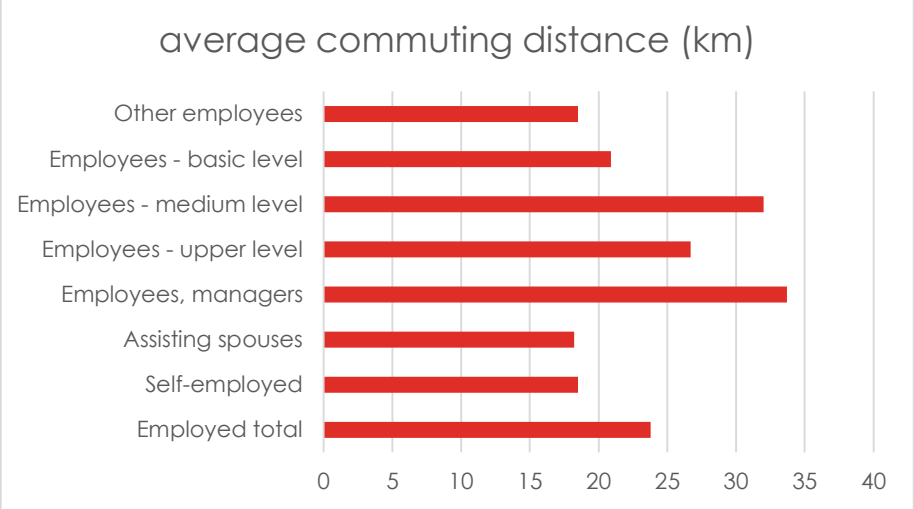

Figure 23: average commuting distance

6.2.2 Energy system

The energy supply mix in Denmark mainly relies for over 45% on renewable energy, coming from wind and solar on the one hand (12%) and biofuels and waster on the other hand (33%) the other part is still fossil fuels like coals, oil and natural gas. In 2020, the Danish government has agreed to phase out oil and gas extraction by 2050[18]. Denmark is committed to reduce greenhouse gas emissions and to replace parts of the current energy system. One aspect is the introduction of district heating systems. These systems move energy in water from place of production to place of consumption and can be used for heating and colling via this collective system. Looking at Central Denmark, it is clear that district heating is already well introduced in dwellings. The energy transition that still needs to take place is mainly at farmhouses where there is still a proportion of dwellings relying on oil or natural gas[19].

[17] StatBank Denmark
[18] Denmark - Countries & Regions - IEA
[19] How district heating is paving the way towards Denmark's climate goals (stateofgreen.com)

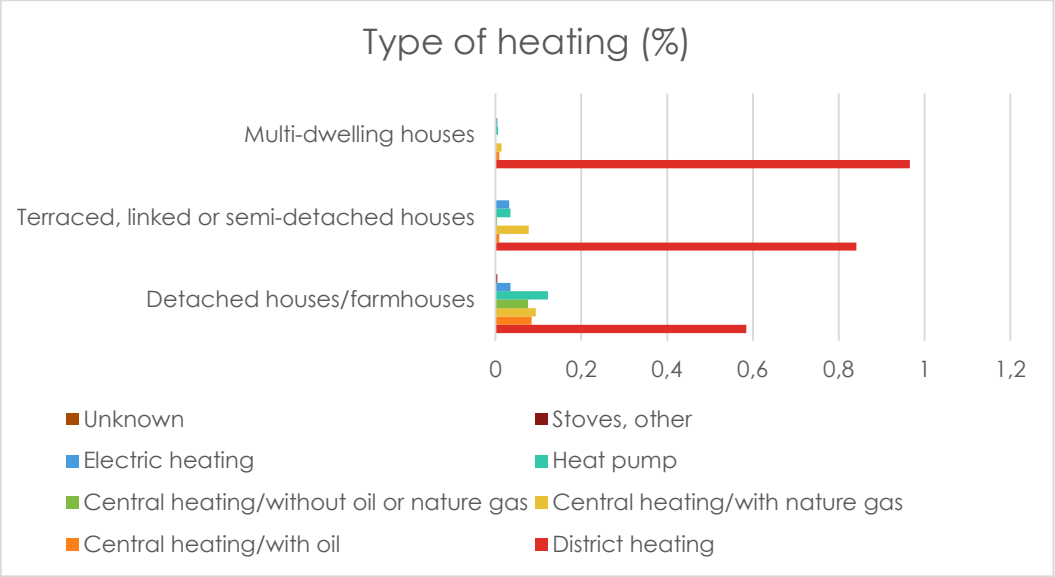

Figure 24: Clean and renewable energy | Denmark leads the way | denmark.dk

6.2.3 Drinking water supply

Denmark has a decentralized water supply structure, meaning that drinking water is typically produced at local waterworks. They extract groundwater, oxygenated and filter it before it is pumped out to consumers' taps. In rare cases, advanced water treatment is necessary to ensure satisfactory drinking water quality. More than 95% of Danes receive drinking water from the country's approximately 2,600 public water utilities. The water utilities vary greatly in size. The largest water supplies provide water to several hundred thousand people daily, while the smallest supply water to just 10 properties. The production apparatus of the largest water utilities often includes multiple waterworks, extensive distribution lines, and hundreds of boreholes. The smallest public water utilities may consist of a small waterworks, a single borehole, and shorter mains.

6.2.4 Sewage system

Denmark has a different systems for waste water management[20].

- Joint systems, where waste water and rainwater are collected in one sewer, which is led to a treatment plant. This is the traditional system which is mostly present in older sewage systems.
- Separate systems, where waste water and rainwater are led in separate sewers to the treatment plant and recipient, respectively. Gradually implemented in systems that already have joint systems, and preferably used in newer developments.
- Decoupled sewage systems where only waste water is led to the sewer, and every property therefore must dispose of the rainwater that falls on the property themselves (e.g. by seepage on their own land). Mainly used in the open country and in summer

[20] Waste water - The Danish Enviromental Protection Agency (mst.dk)

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house areas and sewage catchment areas where, according to waste water plans, it is possible to handle rainwater locally.

6.2.5 Effects of Climate Change on Critical Infrastructure

Heavy precipitation and storm surges may bring significant damages to critical infrastructures including electrical facilities, roads, transportation, buildings, and chemical factories. During the 1970s, a possible sea-level rise of about 30 cm within the next 200 years (corresponding to the projected value without climate changes) was taken into account in the planning of the dike system of southern Jutland. In future planning of flood risks, an expected 50 cm sea level rise is now included.

Projected impacts on roads and railways:

- Increased precipitation and flooding: Higher groundwater levels and extreme precipitation can cause landslides and reduce the bearing capacity of bridge and tunnel foundations. This also poses risks to road and railway infrastructures, especially foundations on sand.
- Erosion and safety issues: Erosion of track cuttings and embankments, along with the vulnerability of modern safety installations to temperature increases, are significant concerns for railways.
- Aquaplaning and road closures: Inadequate drainage during heavy rains can lead to aquaplaning and road closures, affecting safety and accessibility.

Projected impacts on water supply and waste water treatment:

- Sewerage systems: Sewerages, designed to last 50–100 years, are increasingly vulnerable to extreme rainstorms, which cause flooding of land and cellars. Heavier precipitation also degrades water quality in waterways and lakes, impacting bathing water quality due to rain-provoked discharges from treatment plants and sewer system overflows. These issues may hinder compliance with the EU Water Framework Directive and the Bathing Water Directive.
- Climate Adaptation: Danish sewerage systems and wastewater treatment plants were initially planned without accounting for climate-induced sea-level rise. While this possibility is now acknowledged, potential problems are assumed to be manageable with pumping systems.

Projected impacts on energy power plants and supply:

- Storm impacts: Danish as well as foreign electricity distribution grids may be damaged by storms. The Danish distribution grid is currently being cabled underground and is expected to be fully cabled within the next 10 years, which will reduce the impacts of climate change. Increased wind speeds are not expected to cause serious problems for wind turbines since they are protected against extreme wind speeds.
- Increased wind speed: On the one hand, this can lead to greater electricity production from wind turbines, but on the other hand, in storm situations, wind turbines must be

shut down to avoid storm damage. Increased precipitation in the Nordic region may lead to greater electricity production from hydro power.

Communications

Telecommunications Power Supply Vulnerability: Modern electrical power units for railways are vulnerable to higher wind speeds and stronger storms, which can disrupt communications networks.

Emergency Services

Emergency Response and fire stations

DEMA's Preparedness: The Danish Emergency Management Agency (DEMA) plans to equip special vehicles to operate in floodwaters up to 120 cm deep. DEMA is also enhancing its international assistance capacity, which can be utilized for national incidents, including extreme weather events.

Project impacts on buildings

The groundwater table has risen by up to one meter over the past 30 years. Approximately 450,000 homes have less than one meter to the groundwater table for most of the year.

- Rising groundwater table: The groundwater table has risen by up to one meter over the past 30 years, affecting approximately 450,000 homes, where heavy downpours can flood basements. The Danish Government is now empowering municipalities to manage high groundwater levels and enable wastewater companies to create collective solutions were beneficial for society, aiding vulnerable landowners.

Storm and heat damage**:** Stronger storms and heat waves pose risks to the structural integrity of buildings, including roof collapses from snow and health issues related to indoor climate during heat waves.

6.3 Ecosystem

Various ecosystems in Central Denmark are facing (future) risks due to human activities and climate change. Climate change is impacting ecosystems due to sea level rise, increased storm intensity, temperature changes, and altered precipitation patterns. Such climate changes are projected to contribute to habitat loss, altered species compositions, and disrupted ecological balances.

With regards to forests, one expect contribution to species vulnerability due to climate change, more specific due to high temperatures, altered precipitation patterns, and increased storm risks will negatively impact various tree species, particularly non-native conifers, leading to unstable forests and potential forest die-offs (klimatilpasningsstrateg…). Given the long production times for forests (50–80 years for conifers, 80–150 years for deciduous trees), it is critical to start adapting forestry practices now. This includes promoting the use of robust hardwood species and close-to-nature forestry methods to enhance forest resilience (klimatilpasningsstrateg…).

6.4 Food production System

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Floods from storm surges will potentially affect the recreational spaces and properties located near the harbour or coastal zone. Potentially leading to keeping those areas free from buildings. Moreover, heavy precipitation will cause challenges for agricultural areas especially if these lands are filled with clay soil. Saturated fields due to more rainfall, can be a barrier to use a longer growing season.

In general climate change can create both problems and possibilities that in the longer term can best be solved/exploited by conscientious planning of land use, for example by exempting certain areas from residences and other installations.

Increased precipitation with consequent higher water levels in fjords and rivers – will increase the problems associated with drainage of low-lying areas, particularly in coastal areas, where about 43 % of Denmark's population lives. The majority of Denmark's approximately 250,000 summer houses and 73 % of camp sites lie within 3 km of the coastal zone. Moreover, as increased volumes of water may result in landslides (for example roads, the chalk cliffs on Møn), which can affect various types of infrastructure. More powerful storms, especially in winter, can increase risks for people, buildings and installations, and can also increase the risk of flooding in low-lying areas.

Climate change presents overall advantages for agriculture in Denmark, with potential benefits including increased production due to rising temperatures, higher CO2 concentrations, and a longer growing season. Additionally, changes in cultivation practices can be implemented quickly to adapt to these new conditions. However, several barriers must be addressed to fully capitalize on these advantages. There will be an increased need for plant protection and fertilizers, which could lead to greater risks of nitrogen and phosphorus leaching into water bodies. Flooding and high groundwater levels may pose challenges in some areas, while sandy soils will face increased irrigation demands.

Other potential impact on agriculture:

- Productivity changes: Rising CO2 levels and temperatures are expected to lengthen the growing season, potentially increasing agricultural yields by 10-15%. However, this will also result in increased costs for fertilizers and pesticides.
- Environmental concerns: Greater winter precipitation will heighten the risk of nitrogen and phosphorus leaching into water bodies, exacerbating issues like oxygen depletion and potentially harming aquatic ecosystems.
- Water management: Higher summer temperatures and prolonged droughts will increase the need for irrigation, particularly in sandy soils, affecting water availability in rivers and streams.

Climate change poses significant risks to land use and food systems, impacting agricultural productivity, water management, and forestry stability. However, it also presents opportunities for adaptation and innovation. The expected increase in agricultural yields due to longer growing seasons can be harnessed with the right investments in research and technology. Enhanced water management and updated land-use planning regulations are crucial to mitigate flooding and landslide risks.

6.5 Health system

Increased precipitation and flooding are expected to affect the health and wellbeing of citizens. In the first place, it is expected to increase stress among citizens in advance and mental health issues after disasters. On the other hand, increasing sewage overflows will contaminate the groundwater which is the main drinking water source in Denmark and in a worst-case increasing disease epidemic. This is one of the potential physical health impacts of climate change. Other health impacts are related to wetter and warmer conditions that may result in moisture damage leading to mould, consequently affecting health. Changes in the temperature and plant growing season may increase allergies, with longer pollen seasons and rise of dust mites. During heavy downpours, people might get injured. And generally taken, there is a trend of increased climate anxiety and depression amongst the population. All these health impacts will affect wellbeing of Danish people and will put a pressure on the existing health care systems.

Health effects of greening environments; According to regional climate adaptation plans, increasing green infrastructure will have multitude benefits. Green spaces will positively impact human well-being by increasing mental health. Moreover, these spaces will increase social interaction among people and encourage them to have physical activities which leads to increasing health. Additionally, by providing aesthetic value will reduce the stress. However, green spaces may have some negative aspects depending on the size of the city. In the big coastal cities, it may cause social injustice by increasing properties values. It may also increase citizen‘s dissatisfaction due to increasing mosquitos.

Well function green spaces in the city scale which connect different part of the city together will provide synergy between physical activity and social relationship. This will encourage people to walk or cycle through these spaces for reaching to their workspace, educational institutions, or shopping centers.

6.6 Water management system

Climate change is significantly affecting water management in Central Denmark’s coastal regions along the west coast. Climate change effects in this region are increased heavy precipitation, rising sea levels, and elevated groundwater levels.

The region is experiencing more intense rainfall, which overwhelms sewage systems and causes overflows, leading to untreated sewage contaminating waterways and affecting water quality and ecosystems. Additionally, surface runoff from these heavy rains carries pollutants from roads, industrial areas, and urban surfaces into lakes, rivers, and groundwater, further compromising water resources.

Sea level rise exacerbates these challenges by increasing the risk of coastal flooding and saltwater intrusion into freshwater systems. Simultaneously, soil subsidence lowers the land elevation, making coastal areas even more vulnerable to flooding and erosion.

Next to climate change impacts, the current regional human activities are creating more risks on water management both water quality and water quantity related.

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7 Connecting Natural and Social system

7.1 Relations between the systems

The social system in Central Denmark is dependent on the local natural system, mainly because of the significant importance of the agricultural (pollination, water availability, soil fertility)) and tourist sectors (recreational activities in nature and along the coast) for the regions, but also for the health and wellbeing of the people living there. Other economic sectors that rely on natural systems is the energy sector, which consists largely of wind energy and to some extent also for biogas. However, issues like nutrient runoff, pesticide use, soil degradation water pollution, emissions, biodiversity loss, overfishing, marine pollution, greenhouse gasses emissions exist and are tackled mainly via the ambition of the green transition. This ambition indicates that the connection between the natural and social system are acknowledged.

7.2 Nature based solutions

Nature based solutions do play a role in this green transition. More specific, there are already the following examples:

NBS in Region North Denmark

- Utilizing local drainage rainwater to handle rainwater locally
- Implementing basins in rainfall related outlets to store the mixed diluted wastewater and reduce the discharge rate of diluted wastewater in the sewage systems.
- Implementing delay basins and green areas in a municipality scale to reduce surface runoff.
- Implementing mini purification plants covered with vegetation in open county to purify wastewater.

NBS in Region Central and South Denmark

- Citizens have implemented green infrastructures including rain gardens, which are permeable surfaces with green vegetation to reduce rainwater runoff.
- Implementing local management water which contribute as a recreational opportunity with more green areas.
- Increasing biodiversity through enhancement of natural elements.
- Providing equality for all citizens to have an equal access to green infrastructures.
- Implementing delay basins near watercourses to reduce the flooding at the same time cleaning surface runoff.
- Establishment of wetlands and increasing forest areas to reduce rainwater runoff and CO2 emissions.
- Utilizing crops including willow, poplar, elephant grass for fuel purpose instead of fossil fuel which have a positive impact on CO2 balance. Willows will provide the opportunity for a nitrogen reduction as well as an energy crop. In addition, energy willow is harvested in the winter months, making it a suitable crop for seasonal balancing.

In identification of benefits, most municipalities highlight the benefits of adaptation action for nature and biodiversity, as well as for leisure and recreation. Less than half of municipalities highlight health and synergies with greenhouse gas emission reductions, and even fewer municipalities highlight business development, tourism, security.

8 Conclusions & Recommendation

8.1 Conclusions

Natural system

The glacial period has played a significant role in shaping today's soil system, water system, and ecosystems in this focal area.

Soil system: the soils in the NRBACER focal area are fertile and suitable for agricultural use. The area is a rather flat and open landscape, as the result of changes in the Ice Ages.

Water system: the region is characterized by an extensive water system and has a long coastline. Groundwater plays a significant role in the water supply of the region. It sustains both natural habitats and human communities. Rivers, streams, and coastal features contribute to the water system, influencing drainage patterns and supporting diverse aquatic life.

Nature system: the focal area is known for its varied natural landscapes. The challenge is to balance farming and urban development with the ecological preservation of these areas.

Recognizing the natural system's history is crucial for understanding vulnerabilities and identifying effective nature-based solutions.

Social system

Population in the NBRACER focal area is becoming stable, when looking towards the future, although the population distribution is changing. The proportion of elderly people is growing. Most of people are married couple, with also large proportions single women and men. The amount of immigrants is increasing lately as well, mainly due the war between Ukraine and Russia. While most people earn a decent living, Denmark still has a small number of people at risk of poverty. This may differ amongst municipalities. The population knows a mix of home ownership, with tenants mainly living in multi-dwelling houses. There is also a clear trend in the household composition versus the type of houses, with married couples mainly living in detached houses and single men or women mainly living in multi-dwelling houses. The houses in Denmark are decently built, and are already switched to more renewable ways of heating, mainly district heating.

The NBRACER focal area can be labelled as rural area, with lots of land used for agriculture. The cities and towns located in the NBRACER focal areas have different roles for the people in the area. The area is well-known for its food production and processing and plays an important role in Danish export. Main economic sectors in the region, apart from agriculture and food processing are fisheries, renewable energy and environmental management, pharmaceutics and

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biotech and manufacturing. Largest employers are the public administration, education and health care, as well as trade and transport. Due to its rural character, people living in the area mainly rely on private car for transport, as still a large proportion does not have decent access to the public transport. The energy system is in full transition towards renewable energy, with main focus on wind and biomass energy. Denmark intends to phase out oil and gas by 2050. Drink water supply is primarily from groundwater sources and sewage systems are known for three different types of systems, including the joint system which is the traditional one.

Connection between natural and human system

The NBRACER focal area is largely dependent on a balanced connection between the natural and social system as it is clear that the natural system plays a major role in the economy. Denmark has a governance framework that aims to manage the balance. The analysis makes clear that Denmark is making use of legislation and network approach to manage climate resilience, although having made progress, it is still in an early stage. Some topics have been identified to foster further transformation. However, a lot of responsibilities is with the municipalities who have indicated to lack some capacities and are looking for more funding to implement their plans. They have indicated that they would need to coordinate their efforts and resources but a regional coordination mechanism is missing. The region(s) as the level of focus of the European Missions, does not have a formal responsibility for climate change. They could play a more prominent role in coordination of the initiatives at the level of municipalities. The region is also responsible for relevant policy fields which may be affected by climate change, as there are health policies and also regional development. Within Central Denmark promising initiatives are taking place on creating clusters, networks and Living Labs where innovations to deal with water (Water Valley) and to deal with Climate Change (Klimatorium).

Denmark is already quite experienced in working with quadruple helix approaches and clusters, mainly as part of their regional development approach. Sustainability thinking is at the core of innovation and private sector is willing and committed to it.

Climate change poses risks on the NBRACER focal area. The largest concern are storm surges and river flooding, as well as flooding due to heavy rainfall. The baseline report has signalled a few impacts that are already projected for the key community systems. Higher precipitation, rising groundwater levels, and stronger storms necessitate proactive adaptation strategies. Nature based solutions may be an answer to this. However, climate change also presents opportunities, such as increased electricity production from wind turbines due to higher wind speeds, potentially leading to more investment in wind energy. By recognizing these risks and opportunities, and implementing targeted measures, communities can not only mitigate the challenges posed by a changing climate but also capitalize on potential benefits, ensuring a more resilient and sustainable future. To do this, we share the following recommendations to support the transformation of the region towards climate resilience.

8.2 Recommendations

8.2.1 Areas for innovation

The NBRACER Demonstration project has a twofold focus: the first is on decentralised cleaning of rainwater to avoid that utilities run over capacity during heavy raining events. The system

aims for decentralising capture and cleaning of rainwater. Living lab is working on that. The use of natural anaerobic and aerobic zones to mimic the cleaning processes at the utility are explored in decentralised way.

The second NBRACER demonstration is on the Climate Road: this is a road with permeable asphalt to let rainwater drip into the ground. Natural bacteria clean rainwater to prevent contamination. Climate Road 1.0 has been tested and can also be used to generate energy like normal underground heating.

8.2.2 Regional Coordination mechanism

Given that a significant portion of planning and implementation responsibility lies with the municipalities, it is evident that Central Denmark would benefit from more structured coordination and management at the regional level. While numerous initiatives are underway in the region, there is currently no governance structure or framework to integrate these efforts, streamline decision-making, and consolidate information. As a result, decision-making and information are fragmented across multiple horizontal and vertical levels, increasing the complexity of researching, funding, developing, and addressing climate mitigation and adaptation scenarios. This fragmentation also hampers the ability to gain a comprehensive overview of planned, ongoing, and completed actions. There is a need for enhanced coordination and management of the different initiatives and the available resources and a better connection between policies and domains too.

Recommendations with regards to knowledge partners

More specific, limited alignment is experienced between the municipalities and the knowledge domain. Their decisions on climate change adaptation action must be supported by reliable data and up-to-date research. Collaboration between government authorities and knowledge partners, including within transport, building and construction, agriculture and health, will be helpful to identify particularly vulnerable systems in need of adaptation. This can also be be targeted at municipal stakeholders to inform their planning of the society of the future. Continued bridge building between science, experience and policy development needs to be ensured to create the right long-term solutions More systematic inclusion of new knowledge and existing experience in authorities' planning efforts, and more close collaboration between researchers, knowledge institutions, decision-makers and local stakeholders will be beneficial.

Recommendations with regards to entrepreneurs

Protecting the main economic activities for storm surges is a joint public agreement of which the state pays approximately 90% of the funding and the four municipalities pay 10%. To a large extent, climate adaptation is approached as a public responsibility and private sector has long not been mobilized. However, as business opportunities due to climate adaptation are identified, private sector starts to get engaged in climate adaptation like cluster organisations Klimatorium, Water Valley and Food cluster. Climate change challenges are also considered as missions as part of regional development processes and are used as entry point for innovations, value addition and the development of new solutions, new products and services as for instance the development of small treatment plants in order to purify wastewater.

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Recommendations with regards to civil society

Enhancing civil society participation with a focus on vulnerable groups.

In Denmark, citizens are responsible for mitigating flood risks on their properties. However, not everyone experiences these risks equally, as factors such as age, health, or income can affect their ability to cope. It is crucial to address the specific needs of different population groups, ensuring their engagement in adaptation processes so that their voices are heard, and they are not left behind in the regional push for greater resilience.

Local stakeholders, particularly those most affected by climate change need to be more systematically included in climate adaptation planning. Civil society can play a vital role by participating in workshops, contributing their thoughts and visions, and engaging through voluntary organizations and associations. These groups can take on responsibilities such as designing and implementing local development plans, forming working groups around local projects, and contributing to nature-based solutions like rain gardens, green spaces, and green roofs to manage and reduce rainwater locally. Although involving stakeholders in these processes can be time-consuming and may involve lengthy appeals, previous experiences can guide the creation of clear guidelines on when and how to best involve relevant parties, leading to better, locally informed solutions.

Raising awareness of climate change and citizen action

There is a pressing need for targeted information to help citizens and other civic stakeholders understand the impacts of climate change on their daily lives and during extreme weather events. Building social resilience requires campaigns that provide accurate risk profiles, outline actionable steps for those affected, and clarify citizens' responsibilities in managing risks. These campaigns could inform citizens about what they can expect from local emergency services and authorities. Engaging civil society in climate action planning processes, particularly at the level of land and homeowners, is essential to ensure that all individuals are equipped to manage and mitigate the effects of climate change.

Integration of innovation ecosystems/clusters with surrounding natural areas

The question is also on how to better connect the ongoing regional development of innovation ecosystems with their surrounding landscapes and natural areas. What is the natural potential of the surrounding area for business and innovation and how to make value?

Cross coastal collaboration

For the NBRACER case, the challenge is how to coordinate initiatives on the Denmark coastline , how to connect North, Central and South DK along the Atlantic Coast. The coastline is large zone with large distances, with responsibilities at the National level on protection, and marine issues, with limited connection to more regional and municipal interest. Furthermore, these municipalities also belong to three different administrative regions: Southern Denmark, Central Denmark and North Denmark.

8.2.3 Mission driven approach

To further advance as a leading region in mission-driven innovation and a nature-based society, it is recommended that the region optimizes governance by enhancing the management of its systemic approach through an integrated framework. Strengthening connections across the coastal region, landscapes, domains, sectors, and policy fields will be crucial for fostering a more cohesive and collaborative environment. Supporting initiatives from pilot stages to full implementation, coupled with broad involvement and active interplay with regional organizations and citizens, will drive sustainable growth and ensure the region continues to be at the forefront of the EU Mission's key objectives.

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9 References

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Annex 3: Baseline west Flanders

NBRACER
Nature Based Solutions
for Atlantic Regional Climate Resilience

Regional Baseline background report

West Flanders

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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 Mission on Adaptation to Climate Change 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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1 A Regional baseline

1.1 Aim of the Regional Baseline

The aim of this regional baseline is to bring together information about the region that is crucial for their journey to enhance the climate resilience of society. NBRACER aims to work with a systems transformation approach via Nature-Based Solutions (NBS). While NBS is highly relevant for resilience, it has to be emphasized that NBS also play an important role for the mitigation of climate change impacts, as well as the provision of a large range of other benefits, as for instance health and income. This requires a joint understanding of the different regional systems. This regional baseline provides the required information to discuss and to co-develop this joint understanding of the regional systems among partners in the regions involved in NBRACER. Furthermore, the baseline will be helpful to better assess the climate change impacts and the role that Nature-Based Solutions might play in the regional systemic transformation. This information will therefore also be supportive in the design, planning and implementation of Nature-Based Solutions (NBS) that fit with the typical characteristics of this region. The baseline will give direction to region's specializations, unique characteristics, as well as its strengths and weaknesses concerning Nature-Based Solutions (NBS). And finally, the use of the baseline will contribute to facilitating a joint commitment among stakeholders to start the Transformative Adaptation Journey and is expected to be used in joint sense-making for future visions and pathways.

1.2 Key concepts

Climate change can be approached in diverse ways. Therefore, it is important to describe the conceptual approaches that are underlying the NBRACER project and the analysis of information that has been collected for this baseline report. While many studies have been using an impact or risk-based approach, NBRACER is focussing on a systems-based approach to foster resilience. Key concepts related to this approach are:

- Systemic approach and key community systems
- The concept of regional transformation adaptation journey
- The transformational governance; concepts of collaboration and inclusion

1.2.1 Systemic approach and key community systems

The baseline adopts a systemic approach to comprehend the challenges that climate change poses on the region. The systemic approach is focussed to better understand the intricate relationship between the natural system and the social system. This approach starts from the Sustainable Development Goal's wedding cake (Stockholm Resilience Centre, 2016) that illustrates how economies and societies are connected with the natural system and in order to have a well-functioning economy and society, they should be well embedded in the underlying natural system.

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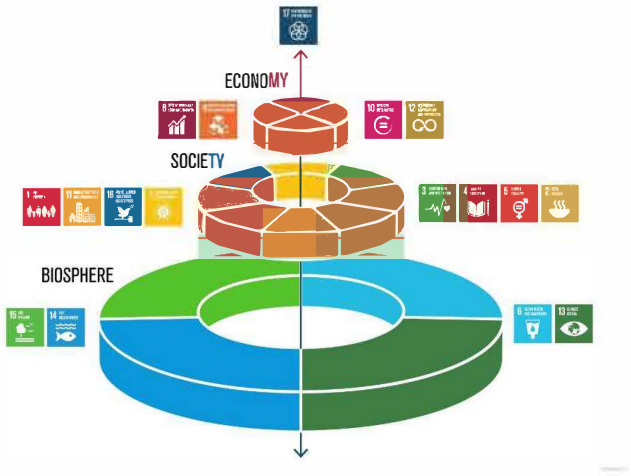

Figure 1: Wedding Cake of Sustainable Development Goals (SDG) (Stockholm Resilience Centre, 2016)

In the baseline, we aim to analyse the various parts of the natural and social systems and their connection. This will help to move away from the environmental or sectoral approach only, that is often used in climate change assessments that considers nature separate from society and economy. Instead, it promotes a more systemic approach that explicitly focuses on the interrelationship between natural and social systems. Nature-based solutions inherently have the potential to strengthen this connection sustainably by leveraging the natural system's capabilities to address societal issues.

Within this approach, three key components are delineated: the natural system, the social system, and the connection between these two systems that includes the governance that is in place to ensure natural and human systems are in balance. Approaching climate change in a systemic way enhance a better understanding on the systems issues that lead to climate change impacts and provide a better understanding on how systems could change in order to regain a balance between the natural and social systems given the context of the climate changes.

Related to this systemic approach are the key community systems that play a dominant role in the European Mission on Adaptation (European Commission, 2021). Key community systems are systems that meet basic needs for society but might be impacted by climate change.

Furthermore, the baseline also summarizes the available information on climate change risks and assess the related vulnerabilities of the key community systems due to climate change. To safeguard our wellbeing, it would be needed to assess the needs for transformation to ensure that the key community systems keep on meeting basic needs. The EU distinct 5 Key Community Systems: the land use and food system, water management system, critical infrastructure system, the health and wellbeing system and the local economic system. The EU Mission Climate Adaptation is focussing on using the ecosystems and nature-based solutions in order to protect the key community systems to the negative impacts of climate change. The ecosystem is crucial for our wellbeing and ensure that we are ecologically connected, that nature is restored and that ecosystems services are delivered.

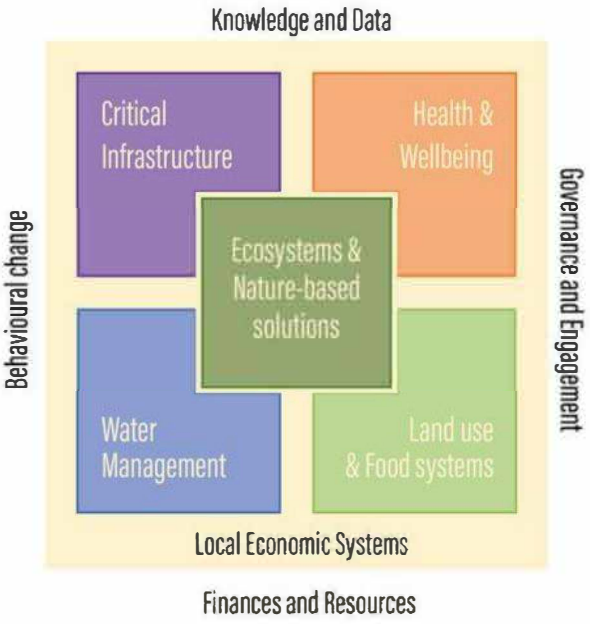

Figure 2: Key Community Systems (European Commission, 2021b)

1.2.2 Regional transformation with the Transformative Adaptation Journey

As NBRACER aims for systemic transformation at the regional level, we are relying on the Transformative Adaptation Journey (also used in Pathways2Resilience) in order to bring forward the regional transformation. This approach is originally based on the adaptation policy cycle but is extended with elements that would enhance the collaboration between public, private, knowledge and societal partners.

The first phase of the Transformative Adaptation Journey - *preparing the ground* – is focusing on understanding what's already being done in the broader policy, social, environmental, and economic contexts, understanding who are the key actors and institutions needed to involve, understanding the socio-economic context and available resources, and providing evidence to determine regional priorities and opportunities for sustainable, climate-resilient regional development. Also, climate risks and opportunities for prosperity need to be assessed. At the end of this phase, regions will have a comprehensive baseline covering, among others, risk assessments, adaptive capacity needs, a stakeholder map and a monitoring framework that will act as a solid foundation for the journey (Climate KIC, DesirMED).

The next step in the regional adaptation journey involves co-developing a *shared vision* with stakeholders. Active engagement is essential for creating commitment and ownership of the process and vision. This co-created vision will be a tool for mobilizing change and holding regional stakeholders accountable. It must be holistic, combining scientific insights with community priorities to foster a sustainable and equitable future. Public-private partnerships will be key to mobilizing resources and driving large-scale innovation. Ultimately, the vision

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must be dynamic, evolving with climate changes and lessons learned, and calls for courage, collaboration, and commitment from all sectors to protect our planet for future generations. (DesirMED)

Next step is developing adaptation pathways for climate adaptation and resilience gather interventions across multiple levers of change in a portfolio of actions, each of them contributing to progress towards the desired pathway, which will coincide with action & investments plans. While implementing the plans, it is aimed to closely monitor progress on the systemic change and to evaluate and learn and adjust actions if needed. In this way, building resilience via transformation becomes an iterative process, a journey, where all relevant regional stakeholders take part.

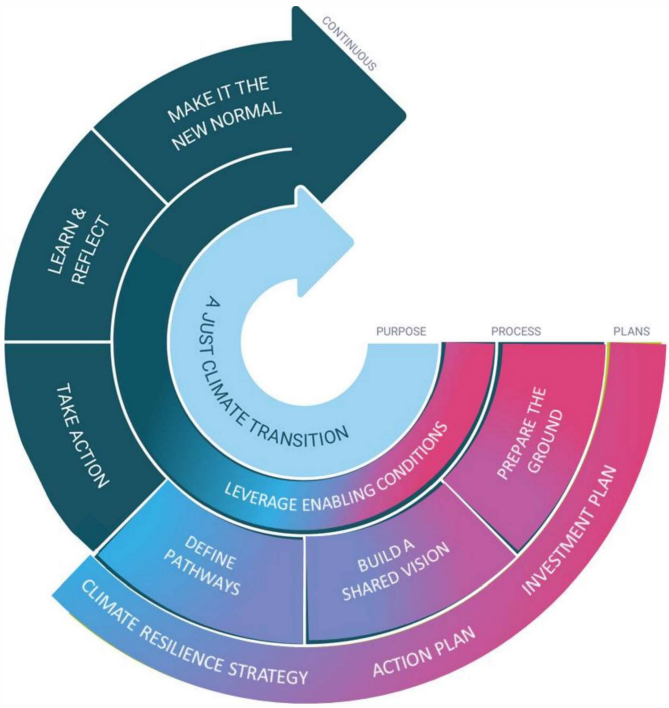

Figure 3: Transformative Adaptation Journey (Climate KIC, P2R)

1.2.3 Collaborative and inclusive approach

The European Mission on Adaptation acknowledge the need to involve organisations beyond the conventional public actors, when it comes to building resilience. It is crucial that private partners, government, knowledge partners and society (quadruple helix) are involved in the regional transformation adaptation journey. This means that these partners need to be mobilized and engaged in the various phases of the transformational process and start with

collaborating on directions and solutions to cope with climate change, and to create dynamics and initiatives within the specific regional context (Smart Specialization).

The European Strategy on Climate Adaptation (2021) (European Commission, 2021a) also promotes the principle of just resilience, indicating that adaptation processes have to be inclusive in order to avoid the risk that adaptation measures put an uneven burden on some groups and that marginalised groups are not well included in the planning and decision-making processes. Therefore, it is crucial to better understand who in the region might be unequally affected due to climate change and to ensure that they are well engaged in the development and implementation of adaptation measures to ensure that these measures meet their needs. Generally spoken, it is assumed that elderly, children, immigrants, single parents and poor people are more severely affected by climate change (Breil et al., 2018). However, it would be needed to explore vulnerable groups in the regional context and identify groups that are now already feel that they are left behind.

1.3 Process of constructing the Regional Baseline

To create the regional baseline, we first defined and listed the required information topics to get a better understanding of the systems characteristics. As mentioned earlier, the baseline examines both the natural and social systems, with a focus on their interconnections and the key community services. For each component, we identified the specific information needed to gain the desired insights for the baseline. More detailed information about this systemic approach and its individual components will be presented in the upcoming chapter.

To gather this information, we distributed a document to regional NBRACER partners based on the list of required information topics. The region, with its valuable insights into local conditions, significantly enriched our understanding of vulnerabilities, challenges, and opportunities. This collaborative knowledge-sharing formed the foundation of our regional baseline.

Additionally, Wageningen Research supplemented this information with relevant online sources. We thoroughly reviewed existing reports, data, and materials to enhance the insights shared by the regions. Our goal was to create an initial overview of the region's current state—a snapshot that captures its unique characteristics, risks, and adaptive potential.

The baseline serves as a starting point. During the regional workshop, we collected additional information and incorporated it into the baseline as needed. The aim is to develop a regional baseline that is tailored to the regional needs and that will evolves dynamically throughout the NBRACER project.

2 Situating the province of West-Flanders

The description of West-Flanders is mainly based on the concept plan spatial plan of the Province of West-Flanders (Provincie West-Vlaanderen, 2022). The province of West-Flanders is intending to work on several focal areas in NBRACER. Information on these sub-areas has been

collected for the purposes of the regional workshops but are not covering the full baselines framework. Therefore, the baseline's focus is the whole of the province of West-Flanders. Information on subareas is not included but is available to the province of West-Flanders for use in the further phases of NBRACER ('Gebiedsrapport focusgebied Landschapspark Zwinstreek – tussen het graafschap Maleveld en De Lieve, not published (living document)'.

2.1 West-Flanders

West Flanders, Belgium's only coastal province, boasts a population of about 1.2 million. It is a key player in Belgian agriculture, fisheries, and tourism, offering Flemish cuisine and a relaxed lifestyle. With lush farmland, quaint villages, and rich cultural heritage, it is a haven for outdoor activities and sightseeing, from cycling, hiking and horse-riding to exploring medieval Bruges and reminders of the WWI in Ypres. The local people, who are perceived as resilient and hardworking, have weathered wars, floods, and economic hardships, and are united by a strong sense of community.

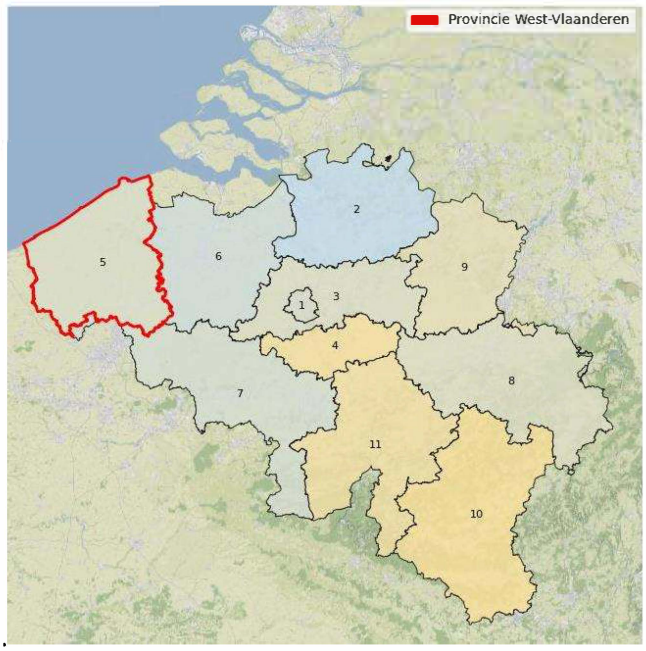

Figure 4: Map of Belgium - the red boarder indicates the province of West Flanders (Provincie West-Vlaanderen, 2023)

3 Understanding the region: Natural System

3.1 The landscape system

The landscape in West-Flanders is shaped via a history of land reclamation and water management, as well as urban development which was the result of trade and agricultural development.

3.1.1 Coastal morphology

West Flanders' coastal zone is defined by a combination of sandy beaches, dunes, and polders. Historically, the coast has been heavily modified by human activity to address the challenges of flooding and coastal erosion. Beginning in the Middle Ages, structures such as sea walls, groynes, and dikes were constructed to protect the low-lying polders from the North Sea. These interventions have continued into the modern era, reflecting ongoing efforts to manage and mitigate coastal risks (Paulissen et al., 2013).

The coastline is also influenced by the development of major infrastructure projects such as Zeebrugge port, which has altered the natural coastal morphology to accommodate maritime trade. As a result of both natural vulnerability and human activity, the region remains at risk of sea-level rise and storm surges. Recent projects, such as Flemish Bays, aim to enhance coastal resilience through strategies that focus on dune restoration and sediment management (Paulissen et al., 2013; (Vlaamse Overheid, 2024).

3.1.2 Polders, inland water management and rural areas

Polders play an important role in the rather flat coastal landscape in West-Flanders. These areas are maintained through an intricate system of drainage ditches, canals, and sluices that regulate water levels and prevent flooding. The water management system is essential due to the region's low elevation, often below sea level. Pumping stations are used to keep the land dry, making it suitable for agriculture and habitation (Paulissen et al., 2013) (Provincie West-Vlaanderen, 2022). The soil type is clay and very fertile for agricultural production, resulting in a landscape that is characterised by expansive, uniform fields, with very few natural elevation changes. The rural landscape is functional and structured, shaped to maximize agricultural productivity in the reclaimed lands (Paulissen et al. 2013; Provincie West-Vlaanderen, 2022).

3.1.3 Urban development and morphological changes

The urban centres in West Flanders, such as Bruges, Kortrijk, Ostend, and Ypres, have also played a role in shaping the region's landscape morphology. While their historic cores are often dense and built around medieval structures, the expansion of these cities has resulted in significant changes to the surrounding landscapes. The spread of urban sprawl and suburbanization has led to the transformation of previously rural or agricultural land into a mix of residential, commercial, and industrial zones. These morphological changes are driven by broader economic forces, including trade, industrialization, and improvements in regional connectivity (Paulissen et al., 2013).

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The next section describes the built environment. This encompasses all structures covering the soil, comprising approximately 12% of the area of West-Flanders, slightly lower than the 14% for Flanders as a whole (Provincie West-Vlaanderen, 2022). The built environment impacts the soil, water, and ecological characteristics of the area, as development can hinder these natural functions. Figure 6 showcases the diversity in soil coverage (percentage of paving) among different municipalities. This variation is primarily attributed to population growth, the concentration and expansion of urban areas, and the development of industrial zones within the province.

Population growth has driven increased urbanization, leading to the conversion of agricultural land into residential, commercial, and industrial areas. The development of the built environment in West-Flanders has been largely shaped by infrastructure projects, especially transport infrastructure, including harbours, navigable waterways, and railways. Additionally, measures to safeguard the land from water, such as dike constructions and the creation of polders, have been crucial. These transport systems have supported the growth of industries and trade. In the past century, the region became known for its textile industry, food processing, and manufacturing sectors. Environmental conservation has also played a role in land use, with certain areas protected for their ecological importance to maintain local and regional ecosystem functions. Large parts of the area are dedicated for agricultural production.

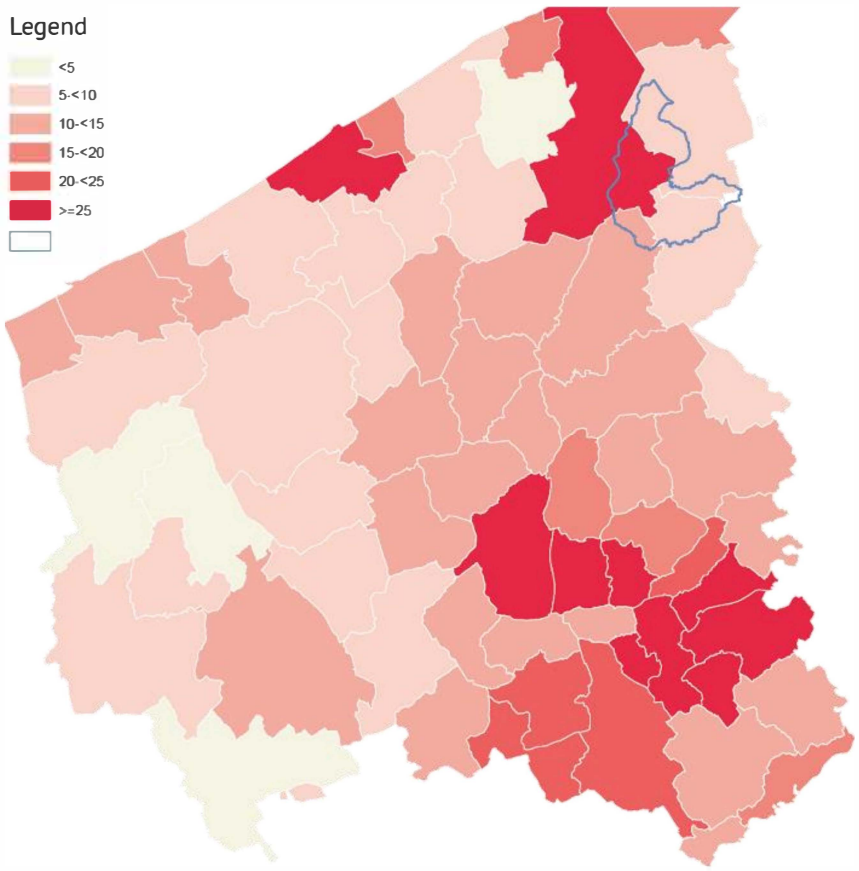

Figure 5: Percentage of paving in West Flanders per municipality (Source: Land cover map of Flanders, 2018; Provincie West-Vlaanderen, 2022).

Along the 70 km Belgian coastline lie densely built and populated coastal cities where apartments form a distinctive line. These apartments emerged after WOII when the road infrastructure from Brussels to the coast received a relaunch. The coastal tram and a highway also connects the coastal areas. In the '60s and '70s the Belgian population experienced an increase in leave and free time, and the middle-income households were earning sufficient money to go on holiday. Coastal villas are replaced by apartments of 7 to 9 floors. This emergence of development played a pivotal role in establishing the Belgian coastline as a prominent holiday destination (Paulissen et al., 2013).

Figure 6: Promenade Blankenberge (source: Klaus-Dieter, Keller)

The areas in the dunes are recognized by a built environment of garden districts with villas that took into account the typical dune landscape (garden cities), to be found mainly in De Panne, Koksijde and Westende as well as De Haan (Paulissen et al., 2013).

Figure 7. Dumontwijk De Panne (source: Google Earth, 2022)

Larger urban settlements like Bruges, Kortrijk, Ostend, and Roeselare have ancient origins, dating back to between the 1st and 9th centuries. Remnants of these historical times still adorn the cities, contributing significantly to their appeal in the tourist and hospitality sectors. These

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cities were hubs of trade and commerce, shaping the region's economic landscape over centuries. Notably, Ostend has experienced multiple relocations inland due to recurrent flooding, highlighting the importance of dike protection measures. Despite its history of flooding, Ostend now enjoys a relatively stable situation, safeguarded by robust flood defences (Paulissen et al., 2013).

Figure 8. Belgium, panoramic view on the historical city centre of Bruges (source: CEphoto, Uwe Aranas)

Small villages in West-Flanders typically feature houses clustered around a central square or a church.

Figure 9. Keiem (source: Google Earth 2021)

The typical 'lintbebouwing,' or ribbon development, are a distinctive feature of Flanders' landscape. This phenomenon entails linear development along roads, creating a unique pattern of settlement and largely affecting the open space in rural areas. Ribbon development emerged with the rise of car use by middle class, to ensure that they were able to travel back and forth to their work in urban areas (Paulissen et al., 2013; Vlaamse Canon, 2023) (Provincie West-Vlaanderen, 2022).

Figure 10. Lintbebouwing (source: Google Earth version 2021)

Additionally, rural sprawl is prevalent across the region, reflecting dispersed development patterns outside urban centres.

Figure 11. Noordstraat 16 (source: Google Earth version 2022)

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These built environments, along with their socio-economic functions, are classified into socio-economic typologies, as outlined in a study by the Belgian bank Belfius. West-Flanders encompasses 11 of the 16 identified typologies (Provincie West-Vlaanderen, 2022).

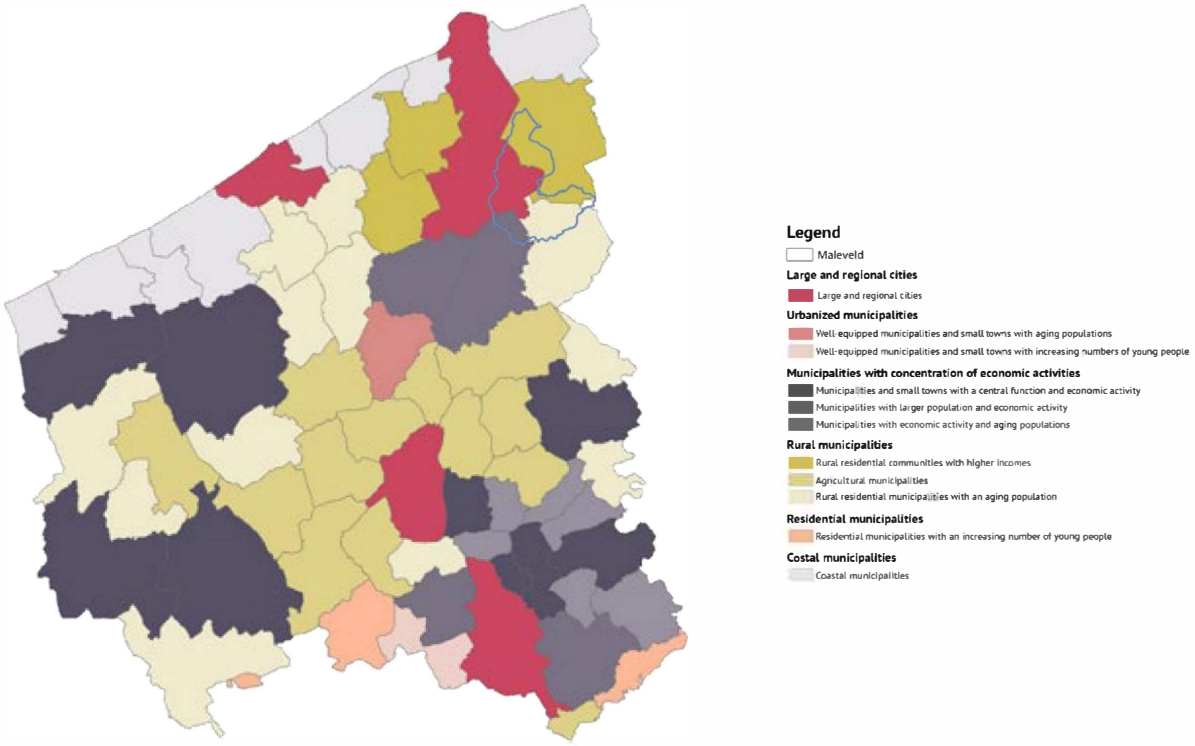

Figure 12: typology of municipalities in West-Flanders (Provincie West-Vlaanderen, 2022)

Age of buildings

In West Flanders, as of today (Statbel, 2024):

- 26% of inhabited homes date from before 1946.
- 36% were built between 1946 and 1980.
- 20% were built between 1980 and 2000.
- 18% date from after 2000.

Many homes are therefore outdated and no longer meet today's energy standards and quality requirements.

3.2 The soil system

The soil system in West Flanders consists of a variety of soil types shaped by its geography, climate, and historical land use. This region mainly comprises coastal lowlands, polders, and inland areas with diverse soil compositions (Provincie West-Vlaanderen, 2022).

- **Coastal and polder soils:** The coastal regions and polders of West Flanders are predominantly made up of marine and estuarine sediments. These soils, rich in clay and silt, are highly fertile and ideal for agriculture. The polders, reclaimed lands safeguarded by dikes, feature heavy, clayey soils that are well-suited for crops such as potatoes, sugar beets, and cereals.
- **Sandy soils:** Inland areas of West Flanders are characterized by sandy soils, especially in regions historically covered by dunes. These soils are generally less fertile due to lower nutrient content and water-holding capacity but are well-drained and suitable for certain crops and vegetation adapted to sandy conditions.
- **Alluvial soils:** Found along rivers and watercourses, alluvial soils are formed from sediments deposited by flowing water. These soils are typically fertile and rich in organic matter, supporting various agricultural activities, including horticulture and vegetable farming.
- **Peaty soils:** In specific low-lying areas, peaty soils are present. These soils are rich in organic material and often waterlogged, posing challenges for agriculture due to drainage issues. However, they play a crucial role for dairy and cattle farmers and in maintaining local biodiversity and wetland ecosystems.

The soil system in West Flanders is a result of the interplay between natural processes and human interventions, creating a landscape that supports diverse agricultural practices and ecosystems. Effective management and preservation of these soils are essential for sustaining the region's agricultural productivity and environmental health.

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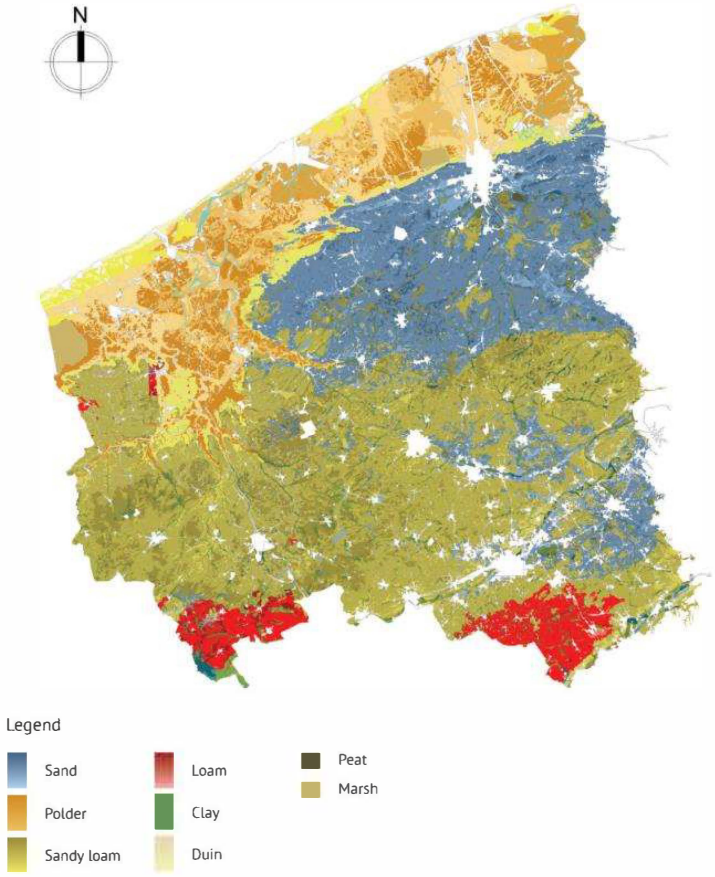

Figure 13: Soil map West Flanders.

3.3 The water system

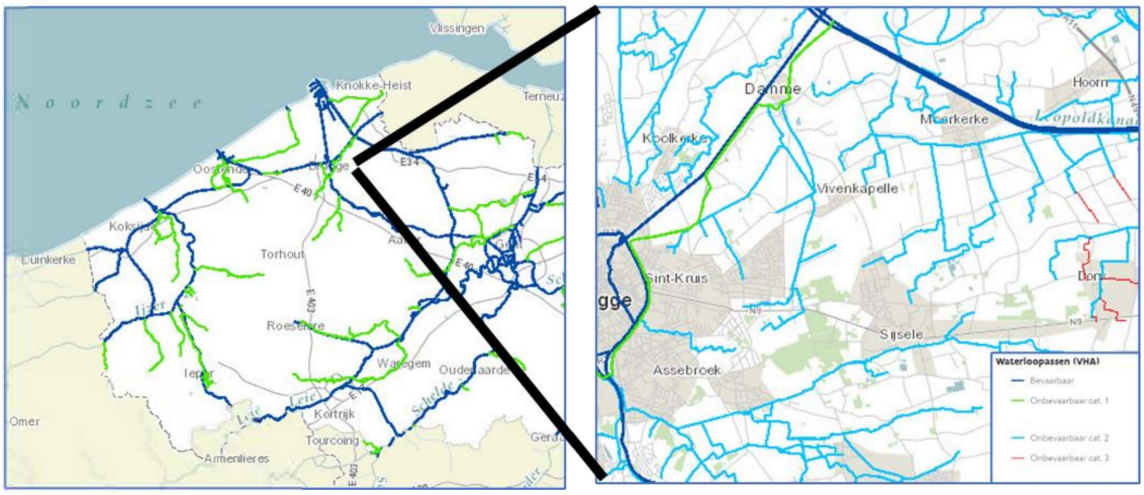

Figure 14 & 15. The water system of West Flanders, located in the northwest of Belgium, consist of a network of rivers, canals, coastal waters, and groundwater resources. (Source: Vlaamse Hydrografische Atlas)

West Flanders has various rivers and artificial canals. The rivers like the Yser (IJzer), the Lys (Leie), and the Mandel are vital for drainage, irrigation, and transportation. The extensive canal network, including the Ypres-Ieper Canal and the Boudewijn Canal, supports inland navigation, local industries, and water level management (Vlaamse Milieumaatschappij, s.d.-b).

Bordering the North Sea, the coastline of West Flanders influences both the climate and economy. Coastal waters are crucial for maritime activities such as fishing, tourism, and shipping. The Belgian coastal zone, especially the port of Zeebrugge, is a hub for international trade. The North Sea also contributes to the unique saline and brackish water environments of coastal wetlands and estuaries (Vlaamse Milieumaatschappij, s.d.-b).

Low-lying coastal areas and polders rely on an extensive drainage system, including dikes, ditches, sluices, and pumps, to manage water levels and prevent flooding. This system controls salinity and ensures the land remains viable for agriculture and habitation.

Groundwater is another vital resource in West Flanders, providing drinking water and supporting agriculture. The region's aquifers have formed over centuries, contributing to a reliable supply. Drinking water is also coming from a large fresh water reserve, De Blankaart (coming from Ijzer and surrounding flows). Waterquality of this water reserve requires treatment and purification of the water before being used as drinking water (Watergroep, 2025).

West Flanders also hosts several important wetlands and estuaries, such as the Zwin Nature Park, a salt marsh and mudflat area. These ecosystems are rich in biodiversity, playing a crucial role in water purification, nutrient cycling, and flood mitigation.

3.4 The nature system

West Flanders encompasses a variety of biodiverse landscapes, each supporting diverse types of ecosystems. Along the coast, sandy beaches, dunes, and salt marshes provide essential habitats for migratory birds and specialized plant communities. Inland, polders and wetlands, such as those in the Zwin Nature Park, offer a mix of freshwater and brackish environments, supporting diverse flora and fauna. These areas are crucial for waterfowl, waders, and unique plant species.

The region also contains woodlands and forests, though limited in size, which provide habitats for various mammals, birds, and insects while offering ecological benefits and recreational opportunities. Grasslands and meadows, often interwoven with agricultural landscapes, are vital for biodiversity, hosting wildflowers, insects, and ground-nesting birds, and supporting sustainable farming practices. Natural river systems, including the Yser and Lys, create riparian habitats rich in aquatic life and serve as important wildlife corridors.

West Flanders is home to several protected areas and nature reserves, including Natura 2000 sites, all aimed at preserving its natural heritage.

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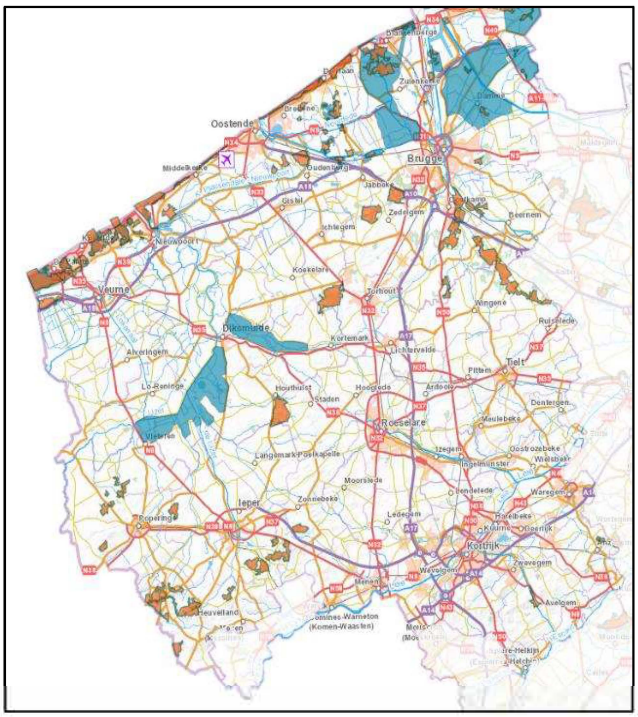
The Biological Valuation Map (version 2) outlines two subzones with valuable ecotopes in the project area:



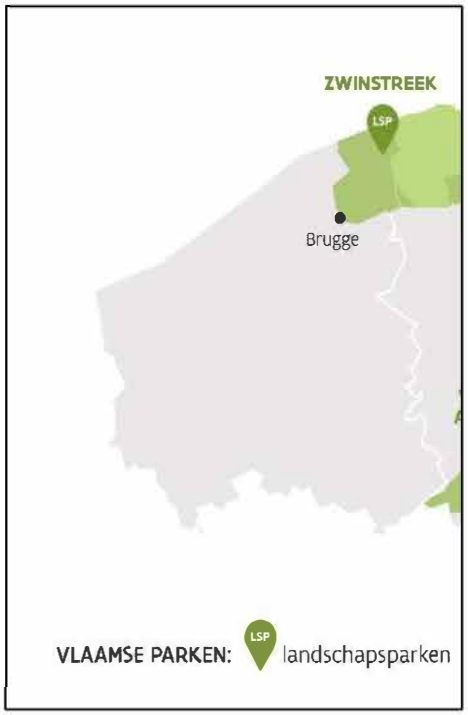


Figure 16(Left) & 17(right). The Biological Valuation Map (version 2) outlines two subzones (in blue) with valuable ecotopes in the project area. (Source: left: Natura2000 gebieden). Landscape Park Zwinstreek in West Flanders (Source: right: Geoloket GisWest)

3.5 Dynamics in the natural system

The natural system in West Flanders is strongly influenced by temperature changes and precipitation patterns, which affect vegetation growth, soil dynamics, and water bodies. Seasonal variations play a key role in shaping the landscape through processes such as sediment transport, and water retention, particularly in the region's low-lying polder areas (narration of the seasonal dynamics, as experienced in West-Flanders).

Winter (December–February)

During the winter months, the processes of freezing and thawing can significantly affect the landscape. While West Flanders typically experiences mild winters, occasional frost and frozen ground can lead to physical weathering, especially in inland areas. As frozen water in soils and rocks expands, it can cause frost heave, pushing soil and rocks upward and subtly altering the landscape. Many farmers in the polders plow before winter and rely on frost to create a more crumby structure of the soil.

Although West-Flanders has a quite stable amount of rainfall, winters do result in more saturated soils due to low evapotranspiration. If temperatures are cold enough, this

precipitation may fall as snow, though snowfall is rare. The accumulation of water and snow can lead to a build-up of moisture in the polders and inland water systems. Riverine flooding may also occur as drainage systems become overwhelmed with excess water.

Spring (March–May)

As temperatures begin to rise in the spring, the landscape enters a phase of renewed growth. Plants begin to sprout. In low-lying areas near rivers and canals, this can cause localized flooding, as drainage systems struggle to manage the additional water. The increased water flow also leads to the transport of sediments downstream, contributing to the reshaping of riverbanks and floodplains.

Early spring is often marked by a period of increased soil erosion, driven by both water and wind. However, as vegetation becomes established later in the season, erosion risks decrease. The growing plant cover helps to stabilize the soil, reducing the likelihood of further erosion and protecting the landscape.

Summer (June–August)

In summer, temperatures continue to rise, reaching their annual peak. This leads to elevated levels of evapotranspiration, particularly in the sandy soils of the coastal dunes and areas with poor water retention. Soils can dry out, increasing the risk of drought in certain areas. Agricultural fields in the polders are particularly vulnerable, as the flat landscape can struggle to retain moisture during hot, dry periods. Summer thunderstorms are common and can bring intense, localized rainfall, which can lead to localised flooding.

Autumn (September–November)

Autumn marks the transition to cooler temperatures, and the landscape begins to prepare for the dormant winter season. Vegetation starts to die back, which is a critical process for replenishing the soil with organic matter. This natural cycle contributes to maintaining soil fertility and improving its structure over time.

Rainfall typically increases in autumn, and if the soils are already saturated from summer storms, this can lead to surface runoff and, in some cases, flooding in the polders and along rivers. The region's intricate network of drainage canals and pumping stations is critical in managing excess water and preventing widespread flooding. Riverbanks and floodplains may experience further sediment deposition as water levels rise, helping to maintain the dynamic equilibrium of the landscape.

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4 Understanding the Region: Social System

4.1 Governance

4.1.1 Responsibilities

Belgium is a federal state, meaning that most powers and responsibilities are divided between the Flemish and Walloon regions. This division also applies to key policy areas relevant to climate resilience, such as water management, nature and environmental protection, and spatial planning. In Flanders, these domains are primarily managed at the regional level by the Flemish government, which sets overarching strategies that must be followed and further specified by the provinces and municipalities.

The Province of West Flanders plays a crucial role in supporting and coordinating the implementation of ground-related policies within this governance framework. It supports policy development and execution at the provincial level, except for larger cities, which have autonomy to develop their own policies within their administrative boundaries. More specific, the province of West-Flanders is in charge to develop spatial plan at the level of the province and assist municipalities in implementing these policies; manage provincial waterways in strong collaboration with the Flemish and local level; maintain and develop green areas and enhance biodiversity, as well as manage provincial roads and cycle paths; support economic growth, innovation and entrepreneurship and support tourist, cultural and social affairs. And last but not least, coordinate emergency planning at the level of the province, in strong collaboration with the local and Flemish level.

Regarding climate change plans, each region—Flanders, Wallonia, and Brussels—develops its own climate action and adaptation plan and the federal government develops an additional plan for the remaining responsibilities. However, Belgium has a single national climate change plan, which integrates the strategies of the Flemish, Walloon, Brussels, and federal governments (European Environment Agency, s.d.).

4.1.2 Policies and strategies

4.1.2.1 Climate adaptation policies and its related governance

Resilience is also referred to as climate adaptation. Belgium has climate adaptation policy that is known as multi-level governance policy that is mainly characterized by network steering as instrument. The approach is that adaptation is mainstreamed into the different policy departments and at various levels. The adaptation officers are most of the time positioned in the respective departments of environment and they mainly have coordinating responsibilities, to ensure the other departments integrate climate change adaptation in their programme, make progress and allocate resources to their actions. Since the latest climate adaptation plan, the Flemish government has launched budgets and programmes like Blue Deal (VMM) and Water-Land-Scape to accelerate actions to prepare for droughts and flooding (see below more).

At the national level, adaptation is part of the National Adaptation Strategy and Plan, which contains actions that are complementary to those contained in the regional (Flanders, Wallonia, Brussels) and federal adaptation plans. To take national decisions there are commissions/coordination committees where governments and ministries are represented. The provinces have a joint committee to exchange about climate adaptation.

Provinces in Flanders are developing their own climate adaptation plans and coordinating efforts through an interprovincial committee. The province of West-Flanders intends to make their own adaptation plan soon. Provinces also provide supporting instruments for municipalities to create their own adaptation plans, while the Flemish Environment Agency (VMM) offers additional assistance via Klimaatportaal.be.

Many local authorities have signed the Covenant of Mayors and are working on adaptation plans (https://eu-mayors.ec.europa.eu/nl/signatories). Some municipalities delegate climate adaptation responsibilities to intercommunal organizations. To encourage municipal action, the Flemish government ties access to water-related subsidies to the development of rainwater and drought plans (Vlaamse Milieumaatschappij, s.d.-a).

In West Flanders, 55 out of 64 municipalities have finalized a rainwater and drought plan (as of March 2025; (Waterbeleid;, 2025), while many others are still in progress. Larger municipalities are more likely to have such plans than smaller ones. Some municipalities, such as Oostende, have chosen to develop a broader climate adaptation plan before tackling rainwater and drought planning. Examples of municipal adaptation plans include Bruges' Climate Adaptation Plan, while Oostende's plan is not yet public but is being developed with the involvement of VITO as an expert advisor.

Only three municipalities in West Flanders have not signed the Covenant of Mayors, two of which are located in the Yzer catchment, a region facing significant climate adaptation challenges. While regional adaptation planning, involving collaboration between provinces and municipalities, has been implemented in some parts of Flanders, it is not yet a widespread practice in West Flanders. The Flemish government, more specific the Flemish Environment Agency (VMM) is supporting provinces and local authorities to make a plan by the information portal www.Klimaatportaal.be.

4.1.2.2 Other policies and strategies relevant for NBS

When it comes to the design and implementation of NBS in coastal, rural and urban areas, the set of organisations involved differs. However, it is often that a combination of different policy fields will collaborate in order to get the NBS organised and implemented. These policy fields are:

- Spatial planning and land use planning: the Flemish government sets the overarching policies, including the Flemish Structure Plan, which provides strategic guidance for spatial planning. The provinces supervise spatial planning within their territory, ensuring alignment with Flemish policies. In West- Flanders, the existing Ruimtelijk Structuurplan West-Vlaanderen serves as a framework, while a new "Beleidsplan Ruimte" is being developed. The finality of these plans differs significantly: structure

plans provide strategic direction, while binding regulations are established in spatial implementation plans ("Ruimtelijke Uitvoeringsplannen" - RUPs) or specific ordinances. Unlike RUPs, structure plans do not impose direct legal obligations on citizens but are binding only for governments. Local authorities play a key role in enforcing land use regulations, zoning laws, and urban planning initiatives, ensuring that community interests are reflected in spatial decision-making. A major challenge in Flanders is that land use is legally determined through RUPs and other formal planning instruments, not directly in the Flemish Structure Plan. This can make land use changes costly and complex, including for nature-based solutions (NBS). Even when NBS align with broader policy goals, their implementation often requires additional permissions, similar to other technical interventions in the landscape. This can lead to procedural delays, impacting the timely realization of NBS projects.

- Urban planning: a number of cities and municipalities located in the Province of West-Flanders have included greening measures into their building permissions. Some of them are also working towards greening their areas, by converting spaces into green spaces and planting more trees. These policies are part of local policies and are initiated by the local governments, but often in line with policies from the Flemish level, as this Flemish level is providing subsidies to support such measures.
- Nature conservation policy is initiated by Flemish government via the Nature and Forest Policy Plan and the Natura 2000 Management Plan, in line with EU legislation. Responsible organisations are the Flemish government - Agency for Nature and Forest and Natuurpunt, which is an NGO advocating for nature conservation and management. Provinces are in charge of nature conservation and monitor compliance at regional level. Local authorities manage local green spaces and may promote local engagement in nature protection initiatives as well.
- Water management policy: water management is very much fragmented in Flanders, depending on the type of water as well as the governance level. Key are policies like the Flemish Water policy plan and the River Basins Management Plans. Flemish level governments are in charge to protect and safeguard citizens and critical infrastructure. Provinces coordinate water at regional level. Local authorities implement local water management. The governance of water management is not anymore adjusted to the current and future changing circumstances, resulting in a call to change it from an institutional perspective.
- Agricultural development policy: key is the Flemish agricultural policy, which is a framework for agricultural development. Agriculture is largely affected by environmental policies nowadays. Relevant organisations are the Flemish Agency Agriculture and Fisheries, Flemish Land Agency for instance. Provinces facilitate agricultural development and monitor compliance. They also support the claims after floods and droughts.

- Regional development policy: the Flemish Regional Development Fund Program 2021 – 2027 is focusing on strengthening sustainable growth and competitiveness and accelerating the transition towards Carbon neutral circular and energy efficient economy. Under the priorities, relevant to the implementation of the Mission on Climate adaptation: health, Agro food industry, Energy, Cleantech and Blue Economy.

Responsible for the Science, technology and innovation strategy is the Flemish government. Main partners in implementing these policies on regional innovations are the Strategic Research Centers (SOC's) and the Clusters (Speerpuntclusters, as Flanders Food, Blue Cluster). In West Flanders the Blue Cluster and the Flanders Marine Institute are present. Quadruple helix partners are challenged to contribute to the societal challenges.

4.1.3 Quadruple helix interplay

Quadruple Helix is the governance concept underlying transformations. It refers to stronger collaboration between public sector, private sector, knowledge partners and civil society.

In West-Flanders, a number of such collaborations are already in place. We have identified three major ones, being part of this baseline report.

Masterplan Water Safety
Coastal defence and protection along tidal rivers have long been a focal point, and risks are being effectively managed; the last areas with high vulnerability are set to be addressed in the coming decades. Initially, these collaborations were government-only approaches, but over time, various organizations—including scientific institutions and private partners—have joined in. This shift has already demonstrated significant potential for transformation. Building resilience with regards to sea level rise is done by a governance model that is focused on network and knowledge driven steering instruments. The main responsible for coastal safety, and consequently also the network coordinating organization is the Maritime department coastal safety from the Flemish department. The Masterplan Coastal Safety was the result of an extensive analysis of the vulnerable areas due to sea level rise. The Masterplan is a collaboration between the Flemish government and the 11 local authorities in the coastal area and aimed to jointly develop measures to tackle the challenges. This Masterplan has already embraced nature-based solutions as a potential way forward to build resilience. To do this, they are collaborating in a knowledge and innovation driven way to test and explore potential solutions like 'dune before dike' and foreshore suppletion. Finance for these pilots is coming from the Flemish government and largely also from European funding as in this case INTERREG program. In these pilots, there is a collaboration between the Flemish government, the local authorities and knowledge partners like UGent, KUleuven and the government knowledge institute Flanders Hydraulics Research. In some of these initiatives, they already work in a living lab way of collaboration. One initiative Coastbusters (kust baaien), also involved private sector (dredging companies). This initiative was financed by the Flemish Agency for Innovation and Entrepreneurship as part of the Blue Cluster. (Reference: Projecten | Agentschap MDK)

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Figure 18. Governance on heat stress and flooding in the urban areas near the dike is comparable to the governance models in the bigger cities inland.

Blue Deal

The Flemish government started the 'Blue Deal', an ambitious plan to combat water scarcity and drought through collaboration. https://bluedeal.integraalwaterbeleid.be/. The Blue Deal incorporates different actions for the government (at different levels), but also many actions for other public stakeholders (e.g., drinking water companies) and private stakeholders. A major pillar of the Blue Deal is based on subsidies for all kind of actions. The Blue Deal also has different research and innovation actions, and funds some research projects.

Water-Land-Schap

These partners bring together their resources to enable their jointly developed vision, including their financial resources, their knowledge, capacities and network mobilisations. Jointly, they collaborate to take up the challenges that are part of their transformative journey. For climate adaptation in rural areas (with a water and landscape focus) the Water-Land-Schap initiative was developed by the Flemish government. The Water-Land-Schap program funds local (bottom up organized) coalitions of farmers, nature NGOs and governments. In a Water-Land-Schap project, they first agree on a vision/plan for their region, and then go to implementation. Focus is more on implementation and less on the plan. Water-Land-Schap is organized as a kind of calls where such local coalitions can submit their proposal. Until now two such calls were organized in a bottom-up way (WLS1.0 and WLS2.0) while a third call ("Weerbaar WLS") had a top-down approach based on five existing local cooperation initiatives.

Towards quadruple helix in the respective landscape systems

In urban landscape systems and larger municipalities, network governance is employed alongside traditional instruments to encourage broader participation. While climate adaptation planning is underway, it often remains a predominantly government-led effort. Current steering instruments are quite conventional, focusing on nudging citizens toward behaviour change through communication and financial incentives, as well as through regulatory measures. However, there is a noticeable gap in collaboration with the private sector regarding the development of green spaces within cities. Additionally, depending on the initiative's success, there is a pressing need to engage multiple policy departments. This necessitates a cultural shift within local authorities, which requires considerable effort.

In rural landscape systems, substantial support for transformation has been fostered through two key programs, employing a pilot approach (Blue Deal and Water-Land-Schap); however, challenges remain in terms of implementation. There are also overlapping collaborations and committees working toward change, which could benefit from a more place-based approach. Aligning these initiatives and embedding successful practices could enhance overall effectiveness. Resilience efforts have primarily focused on drought management, but attention has more recently shifted to flooding. Additionally, resilience against heat stress (urban heat islands) largely falls under local responsibility, leading to considerable variability in implementation across different areas.

Coastal defence and protection along tidal rivers have long been a focal point, and risks are being effectively managed; the last areas with high vulnerability are set to be addressed in the coming decades. Initially, these collaborations were government-only approaches, but over time, various organizations—including scientific institutions and private partners—have joined in. This shift has already demonstrated significant potential for transformation.

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4.2 Economy

The economic landscape of West-Flanders showcases both strengths and areas for development. While the region historically exhibited slightly lower productivity per capita compared to Flanders as a whole, recent years have seen significant improvement in this aspect (POM West-Vlaanderen, 2023).

Key economic activities in West-Flanders are concentrated in specific areas, notably South-West Flanders, Bruges, and the Middenkust region. These areas serve as focal points for economic activities. Notably, West-Flanders boasts a significant presence of small and medium-sized enterprises (SMEs), which form the backbone of its economic fabric.

In terms of employment, it is mainly the healthcare, education, metallurgy, the public sector, and the construction sectors that are the key sectors in West-Flanders. Agriculture also holds prominence as the second-largest sector for self-employment. However, when considering added value, wholesale and retail stand out as the largest contributor (12.4%), followed by business services (9.7%), construction (8.0%), healthcare (7.4%), and metallurgy (7.0%). Agriculture and fisheries rank 11th in added value contribution (1.7%), while related food processing holds the ninth position (4.0%) (Provincie West-Vlaanderen, 2022).

These sectors are partly located in business parks serving as hubs for various industries. These sectors are both concentrated and spread across the region, with strategic planning aimed at maximizing efficiency and growth. Other sectors can be found along the road infrastructure.

Importantly, West-Flanders has significant import-export dependencies, facilitated by its harbours, particularly Zeebrugge, which plays a crucial role in international trade. The region's economic system is closely tied to global markets, with ongoing efforts to enhance competitiveness and adapt to evolving trade dynamics.

Tourism in West Flanders is a significant economic sector, contributing substantially to the region's overall economic landscape. West Flanders is particularly known for its coastal tourism, with popular destinations such as Ostend and Knokke-Heist, as well as cultural and historical sites in Bruges and Ypres. The province is home to notable attractions including the historic city centre of Bruges, the Yser Tower in Diksmuide, and the World War I battlefields and memorial sites around Ypres.

The types of companies that thrive in this sector include:

- Accommodation providers: Hotels, hostels, and short-stay rentals catering to tourists.
- Food and beverage services: Restaurants, cafes, and bars that serve both local cuisine and international dishes.
- Cultural attractions: Museums, historical sites, and galleries that attract visitors interested in the rich history and culture of the region.
- Transport services: Companies involved in tourism-related transport, including tour operators and local transport services.
- Recreational activities: Businesses that offer outdoor activities, tours, and entertainment related to the region's natural and historical offerings

Overall, tourism is a vital part of West Flanders' economy, enhancing local businesses and employment opportunities while showcasing the region's unique heritage and coastal attractions. For more detail https://transition-pathways.europa.eu/nl/node/1733).

4.3 Society - Demography

4.3.1 Population

West-Flanders is a dynamic region shaped by its population. As of 2022, approximately 1.2 million people call West-Flanders home. West-Flanders has a population density of 382 people per square kilometre, which is lower than the Flemish average of 498 per square kilometre. Such a density categorised the region as moderately urbanized, with higher concentrations of inhabitants along the coast. Spanning a total area of 3,197 km2, the region offers a diverse landscape and vibrant communities amidst its changing population dynamics.

The population is expected to see marginal growth, driven by immigration and natural births, with projections indicating it will reach a growth rate of 1.3% by 2027. This growth rate remains steady, unlike the rest of Belgium, which faces population stagnation (Provincie in Cijfers: Stabel).

What distinguishes West-Flanders is its seasonal population surge, particularly during holidays and summers, resulting in over 8.5 million overnight stays from Belgians and 3.8 million from international visitors, notably in July and August. This influx is due to West-Flanders' status as a prominent tourist destination, with most visitors opting to stay in hotels, holiday homes, or parks.

Moreover, many people own second homes in the province, leading to fluctuations in population density outside of holiday periods and during weekdays. Consequently, the province experiences variations in population from day to day.

The age distribution in West Flanders reveals a gradually aging population, reflecting national trends. Currently, 31.1 %% of the population is over 60 years old, and this is projected to increase with 8.3% by 2027. West Flanders exhibits a larger proportion of older residents compared to Flanders as a whole, and over the past decade, there has been a noticeable increase in the number of individuals aged 60 and above. The average age in West Flanders stands at 44.4 years, slightly higher than the Flemish average of 42.5 years.

The dependency ratio in West-Flanders (the proportion of people 65 years and older in relation to the working population between 15 and 64 years) is the highest in whole of Belgium, which was 38.8% in 2021. The top 5 municipalities with the highest dependency ratio are all located in West-Flanders – Koksijde (82.6%), Nieuwpoort, Knokke-Heist, De Haan and Middelkerke (61.6%) (Statbel, 2021)

Life expectancy in the region is slightly above the national average, standing at 82.7 years for West-Flanders.

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	2017	2022	2022 (in %)	2027	Evolutie 2017-2022	Evolutie 2022-2027
West-Vlaanderen	**1.186.532**	**1.209.011**	**100,0%**	**1.225.330**	**+1,9%**	**+1,3%**
- <20j	238.284	240.777	19,9%	240.253	+1,0%	-0,2%
- 20j - 59j	600.366	592.089	49,0%	577.595	-1,4%	-2,4%
- ≥60j	347.882	376.145	31,1%	407.482	+8,1%	+8,3%
Vlaams Gewest	**6.516.011**	**6.698.876**	**100,0%**	**6.825.302**	**+2,8%**	**+1,9%**
- <20j	1.406.625	1.439.486	21,5%	1.450.441	+2,3%	+0,8%
- 20j - 59j	3.413.566	3.406.958	50,9%	3.351.830	-0,2%	-1,6%
- ≥60j	1.695.820	1.852.432	27,7%	2.023.031	+9,2%	+9,2%
Aandeel WVL in VLG	**18,2%**	**18,0%**		**18,0%**		
- <20j	16,9%	16,7%		16,6%		
- 20j - 59j	17,6%	17,4%		17,2%		
- ≥60j	20,5%	20,3%		20,1%		

Table 1. Comparison of the different age groups between West Flanders and Flanders in general (Source: Steunpunt Data & Analyse, 2023)

4.3.2 Household composition

In terms of household composition, West Flanders is home to approximately 548,117 households, representing a notable increase since 2013. The majority of these households are single-person households (188,948), followed by married couples without children (132,768). Additionally, married couples with one or more children account for a significant portion (65,689).

When considering key demographic figures relevant to enhancing resilience:18.5% of households consist of couples with at least one child who has not yet reached adulthood. 3.8% of households, or around 20,871 households, are single-parent families raising at least one child. Approximately 35% of individuals aged 75 and older live alone, a demographic that requires particular attention when designing inclusive and resilient community strategies.

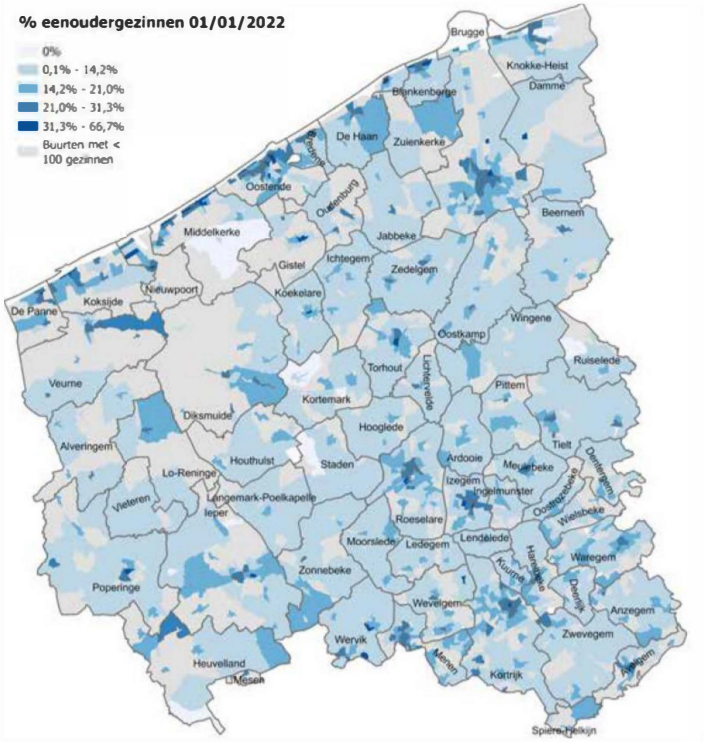

Figure 19. Percentage of single parent households (source: Atlas kansarmoede - Steunpunt Data & Analyse, 2023)

4.3.3 Nationality

Regarding nationality, approximately 85% of West Flanders' population originates from Belgium, while the remaining 15% hails from either EU or non-EU countries. This proportion has shown a notable increase in recent years. Certain areas within the region have a significant presence of children raised in families where Flemish is not the primary language spoken. Research indicates a correlation between non-native speakers and households experiencing economic hardship.

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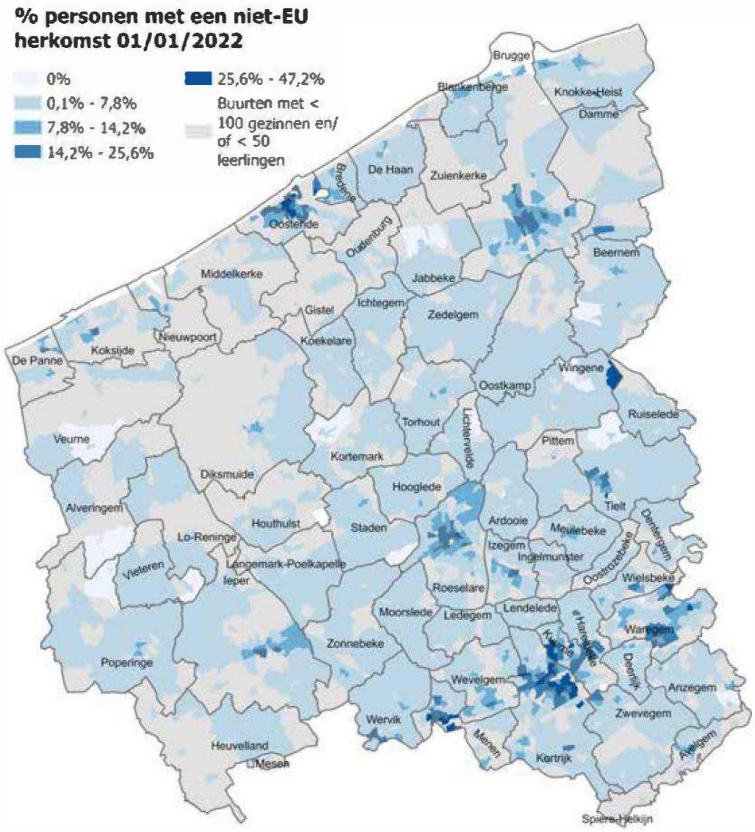

Figure 20. Percentage of people with a non-EU origin in the total population (Source: Atlas kansarmoede - Steunpunt Data & Analyse, 2023)

4.3.4 Income and poverty

The median net income in West Flanders is around €27983, closely aligning with the Flemish average. However, there is a significant disparity in income levels, with approximately 7% of the population at risk of poverty, primarily among single-parent households and immigrants. Poverty is an issue, also in West-Flanders but does not deviate much from the Flemish average situation. The welfare index in West-Flanders is 105, compared to Flanders which is 107. 12.7 percent of the newborn babies are born in poor households. In the latest atlas on poverty, 130 poor districts were identified in 29 municipalities. Kansarmoedeatlas (www.west-vlaanderen.be)

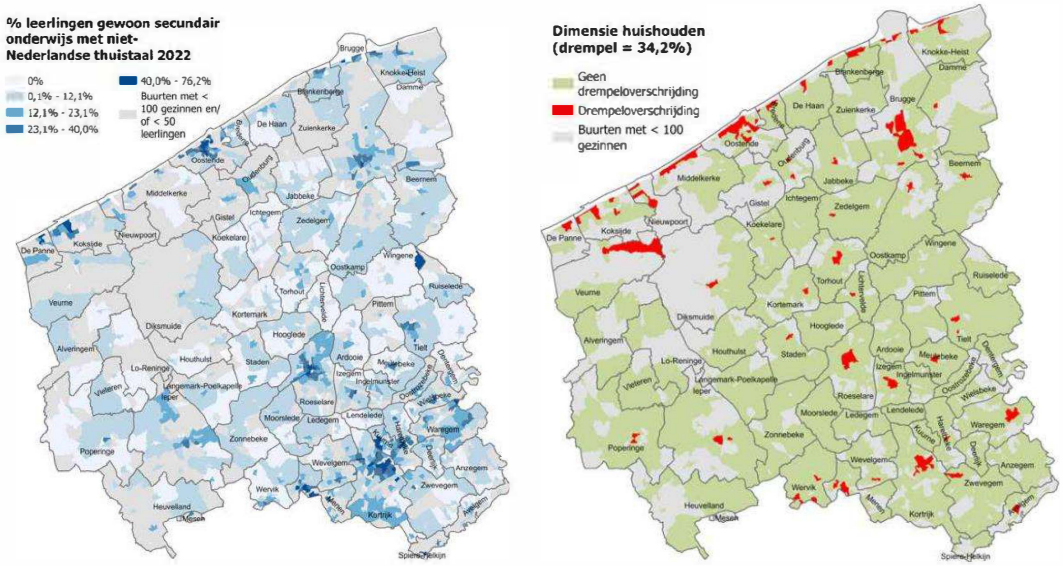

Figure 21. Percentage of non-native Flemish students (Source: Atlas kansarmoede - Steunpunt Data & Analyse, 2023)

4.3.5 House ownership

It is indicated that mainly in cities, the proportion of people between 35-79 years that are renting is relatively high.

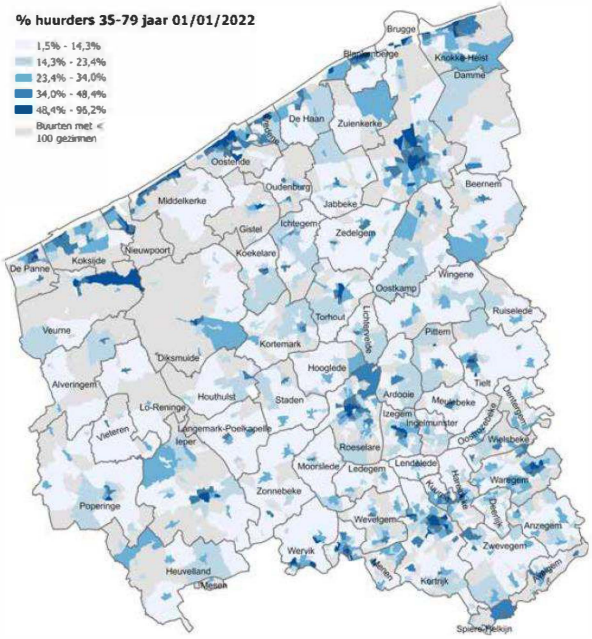

Figure 22. Percentage of renters between the age of 35 and 79 (Source: Atlas kansarmoede - Steunpunt Data & Analyse, 2023).

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5 Climate change risks and impact on key community systems

5.1 Regional climatic changes

Flanders has the Climate Impact Tool that assess the impact of climate change under RCP 8.5 for different time scales. This information illustrates the climate change impacts that can be expected in West-Flanders.

Flanders occupies a unique position between northern Europe, which is expected to become wetter, and southern Europe, which is expected to become drier. This location introduces large uncertainties and significant variability in climate conditions between seasons and years. Therefore, West-Flanders, like the rest of the region, must prepare for a range of possible outcomes due to future climate change. The general projected trends are:

- Wetter winters: Winters are projected to become wetter, primarily due to an increase in fluvial flooding caused by rising river levels.
- Heavy rainfall in summer: Summers may experience more frequent and intense heavy rainfall events, leading to pluvial flooding. These rainfall-driven floods are also possible during winter due to the region's dense urbanization, which reduces natural water absorption and increases surface runoff.
- It is also expected that West-Flanders will experience increased risk to drought.
- Increasing heat stress: Belgian summers are expected to see a rise in heat stress, particularly in densely built areas. Urban zones, including those in West-Flanders, will likely experience the urban heat island effect, where temperatures remain higher than in surrounding rural areas.

Flooding

West-Flanders is at risk of three types of flooding:

1. **Coastal Flooding**: Sea-level rise increases the risk of flooding from the North Sea.
2. **Fluvial Flooding**: Rising water levels in rivers during the wetter winter months are expected to cause more frequent and severe river floods.
3. **Pluvial Flooding**: Extreme rainfall, particularly during the summer, will contribute to surface flooding, with urban areas being particularly vulnerable due to their limited drainage capacity.

All types of flooding are expected to increase due to climate change.

Flooding is expected to have an impact on critical infrastructure like roads and telecom, but it is also expected that buildings will be affected (see figure 28).

Flooding from the sea | Fluvial Flooding | Pluvial Flooding

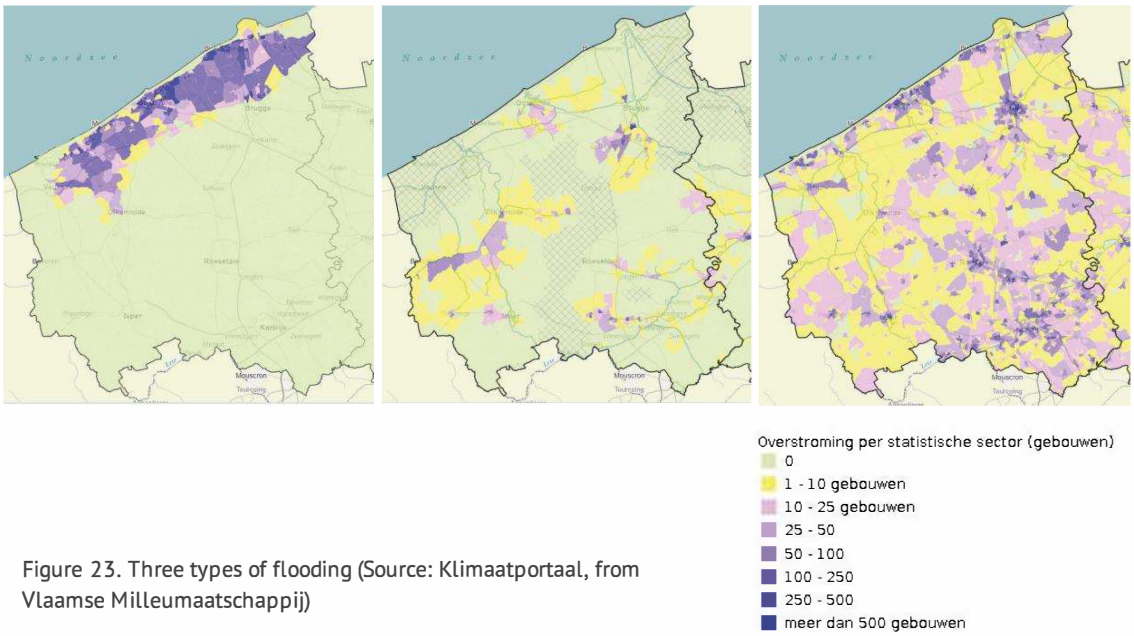

Figure 23. Three types of flooding (Source: Klimaatportaal, from Vlaamse Milleumaatschappij)

Drought and heat

While drought is expected to become a significant issue in parts of Flanders, particularly in agricultural regions, West-Flanders will have relatively low risk for drought, compared to other parts in Flanders. Nonetheless, seasonal drought could lead to water shortages in agricultural zones, impacting crop yields and ecosystem health. The variability between wet and dry periods may make it challenging for farmers and natural systems to adapt.

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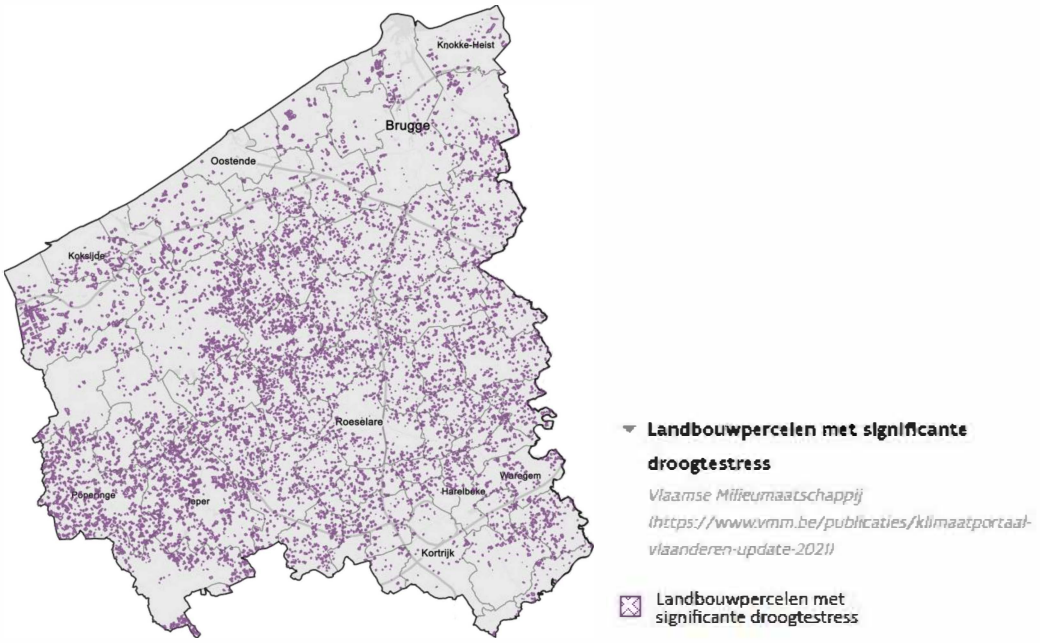

Figure 24. Drought map: farming parcels with significant drought stress (Source: Klimaatportaal, from Vlaamse Milleumaatschappij)

Heat

Heat stress is projected to worsen in urban areas of West-Flanders due to the combination of rising summer temperatures and the urban heat island effect. Built-up areas retain heat, leading to elevated temperatures, particularly during heatwaves. Vulnerable groups, including the elderly and children, are at greater risk of heat-related health problems. The impact of heat stress is expected to disproportionately affect cities and densely populated areas where green spaces and cooling measures are limited.

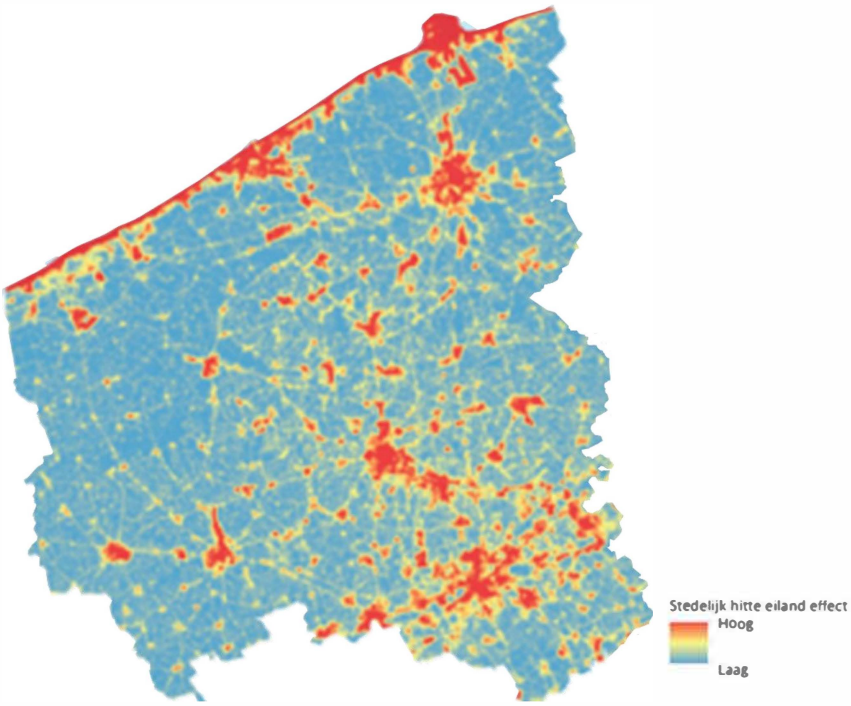

Figure 25. Urban heat island map (Source: Ruimte Vlaanderen & Technum)

5.2 Key community systems: health system

Climate change poses various risks to public health and places additional strain on healthcare systems. Issues such as heat-related illnesses, injuries from flooding, poor air quality, mental health challenges, vector-borne diseases, and changes in allergy patterns significantly impact individuals' well-being. Consequently, a larger proportion of the population will likely seek additional care.

Current data indicate that a considerable number of healthcare facilities are situated in areas vulnerable to severe flooding. Vulnerable populations, such as those in shelters, childcare centres, elderly care facilities, refugee centres, and disability facilities, may be disproportionately affected by climate-related risks. Analyses show that a considerable portion of these facilities is located in flood-prone areas. According to the climate portal, 15.7% of care facilities in Belgium currently reside in regions at risk of dangerous flooding.

Additionally, many facilities struggle with poor insulation and adaptability, leaving staff to contend with uncomfortable working conditions on hot days, which further affects their ability to perform their duties effectively.

Therefore, it is crucial to get a good understanding of the health care system in West-Flanders, in particular General Practitioners (GPs), hospitals, and mental health services. Would the system be able to take on the additional demand for care?

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In West Flanders, the ratio of General Practitioners (GPs) to the population is 7 GPs per 10,000 people, which is higher than the Flemish average. However, disparities exist, particularly in the coastal and southern areas of the province (see Figure 17a). Government initiatives are in place to address these disparities by increasing the quota of students entering medical studies. Despite the availability of GPs, recent analyses indicate that low-income households are hesitant to seek medical care primarily due to financial constraints. This trend must be considered when building resilience, as these vulnerable households are likely to be disproportionately affected.

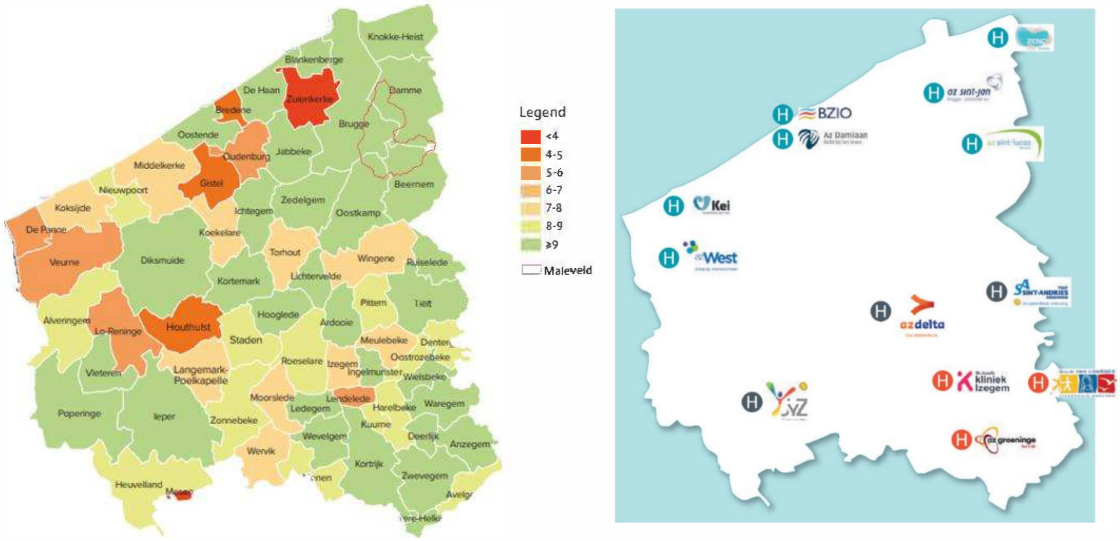

Figure 26 & 27. Number of general practitioners per 10,000 inhabitants and location of hospitals across West-Flanders (Source: www.desocialekaart.be)

Hospital accessibility (see the hospitals in figure 37), particularly the capacity of emergency departments during extreme weather events, is crucial in West Flanders. The region has a considerable number of hospitals (11) that collaborate within three regional networks, with some already expanding their emergency department capacities. Current figures indicate that there are approximately 6,500 hospital beds available in West Flanders, translating to about 540 beds per 100,000 inhabitants. This ratio is much higher than the Flemish average of 385 beds per 100,000 inhabitants and exceeds the ratios found in other countries.

However, several critical issues need to be considered regarding hospital operations, including financial viability, staff capacity, and working conditions.

The availability and accessibility of mental health services remain challenging in Belgium. On average, there are 2.47 clinical psychologists for every 10,000 inhabitants across the country. However, the region east of Bruges appears to have a relatively good supply of psychologists (see map). Despite this, waiting times for mental health care are long, averaging 42 days in 2022, with children and young people often facing significant delays in receiving support. Additionally, the prescription of antidepressants is on the rise, with 86.5 defined daily doses per 1,000 inhabitants reported in 2021, considerably higher than the EU27 average of 64.2.

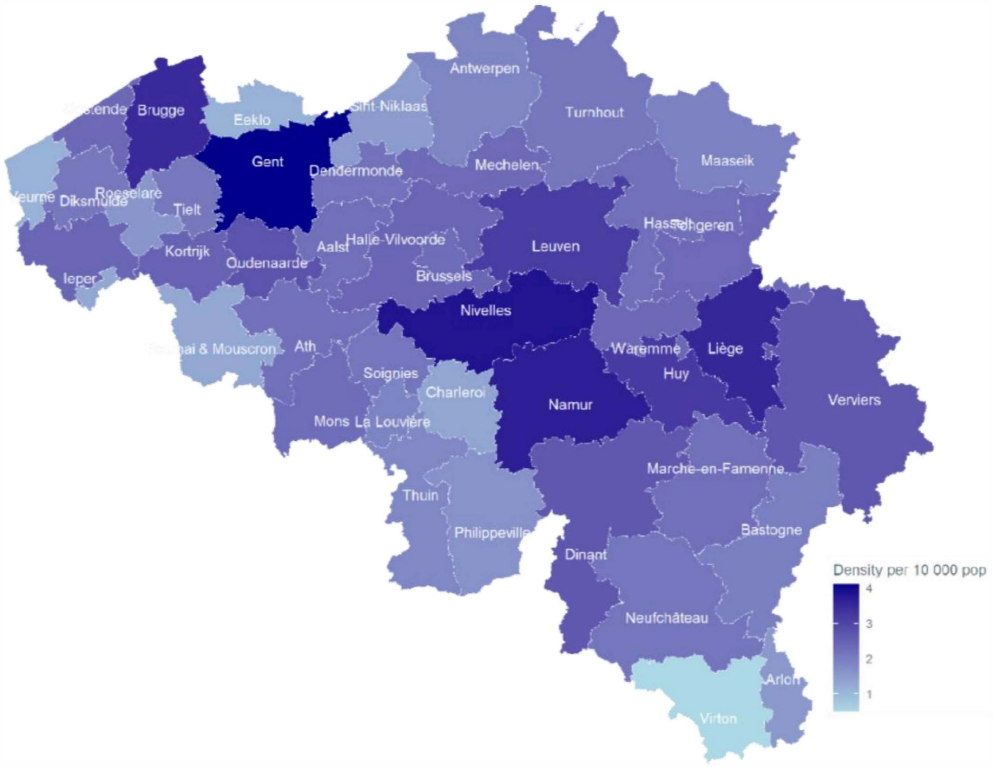

Figure 28. Density of registered psychologists: number of psychologists per 10000 inhabitants (2022) (Source: desocialekaart.be)

While on the one hand, there is an extra demand for care to be expected, it is also necessary to look into impact of climate change to supply that care, more specific by analysing the location of these health care facilities in risk areas. When flooding is affecting hospitals, there care supply chain will be disrupted, and people may not be able to reach the hospital. The same counts for the working circumstances of the staff during heat wave, they may affect their vitality and therefore their ability to deliver care. Collected information illustrates that a significant amount of current care facilities is located in areas that may be confronted with dangerous flooding. Additionally, vulnerable populations in shelters, childcare, elderly care, refugee centres, and disability facilities may be disproportionately affected by climate-related risks. Analysis shows that a significant portion of these facilities are in flood prone areas. The climate portal illustrates that for Belgium as a whole, under present conditions 15.7% of the care facilities would be located in areas with dangerous flooding. There is also indication that due to poor insultation and adaptability of the care facilities, a significant number of staff is struggling to work during hot days, as this is affecting the internal comfort level as well.

5.3 Key community systems: food system

The impact of climate change on land use and food systems in West Flanders is multifaceted. Impacts may alter agricultural productivity, as climate change is likely to lead to shifts in crop

yields due to changing temperatures, precipitation patterns, and increased frequency of extreme weather events. It may also affect soil health and erosion due to changes in rainfall patterns. Increase in pests and diseases as warmer temperatures may expand the range of pests and diseases, posing additional challenges for farmers. Changes in water availability, resulting in increasing strain on irrigation systems. Some farmers may change their land use practices. It can also lead to changes in crop types. Food security might be affected, leading to disruptions in local food provision.

Historically, West-Flanders has been primarily an agricultural region. Over time, changes in agricultural practices, such as the expansion and intensification of food production, have significantly impacted land use. At present, land use distribution in West-Flanders (as shown in table 2) clearly reflects its agricultural character. When West-Flanders was first settled, its land was used for a variety of purposes, including agriculture, trade, and markets. In comparing West-Flanders' current land use with Flanders as a whole, the higher proportion of farmland and grassland stands out, along with the lower amount of forested land and residential areas.

Landgebruik	W-VL (2019) %	VL (2019) %
Huizen en tuinen	10,4	12,6
Industriële doeleinden	2,6	2,8
Commerciële doeleinden & diensten	1,6	1,9
Transportinfrastructuur	5,6	6,1
Recreatieve doeleinden	1,5	2,4
Landbouwgebouwen en -infrastructuur	0,9	0,7
Overige bebouwde terreinen	2,6	3,3
Overige onbebouwde terreinen	2,6	3,4
Bos	2,9	10,3
Akker	42,1	30,5
Grasland	22,6	20,4
Braakliggend en duinen	1,5	0,5
Water	2,3	2,5
Andere: Moeras, Struikgewas, Luchthavens, Groeves.	0,5	2,8
Totaal	100	100

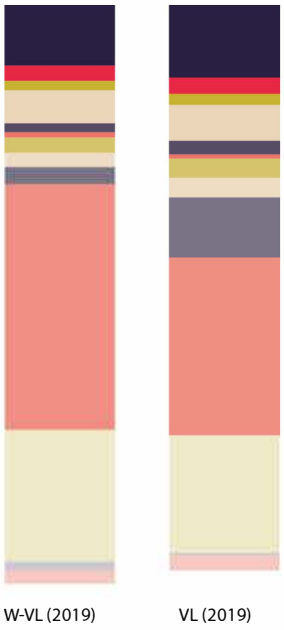

Table 2. Overview of land use within West Flanders and Flanders (source: Landgebruiksbestand; provincies.incijfers.be)

The yellow part of Figure 39(left) shows the agriculture land of the West Flanders. This map was created to show the green areas in Flanders in function of the green policy in Flanders. The right map (Figure 40) indicates the dominant types of agriculture that is taking place across the different municipalities in West-Flanders.

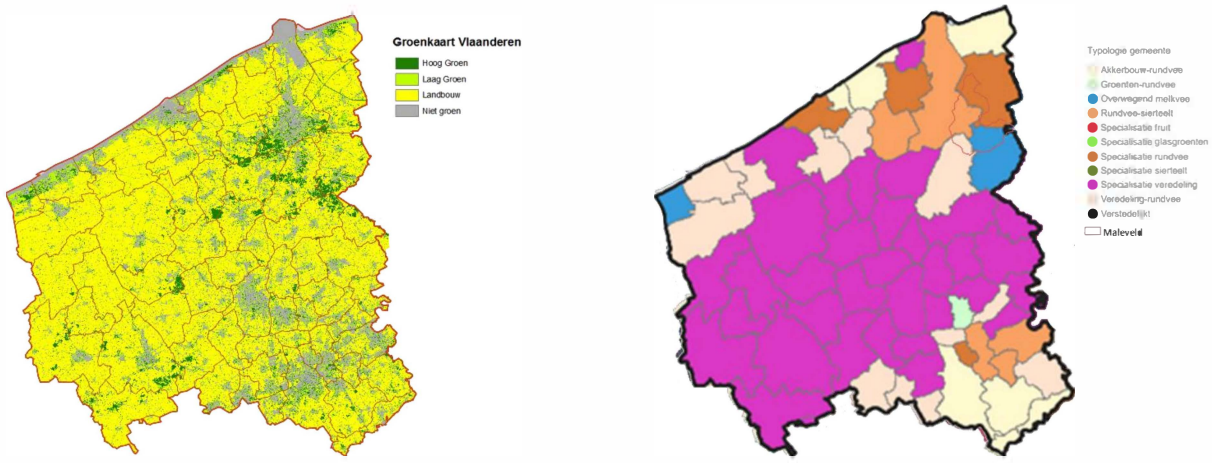

Figure 29 & 30. The green map and the agricultural typology map (Source left: Agentschap voor Natuur en Bos; Right: Agency for Agriculture and Sea Fisheries based on Statbel, 2016) (Overheid, 2021; Vlaamse overheid, 2016)

5.4 Key community systems: water management

The impacts of climate change on flooding are described above. This results in river flooding, coastal flooding and pluvial flooding. This is affecting the way water is managed.

Flood defence

Responsibilities for water management in West Flanders are divided among various governmental institutions. Municipalities oversee local water systems, including small canals, urban drainage systems, and sewage infrastructure. They are also responsible for monitoring local wastewater treatment in relation to water quality. The province of West Flanders develops regional water policies and plans, addressing issues such as groundwater management, flood risk management, and climate change adaptation. Additionally, the province plays a coordinating role among municipalities on water-related topics. Regional Water Authorities like Province of West Flanders, Polders, VMM, Vlaamse department waterwegen en zeewezen manage larger-scale water bodies, including rivers, canals, and dikes. Their primary responsibilities include protecting against flooding by maintaining and enhancing flood defences, as well as managing water levels in significant waterways. They also oversee water quality and quantity in regional systems.

Human activities have significantly altered the landscape in this region. Centuries ago, tidal channels were deepened and expanded inland due to storms and rising sea levels. Dikes have been constructed since the 10th century to protect settlements. The creation of polders, particularly around the IJzervlakte and Zwin, allowed land to be reclaimed from the sea. The formation of islands like Wulpen and Cadzand further facilitated land reclamation and dike reinforcement. Notably, Ostend has had to relocate inland multiple times due to recurrent flooding, underscoring the importance of dike protection measures. Despite its history of flooding, Ostend now enjoys a relatively stable situation, safeguarded by robust flood defences.

Historically, West Flanders featured a balanced agricultural landscape intertwined with water and nature. However, post-World War II land consolidations and agricultural intensification

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drastically disrupted this equilibrium. The straightening of streams, removal of vegetation, and conversion of wetlands to farmland have diminished natural water retention, increasing the region's vulnerability to drought.

Drinking Water Supply

In West Flanders, the majority of the drinking water supply is coming from surface water, like De Blankaart, De Gavers, Dikkebusvijver and Zillebeke vijver and the Aquaduin. Municipalities are responsible for the public drinking water supply, often relying on water companies to deliver tap water. The Flemish government maintains oversight of both public and private water suppliers.

The drinking water supply in West Flanders is managed by several regional water companies that ensure clean and safe drinking water for residents. The drinking water company Farys organizes the drinking water supply on the territory of Damme and Bruges. Infrastructure includes extensive networks of pipelines and treatment facilities designed to maintain water quality and ensure efficient distribution. Regular monitoring and maintenance programs are in place to respond to potential contamination risks and manage water scarcity issues, particularly considering climate change and increasing demand.

Sewage System

West Flanders is equipped with a comprehensive sewage system designed to manage wastewater effectively. The infrastructure includes a network of sewers that collect wastewater from homes and businesses, directing it to treatment plants where it is processed before being released back into the environment. However, a number of buildings are still not connected to a sewage system. These areas need local water purification.

The municipal sewerage network on the territories of Damme and Bruges is managed by Aquario, which is a daughter company of Farys. The sewage from the municipal sewerage network is delivered to supramunicipal collectors that transport the sewage for sewage treatment. The latter are managed by the public Flemish Company Aquafin.

The region prioritizes sustainable practices, with many treatment plants utilizing advanced technologies to reduce environmental impact and promote resource recovery. Additionally, efforts are underway to improve stormwater management to prevent flooding and enhance the resilience of urban areas to climate-related events.

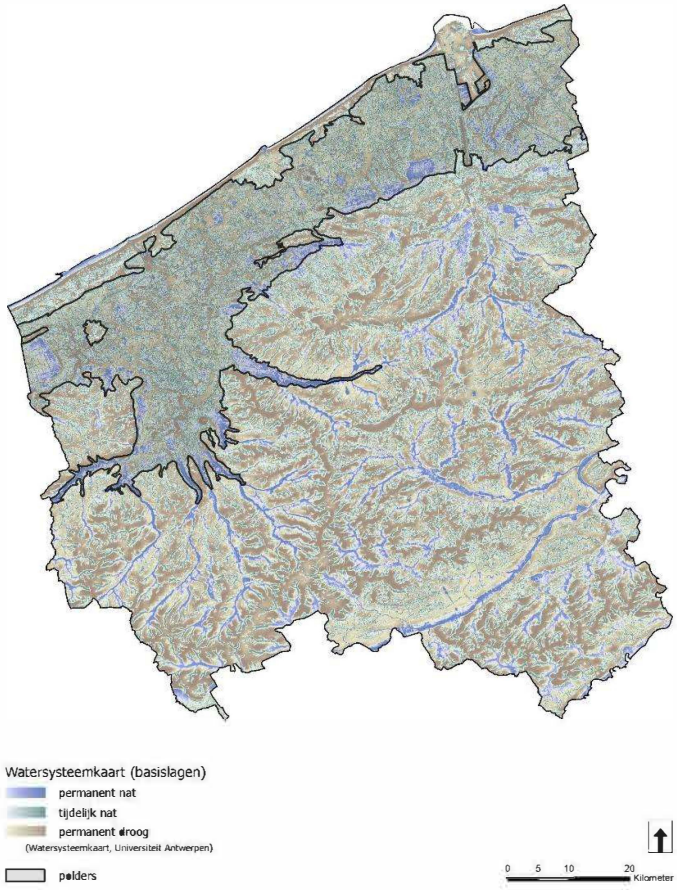

Figure 40. Water system map as a basis for a climate-proof space (Beleidsplan Ruimte West Flanders, 2022)

West Flanders is experiencing more intense rainfall, resulting in sewage system overflows that contaminate waterways and negatively impact water quality and ecosystems. Heavy rainfall leads to surface runoff that carries pollutants from roads, industrial areas, and urban surfaces into lakes, rivers, and groundwater, further compromising water resources.

Sea level rise exacerbates these challenges by increasing the risk of coastal flooding and salinization. During dry summer months, reduced water levels can allow saline groundwater to rise, especially when insufficient rainfall fails to flush out saltier water. This rising salinity can significantly affect agriculture, nature, and human activities. Additionally, soil subsidence lowers land elevation, making coastal areas even more vulnerable to flooding and erosion.

5.5 Key community systems: Critical infrastructure

Climate change is expected to impact the critical infrastructure to a certain extent, in particular due to flooding, as described above. It is valuable to assess which parts of the critical infrastructure might be affected by climate change, and in particular due to flooding.

Transport system

Transportation and mobility infrastructure are vital in West Flanders, comprising harbours, waterways, railways, roads, and cycling paths, which together cover 5.6% of the area. Harbours have both an economic as well as an ecological function and NBS might play a role in capturing

CO2. Roads, highways, and railways run parallel, connecting key economic hubs such as Ostend, Bruges, Roeselare, and Courtrai. The E40 highway links Ostend and Bruges to Ghent and Brussels, a route established in the late 1930s when inland residents sought coastal leisure. The development of the railway and the E403 highway between Courtrai and Bruges has significantly contributed to Roeselare's economic growth.

Key transportation routes, including the E17 highway and the navigable waterways of the Leie and Scheldt, facilitate trade with France and the Netherlands, connecting Belgium to global markets via the Zeebrugge and Ostend harbours. Container processing occurs at terminals in Avelgem, Wielsbeke, and Wevelgem, with a new terminal soon to be established in Roeselare.

However, congestion, accessibility, and liveability issues are prevalent in and around cities and areas of economic concentration. West Flanders has two airports: Ostend-Bruges Airport serves both goods and passenger traffic, while Kortrijk-Wevelgem Airport caters to private and business aviation, including helicopter services. Additionally, recreational airports are located in Koksijde and Moorsele.

Primary transport routes around eastern Bruges include the E40, E34/A11, N9, and smaller connecting roads. Recent analyses by Steunpunt Werk have visualized commuting patterns, highlighting congestion issues, particularly in urban areas. While many residents of Bruges work within the city, approximately 90% of residents in surrounding municipalities commute elsewhere. This is leading to cut-through traffic on smaller roads, affecting the liveability of the municipalities. The region also boasts an extensive cycling path network, catering to recreational cyclists—a common feature across Flanders—with four distinct cycling path networks available.

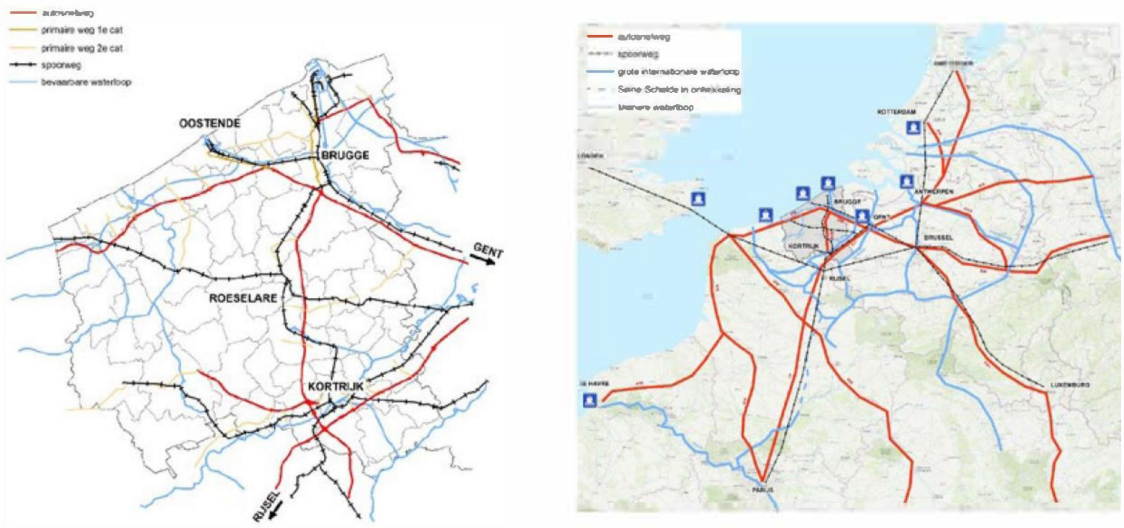

Figure 41 & 42. Left: Overview of the major line infrastructures in West Flanders (Source: Beleidsplan Ruimte West Flanders, 2022); Right: Location of West Flanders within NW Europe with indication of the most important line infrastructures (Source: Beleidsplan Ruimte West Flanders, 2022)

Telecommunication Networks

Telecommunication networks encompass all forms of communication via telephone and the internet. The National Crisis Centre of Belgium has investigated the risks and potential effects of interruptions to telecommunications caused by external factors, including climate change. In its assessment, the Centre highlights that while interruptions to telecommunications in Belgium are likely, their societal impact is expected to be low. This resilience is partly due to the redundancy built into telecommunications systems across the region, ensuring continued connectivity during disruptions.

5.7 Key community systems: ecosystems and their services

Climate change is significantly impacting ecosystems and their services in Flanders, with evident consequences such as species relocation, adaptation, or extinction. Key ecological processes—including plant growth, organic matter decomposition, and nutrient cycling—are affected by changes in precipitation patterns, droughts, flooding, heat stress, fires, and storms. These alterations can lead to pollution, eutrophication, acidification, and soil salinization, ultimately transforming suitable habitats for various species. For example, heat-loving plants and animals have become more prevalent in Flanders compared to the 1980s and 1990s, and the peak pollen season has shifted significantly earlier since 1975. While some organisms adapt by changing their habitats or life cycles, others that cannot keep pace are at risk of extinction. The rapidity of these changes, compounded by land use alterations and habitat fragmentation, decreases the likelihood of adaptation without significant losses in ecosystem quality. Flanders has implemented an extensive nature monitoring program to track these impacts.

In West Flanders, various ecosystems face future risks from both human activities and climate change. Rising sea levels, increased storm intensity, temperature fluctuations, and altered precipitation patterns threaten these ecosystems. Coastal areas are particularly vulnerable, as rising sea levels contribute to the erosion of vital salt marshes and estuaries, which support numerous species. Additionally, saltwater intrusion into freshwater habitats increases salinity, making them less suitable for freshwater flora and fauna and altering species distributions.

In freshwater systems, such as rivers and wetlands, changing precipitation patterns impact water levels and quality. More frequent and intense rainfall leads to increased runoff that carries pollutants from urban and agricultural areas into waterways, degrading water quality and disrupting aquatic ecosystems. Conversely, prolonged dry periods can result in reduced water levels, adversely affecting the habitats of aquatic and semi-aquatic species.

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6 Conclusions

6.1 Readiness for Nature-based solutions

NBS can provide an added value to West-Flanders with regards to a number of issues. Some of these NBS are already initiated at pilot level. For these pilot projects, the question is mainly how to scale these good practices to the level of the province or even the Flemish or Belgian level. Nature-based solutions are also an integral part of climate adaptation strategies. The Flemish government has promoted six strategies to deal with climate change impacts (Vlaamse Overheid, s.d.). Some of them are related to nature-based solutions, as there is:

- 'Ontharden' – which refers to removing concrete to enable more space for green infrastructure.
- Forestation – which refers to planting more trees in cities and rural areas
- Ventilation – which refers to making use of the wind to cool places
- Heat reduction by covering materials with green infrastructure for instance
- Space for water, including rainwater retention

Furthermore, NBS are also promoted as part of the nature conservation and biodiversity policies, and they play a role in water management as well. Nature and landscape are also used as part of the economic strategy go promote tourism in the region.

6.2 Recommendations for NBRACER

The Province of West Flanders has several unique characteristics that must be considered when developing nature-based solutions. The region's natural system is heavily influenced by artificial interventions to manage water, both from the sea and inland waterways. These interventions have played a crucial role in unlocking the area's economic potential. Agriculture dominates land use and also plays an important role in the economic fabric of the region.

The food has gathered in the area and are significant sectors. At the same time, tourism is a key driver of the local economy. The province's social fabric is also distinct, with some regions having a high proportion of elderly residents, while others are characterized by a significant number of people at risk of poverty.

Seasonal fluctuations in population further shape the province's dynamics. During peak tourism periods, particularly in the summer months (July and August), the number of people residing in the region increases substantially. This is particularly relevant during heatwaves, which often coincide with the summer holidays.

It should also be observed that the rural, coastal and urban landscape are very intertwined in the Province of West-Flanders, meaning that the NBS will have to fit into multiple landscape challenges. Additionally, West Flanders faces a unique urban-rural challenge. It has both densely populated areas and widespread population sprawl, with a high dependency on cars for commuting. These factors create distinct conditions that must be taken into account when designing and implementing nature-based solutions.

To effectively scale nature-based solutions (NBS), it is essential to focus on its unique characteristics and its role within the surrounding region. The goal is to identify NBS that directly address both the current challenges this region faces and the future risks it is expected to encounter. The NBS will integrate different challenges and should be able to solve multiple challenges at the same time, by their integrated approach.

Integration is also recommended for the various stakeholders networks that already exist in the region. A broad range of stakeholders will be engaged in NBS development, which is currently driven primarily by the public sector. To ensure a more inclusive and effective approach, mechanisms must be established to engage all domains of the quadruple helix: private sector partners, knowledge institutions, and civil society. A key priority is determining how to actively involve farmers in this transformative adaptation journey.

Furthermore, planning, decision-making, and implementation of NBS must navigate and align with multiple existing frameworks and policies. This alignment must take place within the broader context of ongoing changes in the water governance model, which have been driven by years of recurring flooding issues.

Within the NBRACER project, a critical challenge will be overcoming the "pilot paradox"—the difficulty of moving beyond isolated pilot projects to achieve large-scale impact. Developing a clear strategy for scaling up proven solutions will be essential. Additionally, there is a strong need to establish a provincial climate adaptation plan to ensure long-term, coordinated action, supported by an inclusive engagement of all domains of the society.

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Annex 4: Baseline Nouvelle Aquitaine

NBRACER
Nature Based Solutions
for Atlantic Regional Climate Resilience

Regional Baseline background report

Nouvelle-Aquitaine

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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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1 A regional baseline

1.1 Aim of the Regional Baseline

The aim of this regional baseline is to collect and share the regional information and to discuss the current situation among partners in the regions involved in NBRACER. By creating a baseline first insight on the current physical and social-economic context will be developed, relevant to deal with climate change, to plan and implement Nature-based Solutions (NbS) and to start the Transformative Adaptation Journey in each Demonstration region towards a climate resilient society.

The regional baseline comprises a collection of general regional information both qualitative and quantitative data. The baseline adopts a systemic approach to comprehend the intricate relationship between the natural system and the human/social system. Within this framework, three key components are delineated: the natural system, the social system, and the connection between these two systems within the key community services. Through this systemic approach, a clearer understanding of resilience-building mechanisms and pathways can be attained.

The baseline will give direction to region's specializations, unique characteristics, as well as its strengths and weaknesses concerning Nature-based Solutions (NbS). The baseline will facilitate a common understanding, to support the joint sense-making for future visions and pathways.

1.2 Key concepts

Climate change can be approached in different ways. Therefore, it is important to describe the conceptual approaches that are underlying the NBRACER project and the analysis of information that has been collected for this baseline report. While many studies have been using an impact or risk-based approach, NBRACER is focussing on a systems-based approach to foster resilience. Key concepts related to this approach are:

- Systemic approach and key community systems
- The concept of regional transformation adaptation journey
- The transformational governance; concepts of collaboration and inclusion

1.1.1 Systemic approach and key community systems

The baseline adopts a systemic approach to comprehend the challenges that climate change poses on the region. The systemic approach is focussed to better understand the intricate relationship between the natural system and the social system. This approach starts from the Sustainable Development Goal's wedding cake that illustrates how economies and societies are connected with the natural system and in order to have a well-functioning economy and society, they should be well embedded in the underlying natural system.

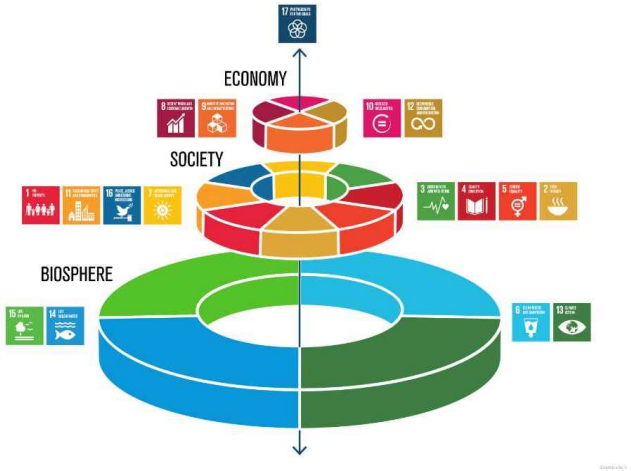


Figure 1: Wedding Cake of sustainable development goals (SDG), United Nations

In the baseline, we aim to analyse the different parts of the natural and social systems and their connection. This will help to move away from the environmental or sectoral approach only, that is often used in climate change assessments that considers nature separate from society and economy. Instead, it promotes a more systemic approach that explicitly focuses on the interrelationship between natural and social systems. Nature-based Solutions inherently have the potential to strengthen this connection sustainably by leveraging the natural system's capabilities to address societal issues.

Within this approach, three key components are delineated: the natural system, the social system, and the connection between these two systems that includes the governance that is in place to ensure natural and human systems are in balance. Approaching climate change in a systemic way enhances a better understanding of the systems issues that lead to climate change impacts and provides a better understanding on how systems could change in order to regain a balance between the natural and social systems given the context of the climate changes.

Related to this systemic approach are the key community systems that play a dominant role in the European Mission on Adaptation (European Commission, 2021). Key community systems are systems that meet basic needs for society but might be impacted by climate change. The EU distinct 5 Key Community Systems: the land use and food system, water management system, critical infrastructure system, the health and wellbeing system and the local economic system. The Mission Climate Adaptation is focussing on using the ecosystems and nature-based solutions in order to protect the key community systems from the negative impacts of climate change. The ecosystem is crucial for our wellbeing and ensures that we are ecologically connected, that nature is restored and that ecosystem services are delivered.

Furthermore, the baseline also summarizes the available information on climate change risks and assesses the related vulnerabilities of the key community systems due to climate change. To safeguard our wellbeing, it would be needed to assess the needs for transformation to ensure that the key community systems keep on meeting basic needs.

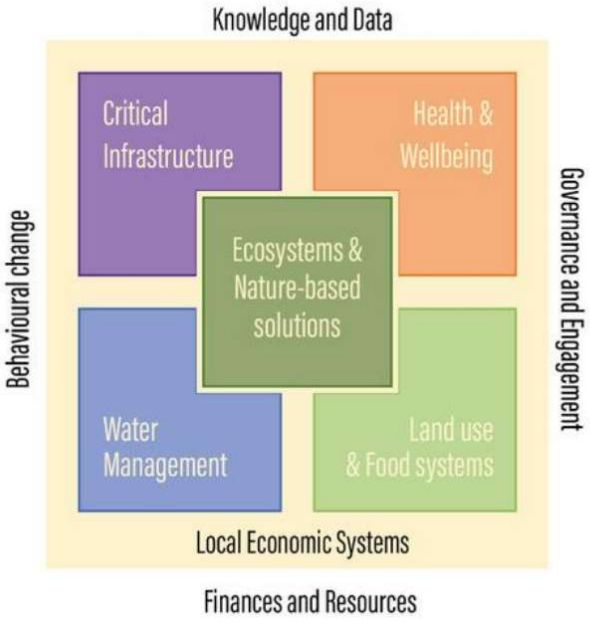


Figure 2: Key Community Systems (EU Mission of Climate Adaptation)

1.1.2 Regional Transformative Adaptation Journey

As NBRACER aims for systemic transformation at the regional level, we are relying on the Transformative Adaptation Journey (also used in Pathways2Resilience program) in order to bring forward the regional transformation. This approach is originally based on the adaptation policy cycle but is extended with elements that would enhance the collaboration between public, private, knowledge and societal partners.

The first phase of the Transformative Adaptation Journey - *preparing the ground* – focuses on understanding what's already being done in the broader policy, social, environmental, and economic contexts, understanding who are the key actors and institutions needed to involve, understanding the socio-economic context and available resources, and providing evidence to determine regional priorities and opportunities for sustainable, climate-resilient regional development. Also, climate risks and opportunities for prosperity need to be assessed. At the end of this phase, regions will have a comprehensive baseline covering, among others, risk assessments, adaptive capacity needs, a stakeholder map and a monitoring framework that will act as a solid foundation for the journey. (Source Climate KIC, DesirMED).

The next step in the regional adaptation journey involves co-developing a *shared vision* with stakeholders. Active engagement is essential for creating commitment and ownership of the process and vision. This co-created vision will be a tool for mobilizing change and holding regional stakeholders accountable. It must be holistic, combining scientific insights with community priorities to foster a sustainable and equitable future. Public-private partnerships will be key to mobilizing resources and driving large-scale innovation. Ultimately, the vision must be dynamic, evolving with climate changes and lessons learned, and calls for courage,

collaboration, and commitment from all sectors to protect our planet for future generations. (DesirMED)

Next step is developing *adaptation pathways* for climate adaptation and resilience gather interventions across multiple levers of change in a portfolio of actions, each of them contributing to progress towards the desired pathway, that will coincide with action & investment plans. While implementing the plans, it is aimed to closely monitor progress on the systemic change and to evaluate, learn and adjust actions if needed. In this way, building resilience via transformation becomes an iterative process, a journey, where all relevant regional stakeholders take part.

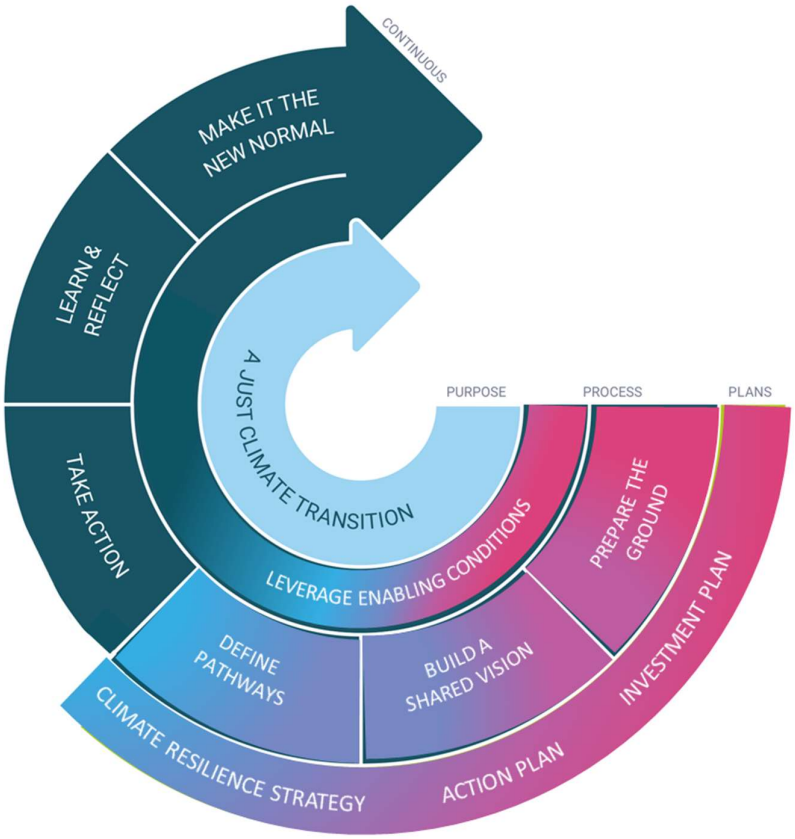


Figure 3: Transformative Adaption Journey (Climate KIC, P2R)

1.1.3 Collaborative and inclusive approach

The European Mission on Adaptation acknowledges the need to involve organisations beyond the conventional public actors, when it comes to building resilience. It is crucial that private partners, knowledge partners and society (*quadruple helix*) are involved in the regional transformation adaptation journey. This means that these partners need to be mobilized and engaged in the various phases of the transformational process and start with collaborating on directions and solutions to cope with climate change, and to create dynamics and initiatives within the specific regional context (*Smart Specialization*).

The European Strategy on Climate Adaptation (2021) also promotes the principle of *just resilience* or *just transition,* indicating that adaptation processes have to be inclusive in order to avoid the risk that adaptation measures put an uneven burden on some groups and that marginalised groups are not well included in the planning and decision-making processes. Therefore, it is crucial to better understand who in the region might be unequally affected due to climate change and to ensure that they are well engaged in the development and implementation of adaptation measures to ensure that these measures meet their needs. Generally speaking, it is assumed that elderly, children, immigrants, single parents and poor people are more severely affected by climate change (EEA, 2019). However, it would be needed to explore vulnerable groups in the regional context and identify groups that are left behind.

1.3 Process of constructing the Regional Baseline

To create the regional baseline, the required information topics were defined and listed. As mentioned earlier, the baseline examines both the natural system and the social system, emphasizing their interconnections and key community services. For each component, we specified the necessary information to obtain the desired insights for the baseline. More detailed information about this systemic approach and its individual components will be presented in the upcoming chapter.

To gather this information, we distributed a document to the region that could be filled out, based on the list of required information topics. The region, possessing valuable insights into local conditions, significantly enriched our understanding of vulnerabilities, challenges, and opportunities. This collaborative knowledge-sharing formed the bedrock of our regional baseline.

Additionally, Wageningen Research supplemented this information with relevant online sources. We meticulously reviewed existing reports, data, and materials to enhance the insights shared by the regions. Our goal was to create an initial overview of the region's current state — a snapshot that captures its unique characteristics, risks, and adaptive potential.

The baseline serves as a starting point. During the regional workshop, we collected additional information and incorporated it into the baseline as needed. Our aim is to align with your perspective and regional expertise, ensuring that the baseline evolves dynamically throughout the NBRACER project.

2 A regional description

Nouvelle-Aquitaine is the largest region in France, home to about 6 million inhabitants. It boasts an extensive network of 74,000 km of streams and 700 km of coastlines. The regional economy is primarily driven by agriculture, viticulture, and tourism, making it a vital area for these sectors in France. Water availability is a prominent challenge, addressed through strategic initiatives like the 2018 regional strategy on water and the 2019 Néo Terra roadmap, which focuses on ecological and energetic transitions, including preserving natural resources and biodiversity. The local authority, led by President Alain Rousset, comprises 8,000 agents and 183 elected members. Their responsibilities encompass economic development, land use planning (including harbours and nature reserves), youth services (such as high schools), and ecological/environmental transitions.

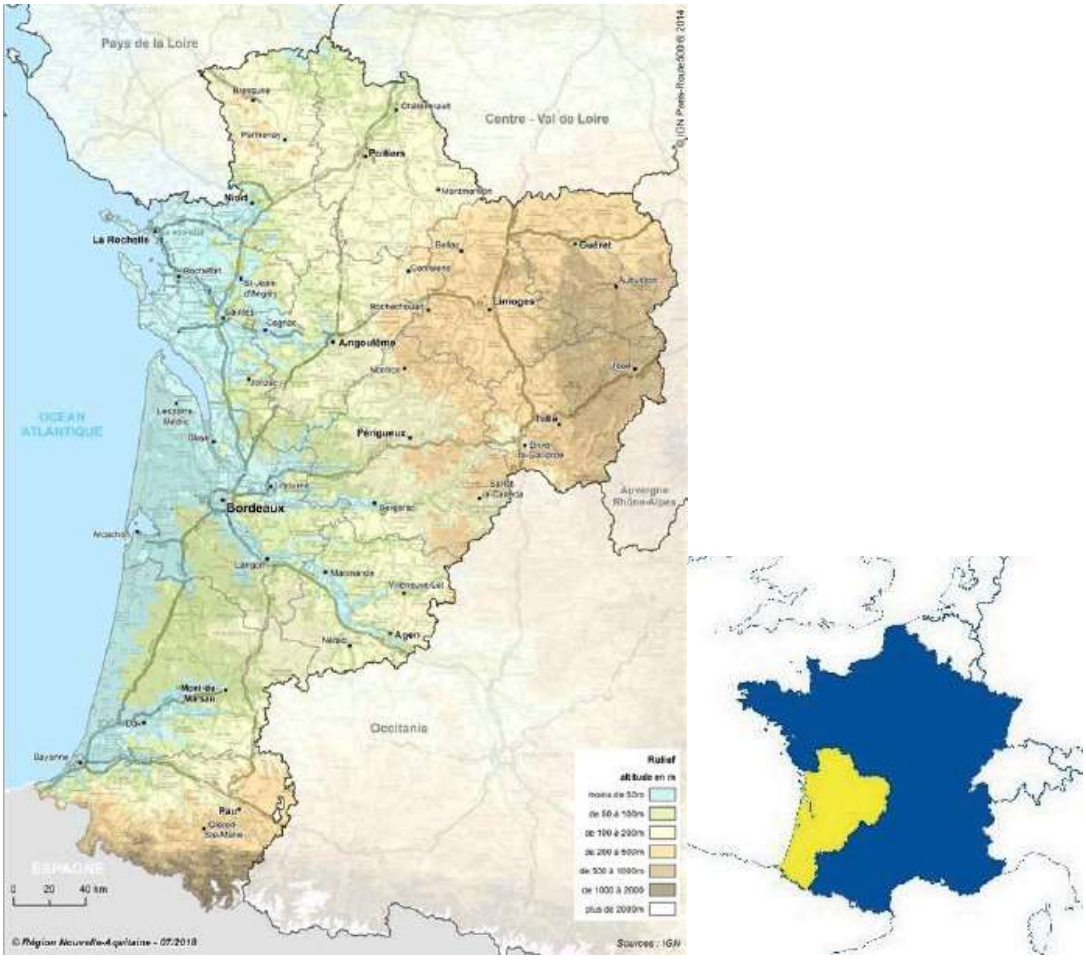


Figure 4: The Nouvelle-Aquitaine region

2.1 Rural areas

Rural areas are present at various levels in a large part of the Nouvelle-Aquitaine region. Despite their diversity, they constitute a spatial entity in their own right: small towns, market towns, peri-urban fringes, sometimes sparsely populated and isolated communes. Rural areas

are characterised by their low population density and their relative isolation compared with urban centres, the size of their agricultural and natural areas. Rural areas that are inventive and aware of their assets, enabling everyone to live a balanced lifestyle in the region. They are faced with dependence on the car, urban sprawl and the artificialization of land, a feeling of neglect and an inability for residents to satisfy certain basic needs within a “reasonable” travelling time.

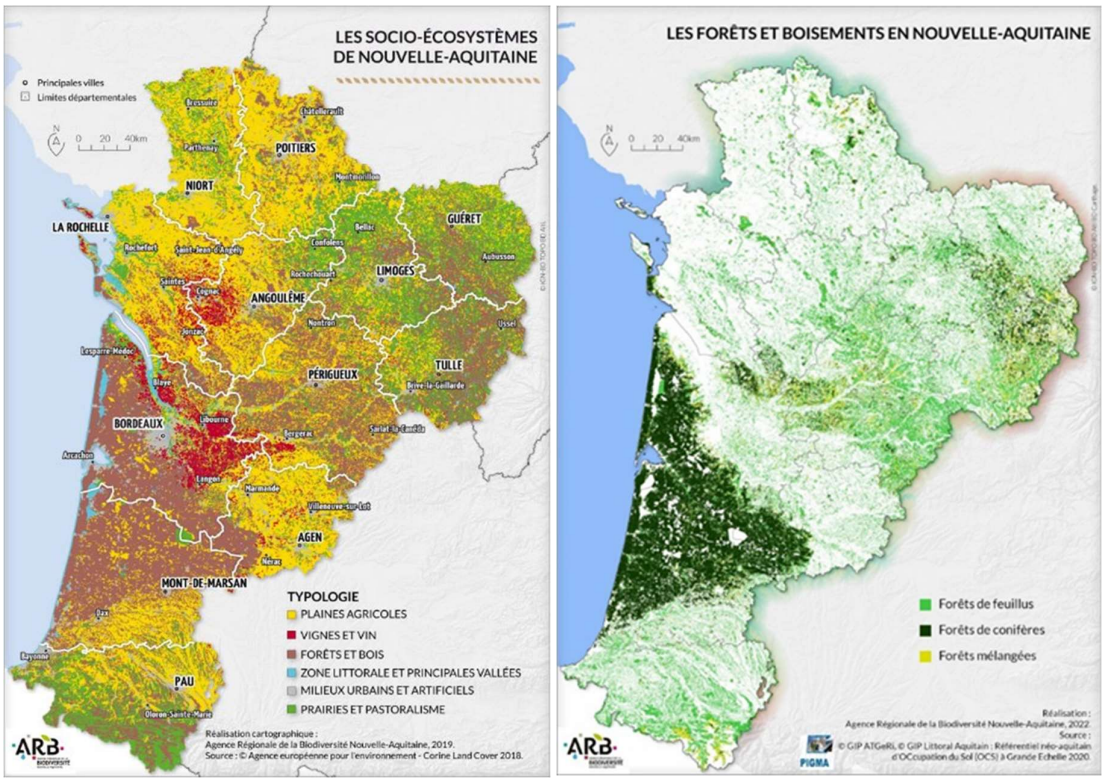


Figure 5: Rural landscape in Nouvelle-Aquitaine, source ARB NA.

As seen in the image above, the rural areas represent a vast territory in the Nouvelle-Aquitaine region. Several main activities-based rural areas contribute to the region’s economic incomes and together with the protected areas make the richness of this territory. Agriculture is a major sector of activity in Nouvelle-Aquitaine, in terms of land use, production of economic value and generated jobs, both direct and indirect. Forests play a predominant role in the region, not only in terms of surface area, but also the region's economy and ecology. With 2.8 million hectares of forest, the Nouvelle-Aquitaine is the largest forest region in France (17 % of France's forests).

2.2 Coastal and Marine Landscape

The Nouvelle-Aquitaine region features a highly diverse coastline, including rocky coasts, beaches, large sedimentary barriers, estuaries, tidal inlets, bays, tidal flats, and coastal plains below the highest sea levels. These coastal morphologies control ecosystems and human activities. Despite many natural coastlines, substantial portions are artificialized mainly to defend against marine submersion and erosion. The region faces hazards, especially erosion and marine submersion, marked by extreme events like storms Lothar, Martin (1999), Klaus (2009), Xynthia (2010), and severe storms in 2013/2014, causing significant coastal erosion and highlighting vulnerability to marine submersion. Climate change will further impact these events. Currently, sea level rises about 3 mm/year in Nouvelle-Aquitaine and is projected to rise 0.3 m to 1.5 m by 2100, depending on GHG emission reductions. Climate change will affect low-pressure systems and extreme wave events. Simulations suggest the Bay of Biscay will be relatively spared, but uncertainties remain. Sea level rise could impact tides, with a less than 2% increase in spring tidal ranges in Nouvelle-Aquitaine and larger changes in estuaries. By 2100, reduced precipitation in watersheds will decrease river flows, affecting estuarine

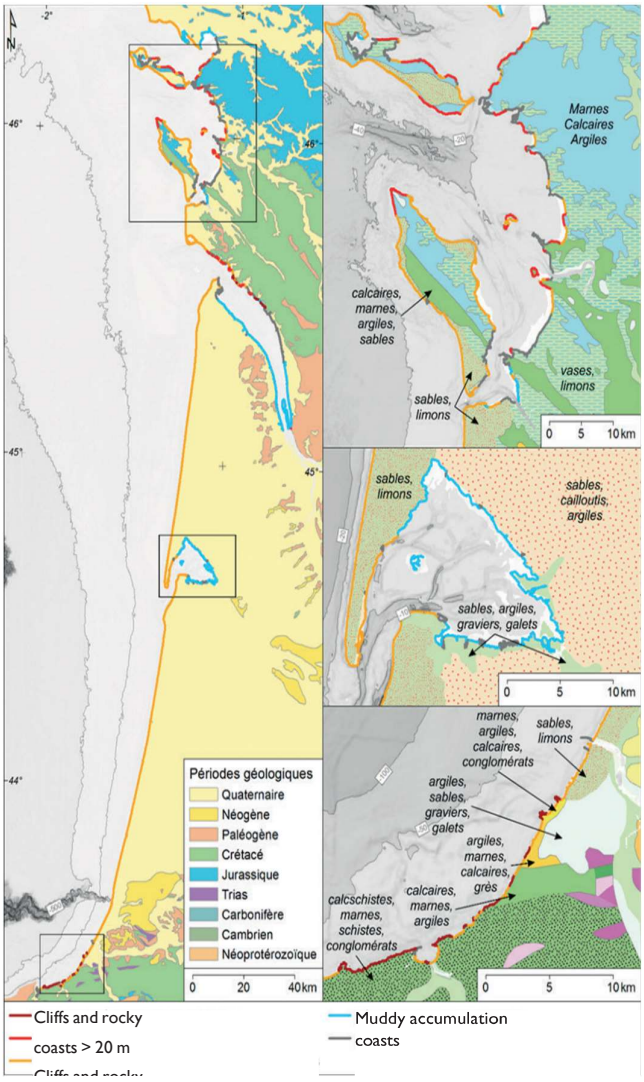


Figure 6: Coastal landscape in Nouvelle-Aquitaine, source : BRGM.

environments and coastal sediment supply. Adaptation strategies now include protection, relocation, and mitigation, emphasizing a phased approach and community consultation. New governance forms are needed to facilitate adaptation projects. Choosing the best adaptation to climate change remains complex, depending on timescales, the object, and the hazard of interest. As seen in figure 6, it's possible to identify three distinct coastal zones from the north to the south of the Nouvelle-Aquitaine coastline.

The North is made up of estuaries with mudflats and bays of rocky or sandy nature. In the median zone, the Atlantic coast has an almost rectilinear sandy front, generally oriented north-south, subject to the action of waves and swells, and only interrupted by the lagoon of the Arcachon basin and a few Landes tidal channels. To the south, the shores become rocky (Basque Country), a legacy of the geological formation of the Pyrenees Mountain range.

2.3 The Urban Landscape

Urban areas, contributing up to 70 % of CO_2 emissions, will be significantly affected by rising temperatures and its impact on natural balances. In Nouvelle-Aquitaine, Bordeaux and other urban areas face the dual challenge of mitigation and adaptation. Climate change risks in urban areas depend on their physical and social characteristics (topography, proximity to water, population density, income levels, economic activities) and the local authorities' capacity to implement measures.

Two dimensions were highlighted in the 2018 AcclimaTerra report[1]:

- Heat Islands: These have serious public health impacts and affect both large cities like Bordeaux and Poitiers, and medium-sized cities like Agen. Mitigation involves proactive policies for revegetation and protecting wetlands and natural areas.
- Sea Level Rise and Flooding: Expected to be significant by 2050 and more so by 2100, posing risks to urban areas in Bordeaux. This calls for updated town planning rules and an integrated estuary management strategy.

Urban sprawl, characterized by transport network extensions, destruction of natural areas, soil artificialization, and car dependency, affects most regional cities like Limoges and Bordeaux. From 1960 to 1990, Bordeaux's urban area doubled in size but lost density, hampering public transport development. Urban sprawl increases commuting distances, traffic congestion, and air pollution. Densifying urban areas doesn't guarantee better environmental performance; effective spatial distribution of economic, residential, and recreational areas is crucial.

Despite the important development of the public transport offered in the Bordeaux metropolis and an expansion of soft modes of transport (biking, walking), whose co-benefits in terms of health and urban sociability are underestimated, the share of the automobile remains far high, due not only to residential sprawl but also to the development of giant shopping centers on the outskirts of the city, with their parking lots.

[1] AcclimaTerra is the Nouvelle-Aquitaine scientific group on Climate Change. See https://www.acclimaterra.fr/en/

Multipolar urban organization, well-connected by public transport and separated by green spaces, has proven effective. Bordeaux's policy of residential densification along tram lines and new districts should avoid exacerbating heat island effects.

3 Regional climate risks

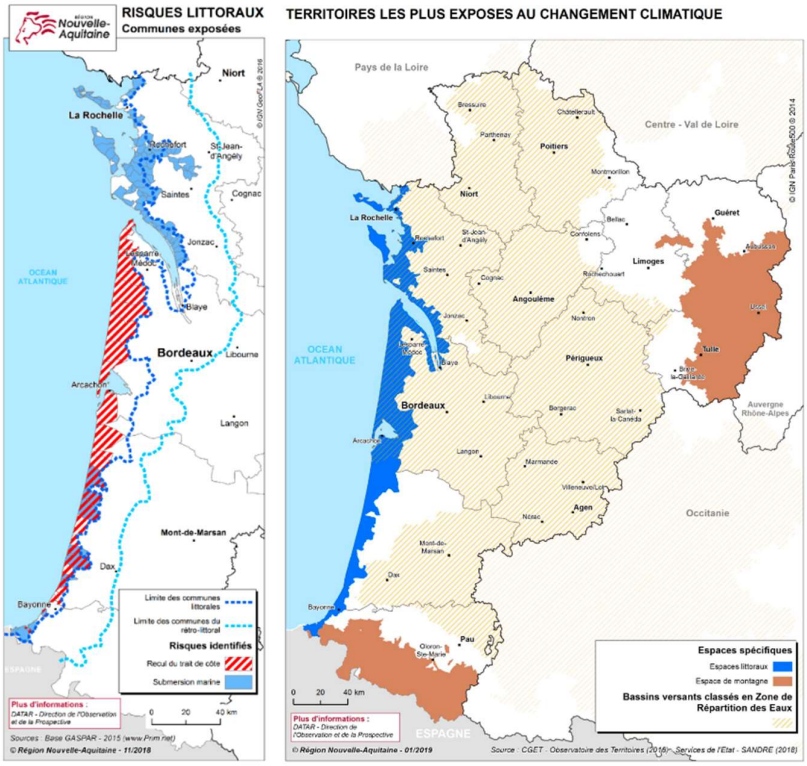


Figure 7: Maps showing climate risks in Nouvelle-Aquitaine. Left image: coastal risks, right image: territories the most exposed to climate change.

Key hazards / Main stakes	Floods	Droughts	Rise of temperatures	Marine submersions	Landslides and avalanches	Coastal erosion
Water resources and water cycle	X	X				X
Biodiversity		X	X	X		
Agriculture	X	X			X	
Forest		X	X		X	
Ocean and coasts	X			X		X
Health and urban landscapes	X		X			
Economic activities			X	X	X	X

The stakes exposed to climate change in Nouvelle-Aquitaine and the hazards associated with them.
DREAL Nouvelle-Aquitaine, 2022

3.1 Flooding

Climate change is impacted by extreme events, such as those of the winter of 2013/2014, which was the most energetic in Nouvelle-Aquitaine for at least 70 years and eroded sectors that had been stable in recent decades, or accelerated erosion in others (e.g. 60 m in one winter at Pointe de Gatseau). The rocky areas evolve according to localized land movements of continental and/or marine origin. Average retreats of around 0.6–0.8 m/year at Anglet, 0.15–0.3 m/year between Biarritz and Bidart, and very stable and homogeneous erosion of around 0.15 m/year south of Bidart (Guétary – Hendaye) are observed. Similar orders of magnitude are measured further north at Pointe du Chay (Angoulin sur mer) or Chef de Baie (La Rochelle). Quantifying the impacts of climate change on erosion is a real scientific challenge and there is no generic approach to work on this problem. The rise in mean sea level, the decrease in river flows and sediments carried to the coastlines, and the possible increase in the intensity and frequency of extreme events will all aggravate current trends. Even if, locally, we could observe erosion trends reversing towards accretion on short timescales (a few years), in particular on the coasts adjacent to estuary mouths, chronic erosion will continue and will be accelerated. Simulations suggest that sea level rise will explain the widespread increase in erosion.

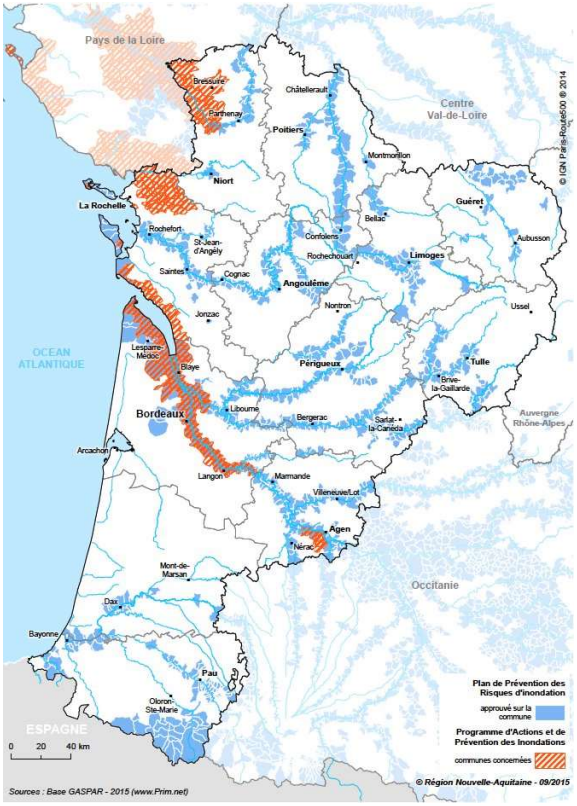


Figure 8: Map showing in blue the Flood Risk Prevention Plan and in orange the Flood Action and Prevention Program

The expected rise in sea level by 2100 –already very significant by 2050 – associated with the risk of river floods caused by exceptional and brutal rainfall, increases the probable intensity

and frequency of the flooding hazard for certain urbanized areas, like the Bordeaux metropolitan area.

In coastal areas, affected by the flooding hazard, the systematic rising of the dykes is not the only solution. Lowering the dykes and letting areas with low-stakes flood could significantly reduce water levels and reduce submersion in the nearby areas with high stakes. The establishment of large flood plains with second-row dykes could therefore be considered. More broadly, sanctuarizing areas with low stakes in order to leave them in free evolution will allow a better understanding of the natural resilience of these systems to climate change.

3.2 Heat

The available temperature records since the end of the nineteenth century indicate that Nouvelle-Aquitaine's climate has already warmed by around +1.4 °C during the 1959–2016 period. Computed over a longer period – for example, 1900–2016 – the estimate is not very different (+0.1 °C to +0.2 °C of additional warming); most of the warming has occurred in recent decades, mainly since the 1980s. This amount is clearly higher than the fluctuations expected due to the natural variability of the climate. Warming is more marked in spring and summer than in autumn and winter. It is also relatively uniform over the region, and very close to the average warming observed in France. It can be noted that this value of +1.4 °C is significantly higher than the global warming observed since the beginning of the twentieth century (around +1 °C), which is consistent with our understanding of the phenomenon, more marked on the continents, and confirms our anticipations for the future. The objective, mentioned in the Paris agreement, of global warming capped at +1.5 °C on average, would therefore not be achievable if it were limited to Nouvelle-Aquitaine only.

Since 1958, on the other hand, the annual and seasonal accumulations of precipitation have not shown any significant change. This is due both to the greater natural variability of the rain, which prevents a stable diagnosis, and to the fact that this variable is less directly impacted by the increase in the greenhouse effect. However, other variables linked to the water cycle are already showing signs of evolution, such as soil humidity (linked to the increase in temperatures, and therefore in evaporation). Many studies have described the evolution of the so-called 'extreme' weather events, such as heat or cold waves, droughts, storms, episodes of heavy precipitation, etc., due to the strong impact that these events have on our societies. From this point of view, the results obtained at the scale of France concerning the observed increase in heatwaves and the decrease in cold episodes are applicable to Nouvelle-Aquitaine (and consistent with average warming).

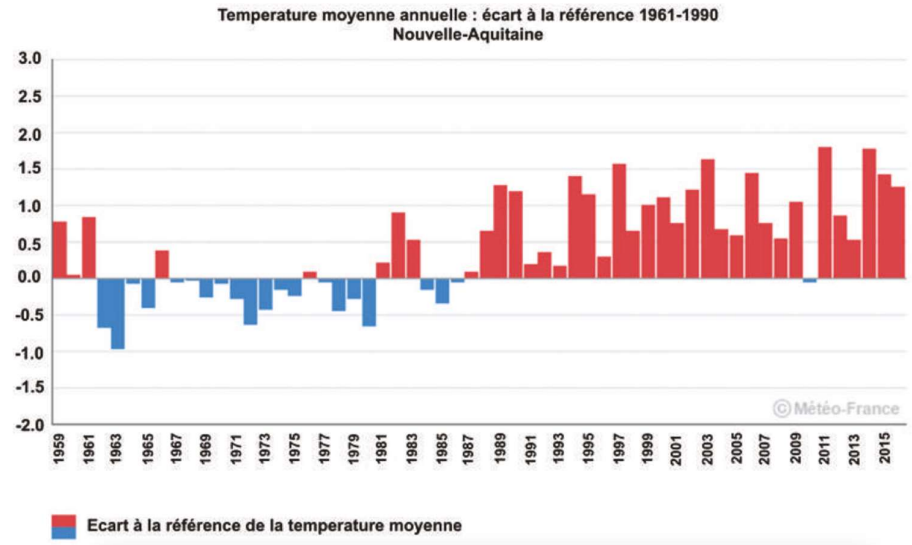


Figure 9: graphic showing the mean annual temperature and the deviation from reference from 1961 to 1990. Source: AcclimaTerra, 2018.

3.3 Drought

A significant fact is the trend towards an increase in the extent of agricultural droughts across the country (due to the decrease of water quantity in the surface soil). This is also true for the Nouvelle-Aquitaine region, with an increase in agricultural droughts of 6 to 7 % since 1959. The evolution of agriculture, a central activity for the economy of the region, is strongly linked to the constraints of water management. The already noted increase in certain climatic hazards (e.g. summer droughts, heatwaves, but also spring frosts), a situation which can only increase in the future, is indicative of the agriculture and livestock future problems.

The year 2022 began with below-normal rainfall from January to March. Cumulative rainfall from November 2021 to March 2022 showed 5 months of deficits across the whole country (-25 % on average). This low rainfall has prevented favourable recharge of the various water resources, particularly groundwater, where levels fell rapidly from October onwards. At the end of December, piezometers showed a level below their interannual average for all types of water table, which was the 7th worst situation in the last 22 years. (Source: BSH, biodiversite-nouvelle-aquitaine.fr)

3.4 Salinization

Analysing the already visible impacts of climate change on the quality of surface waters can currently only reasonably focus on global parameters such as temperature, or even salinity in the case of transitional waters. Acidification of seawater, and therefore of coastal waters, is another significant indicator, with obvious impacts on marine organisms, in particular. Water abstraction in general (which may itself be partly an indirect effect of climate change) and the inter-annual variability of rainfall do not provide clear evidence of the direct effect of climate change on this quality parameter. In other words, transitional and coastal zones combine direct and indirect effects without being able to clearly separate them. However, certain observations

on the trajectories of ecosystems can serve as revealing indicators of the increase in salinity in coastal waters (often coupled with an increase in temperature). The main direct effects are the consequences of changes in the hydrological cycles of the resources (flows and levels), the increase in the temperature of the water/soil pair and, for the coastal zone, the increase in the salinity of the water.

The main direct effects are the consequences of changes in the hydrological cycles of resources (flows and levels), the increase in the temperature of the water/soil pair and, for the coastal zone, the increase in salinity due to submersion (even temporary) by seawater.

In these coastal ecosystems which are very variable by definition (interface zones between land and sea), research is struggling to identify clear and direct manifestations of the effect of climate change beyond the increase in temperature. In contrast, indirect effects such as temporal and spatial variations in salinity, which reflect the supply of fresh water to the littoral zone, are visible and have a direct impact on shellfish farming. The extreme dependence of shellfish and producers on variations in the coastal environment requires very close monitoring of the evolution of physical, biological and sociological elements by identifying potential ruptures.

3.5 Wildfires

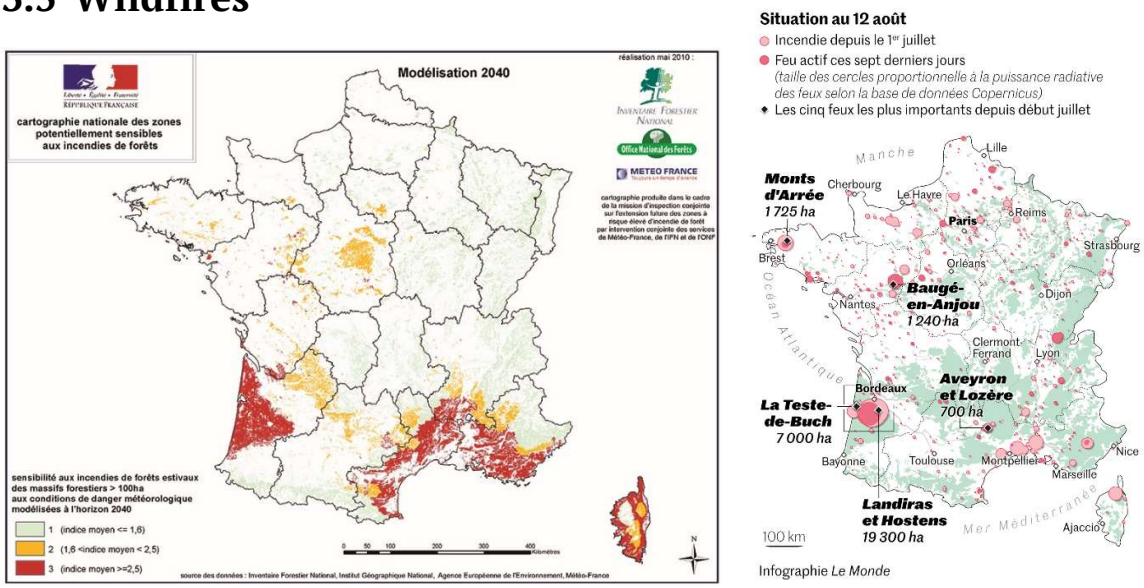


Figure 10: Wildfires. Figure left: Map of areas potentially sensitive to forest fires by 2040. The highest level is in red, the average level in orange and the low level in pale green. In white are areas without forests larger than 100 ha or with very low sensitivity (Source: Chatry et al.). Right: Map showing fires in France for summer 2024 and the surfaces burnt.

Sources : Report AcclimaTerra, 2013, Report AcclimaTerra 2018. La carte des incendies en France depuis le début de l'été (lemonde.fr). Surface impactée par des feux de forêt (biodiversite-nouvelle-aquitaine.fr)

In 2010, an interministerial mission worked on the impact of climate change on forest fires. In this report, the classification of the massifs takes into account the drought parameter, taken from the weather forest index (IFM) and the sensitivity characteristics of the vegetation. The Landes massif, without any notable change in the composition of its forest cover, sees its level of risk increase from medium to high by 2040.

Although the issue of climate change has been on the scientific media and political agenda for three decades, the forest owners who own 90 % of the forests of Nouvelle-Aquitaine became aware of this subject late. This issue has in fact often been confused with the question of risks, which is more familiar to forest owners. Thus, during a national survey carried out in 2011, the question “what risks do you fear for your woods?” » only 4.6 % of forest owners considered climate change as a risk in itself while they clearly identified storms (42 %) and fires (36 %) as the first two major risks, far ahead of health risks (17 %). In fact, the question of climate change seems inseparable from the more general question of risk perception.

In 2022, eight major fires affected the country. Since January, more than 48,500 hectares have burned, three times more than the annual average of the last ten years. 653 fires broke out in the Nouvelle-Aquitaine region in 2022, with a peak in August (225 fires). 98 % of areas burned during the year were due to large-scale summer fires. Thus, nearly 30,700 ha burned in July, August or September. The second image shows that the predictions made more than a decade ago were very accurate.

4 Key Community Systems

4.1 Health system

Description current situation KCS

Higher health issues due to more natural disasters, new vectors of disease (tiger mosquito) and more extreme temperatures. The big hospital buildings also have stakes due to the temperature rise, to ensure a cool enough temperature for their patients' health. With the more common heatwaves, often coming with a rise of air pollution, and new plant species with more allergenic pollens, the buildings welcoming sensitive people must be rethought.

It has now been shown that good interpersonal relationships have positive effects on health. Social ties help to provide individuals with the emotional and practical resources they need. Belonging to a network of relationships and mutual support gives people a feeling of being recognised, loved and appreciated, which has a particularly protective effect on health. The social norms of a group and/or social support can lead to the adoption of more health-promoting behaviour. Thus, the effectiveness of the heatwave plan is largely based on the existence of a local network of solidarity. Relatives, friends, neighbours, building wardens, associations, care services and home help are all called upon to help. Participation in social activities clearly benefits the health of people in unfavourable socio-economic situations. Soft mobility and green spaces encourage social links, dialogue and exchanges between people. Social ties in situ are therefore a strategy that should be developed to promote environmental health.

4.2 Key Community System: Food system

Description current situation KCS

Agriculture

The region is hosting very diverse agricultural systems with many emblematic productions, such as wine and cognac, corn and wheat and even fruits, and a diversified and high-quality livestock. All of these productions are highly exposed to the consequences of climate change because in Nouvelle-Aquitaine, temperature has increased to a larger extent than the national level. In addition, agricultural activities use a lot of water and in a context where this resource is locally limited and where the water deficit in summer is increasing (cf. regional climate projections) risks increase too. Furthermore, because of its importance, the regional agricultural sector contributes to a quarter of direct greenhouse gas (GHG) emissions, in particular methane (CH_4), linked to livestock farming, and nitrous oxide (N_2O), linked to the use of synthetic nitrogen fertilizers. The effort to adapt agriculture to associated to an effort to reduce GHG emissions from this sector. Tensions linked to societal requirements in terms of food and respect for the environment, but also to the majority socio-economic model of agriculture, must be considered as additional factors of vulnerability in this sector, but will not be analysed in this document.

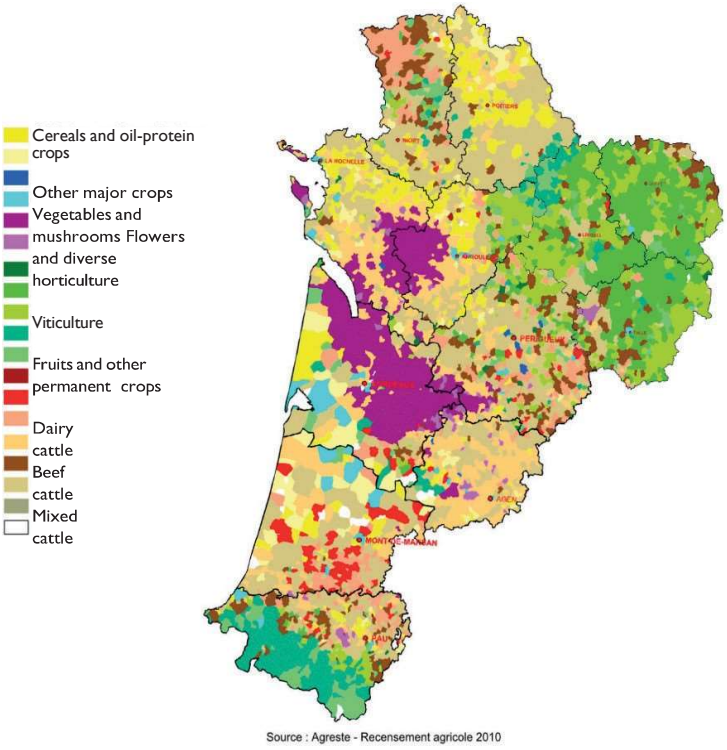


Figure 11: Nouvelle-Aquitaine, Agriculture. technical-economic orientation of a given municipality. Source: Agreste

4.3 Key Community System: Local/Regional Economy

Economic structure

The Nouvelle-Aquitaine is France's third-largest region in terms of economic activity. It is renowned for its dynamism in the aeronautical, digital, wood and new energy sectors (wind, geothermal and marine energies). France's leading R&D region (70 clusters, 11 competitiveness clusters), the Nouvelle-Aquitaine also boasts 14 industrial areas. But the region is also very active in the agri-food industry (winegrowing and winemaking), with agriculture (the sector that

creates the most jobs) ranking second nationally for the number of organic farms. The region also stands out in terms of tourism (€12.2 billion in tourist spending, 8 % of regional GDP, 103,000 jobs). The attractiveness of the region is likewise reflected in its foreign investment: more than 1,300 foreign companies employ over 55,000 people, making it the 6th most attractive region in France for foreign investment projects.

If the focus is made on the three main sectors at stake, it is possible to first talk about *agriculture,* Nouvelle-Aquitaine being the 1st economic place of national and European agricultural regions. With the current and future issues for quality and quantity of water, this sector is significantly affected, as it was responsible for 46 % of the freshwater consumed in Nouvelle-Aquitaine in 2015. In addition, the erosion of soils and the increase of pests result in a phenology modification, less performance and lower quality. The *fishing and shellfish farming* in the region is also affected by climate change with 69 % of its annual production consisting of 6 species. It is known that climate change will result in the displacement of species. For this sector holding 4,600 jobs in Nouvelle-Aquitaine and 484 M€ a year, resilience is a huge stake. In Nouvelle-Aquitaine, 34 % of the surface is made of *forests*, making it the 1st French forestry region. Climate change modifies the phenology of trees as well, resulting in shorter rotation. New species also appear due to the lack of water. Eventually, with major changes in the Pyrenees mountains losing 2 to 3 days of snow by decade (between December and April, since 1980) and in other areas like the coast, tourism could experience a long-term crisis. (AcclimaTerra, 2018)

4.4 Key Community System: Water management

Description current situation KCS

The water management system in Nouvelle-Aquitaine is crucial for maintaining the region's ecological balance, supporting agriculture, and providing potable water to its residents. The region's diverse water system includes extensive river networks, significant lakes and reservoirs, and underground aquifers. Two primary river basins, Adour-Garonne and Loire-Bretagne, dominate the region, further divided into seven major basins such as the Garonne, Dordogne, and Charente rivers. Key water bodies, like Lac d'Hourtin-Carcans and the Gironde estuary, play vital roles in water supply, agriculture, recreation, and conservation.

Water resources in the region are managed on an integrated river basin basis, involving collaboration between local authorities, industries, farmers, and conservation groups. This integrated approach helps balance ecological health with economic and social needs, ensuring the sustainable use of natural resources. Freshwater withdrawals in Nouvelle-Aquitaine amounted to 1.5 billion m^3 in 2015, with 46% used for agriculture, 34 % for drinking water, 12 % for industrial purposes, and 8% for energy production.

Climate risks and impacts on KCS

The region faces significant climate risks that threaten its water management system. A projected rise of 2 to 3 °C over the next 40 years will reduce oxygen levels in water by 5 % and decrease the dilution of pollutants and sediments, severely impacting water quality. This

deterioration in water quality will have considerable consequences for drinking water and water used for personal and professional purposes.

Additionally, climate change is expected to disturb the hydrological cycle, leading to longer and more severe low-flow periods. River flows are anticipated to decrease by 20 to 40 %, which could result in the overexploitation of groundwater resources. The expected rise in temperatures will also increase drinking water consumption by approximately 1.6 % for each 1 °C rise. These changes will place further strain on the region's water resources, necessitating adaptive management strategies to ensure water availability and quality.

The current water management system in Nouvelle-Aquitaine is highly integrated and involves multiple stakeholders working together to balance ecological and economic needs. To address the water-related challenges due to climate change and water use, the region will need to adopt adaptive management strategies that enhance water conservation, improve pollution control, and ensure sustainable groundwater use.

4.5 Key Community System: Critical infrastructure

On March 12th 2023, the French Revenue Court pointed out the lack of resilience of the rail infrastructure. Already weakened by weather hazards, the network isn't adapted enough to future changes. Thus, SNCF Réseau, in charge of this network, is currently working on its resilience. The electricity network will have to adapt itself to a consumption rise during summer, due to the use of air conditioners during heatwaves. If it happens during droughts, then in addition some electricity will not be produced because hydraulic and nuclear centrals might have to stop their production. Moreover, high-voltage structures will be at risk in case of forest fire. In addition, the Cerema estimates that 25,000 bridges need work to reinforce them in the face of climate change's future effects. The fluvial roads are also used in the Region for transport. With the advent of more droughts in the future, these infrastructures will also have to think about their resilience.

4.6 Key Community System: Ecosystem

Description current situation KCS

As mentioned before, Nouvelle-Aquitaine is characterized by a rich diversity of ecosystems, ranging from coastal zones and wetlands to forests and mountainous areas. This diversity supports a wide array of habitats, including forests, marshes, dunes, and riverine environments, fostering a high level of biodiversity. The region is home to numerous endemic species and critical natural areas protected under the Natura 2000 network, which emphasizes the conservation of rare and threatened habitats. Human activities, including agriculture and urban development, have significantly shaped these ecosystems, leading to habitat fragmentation and changes in land use.

Climate risks and impacts on KCS

Change in temperature and changing precipitation patterns will impact the regional ecosystems. Climate change presents substantial risks to the ecosystems of Nouvelle-Aquitaine. Additionally, coastal areas may face increased erosion and saltwater intrusion due to rising sea levels, threatening biodiversity, and habitat stability. As these ecosystems are interconnected, the decline of one habitat type can have cascading effects on others, potentially reducing overall biodiversity and ecosystem resilience.

Key insights

The ecosystems of Nouvelle-Aquitaine are diverse and ecologically significant. However, these ecosystems are currently under increasing pressure from climate change and human activities. This potentially leads to losses of the ecosystem and its provided services. Effective conservation strategies, transformation to sustainable land management practices, and increased efforts to protect endangered species, are important to maintain the ecosystem services. Nature-based solutions can play a significant role in this transformation.

5 Understanding the region: the Natural system

5.1 Soil

Nouvelle-Aquitaine has a diverse soil system ranging from coastal areas to mountainous regions and fertile plains. Coastal areas feature sandy and loamy soils suitable for vineyards, vegetables, and flowers. These well-draining sandy soils require irrigation due to low water retention.

Inland, expansive fertile plains like the Limousin Plain are renowned for their rich clay and loam soils. In higher elevations, such as the Pyrenees and the Massif Central, thin stony soils prevail. Less fertile, they primarily support extensive livestock farming and forestry. The presence of limestone in these areas results in karst landscapes with unique soil features and hydrological systems, including underground rivers and caves.

The region also features alluvial soils along major rivers like the Garonne and Dordogne. Formed by sedimentation, these soils are highly fertile. In marshlands like the Landes de Gascogne, acidic and peat soils prevail. These areas, characterized by high water levels and unique vegetation.

On a national scale, soil depth primarily varies based on the underlying rock formations. Very deep soils (over 100 cm) are predominantly found in silty formations. Deep soils (50-100 cm) occur mainly in large ancient crystalline massifs (such as the Massif Armoricain, Massif Central, and Vosges), as well as in the Aquitaine Basin and Champagne region.

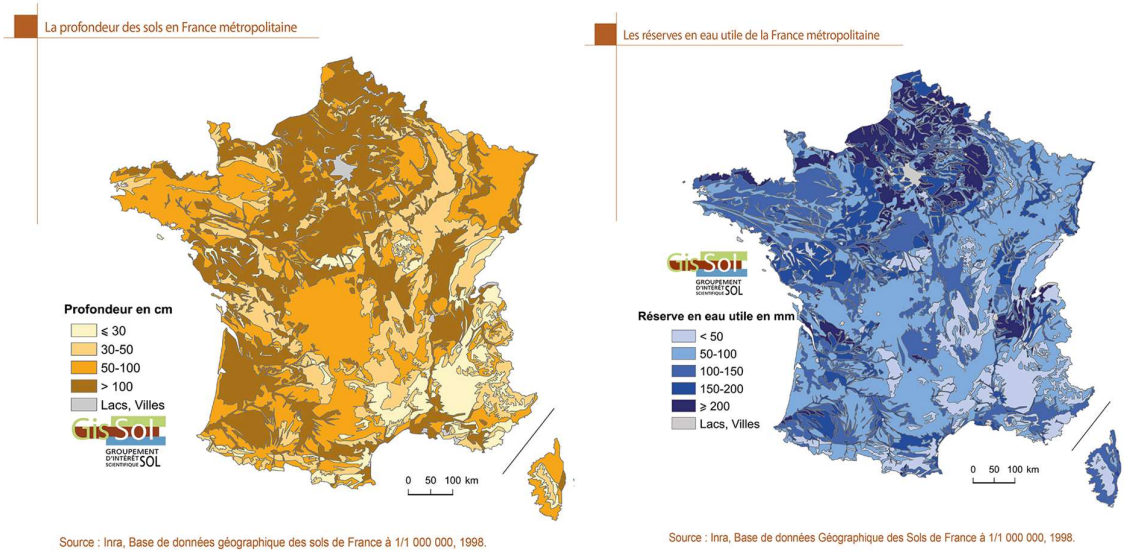


Figure 12: maps showing Soil's depth and water storage. Source: Gis Sol » Cartes

These soils have developed on crystalline rocks (including gneiss, granite, micaschists, and schists), as well as sandy or silty sedimentary rocks and chalk. These deep to very deep soils, which are favourable for agriculture, coincide with the most cultivated areas and constitute approximately two-thirds of the soil cover. Very shallow soils cover only 10 % of the surface area, while moderately deep soils account for 20%. The latter are primarily found in the southeastern quarter of France and correspond mainly to soils developed on limestone rock or at high altitudes.

The second map illustrates the significant relationship between soil depth, texture, and available water reserves.

5.2 Water

Nouvelle-Aquitaine has a diverse water system comprising rivers, lakes, coastal areas, and aquifers. This varied water system plays a crucial role in the ecology, economy, and quality of life in the region.

Hydrographic basins are delimited by surface water divides. The Nouvelle-Aquitaine region shares two river basins: Adour-Garonne and Loire-Bretagne. These two river basins are divided into 7 major basins:

- The Garonne, whose source is in the Val d'Aran in Spain
- The Dordogne, which flows from the Massif Central before entering Aquitaine and merging with the Garonne to form the Gironde estuary
- The Adour and Gaves rivers

- The Vienne and the basins of its tributaries the Clain and the Thouet
- The Sèvre-Niortaise
- The Charente
- The many coastal rivers, many coastal rivers, Médoc lakes and Landes tidal lagoons.

In addition to the rivers, there are significant lakes and reservoirs in the region, such as Lac d'Hourtin-Carcans, the largest natural freshwater lake in France, and Lac de Vassivière, a large artificial lake popular for recreation and water sports. These lakes serve various purposes, including drinking water supply, agricultural irrigation, recreation, and conservation. The region also boasts an extensive coastline along the Atlantic Ocean, featuring beaches, dunes, and estuaries. Among these, the Gironde estuary stands out as one of Europe's largest estuaries, where the Garonne and Dordogne rivers converge and flow into the Atlantic Ocean. The coastline is vital for tourism, fishing, and shipping, while the estuaries and coastal marshes are rich in biodiversity and serve as breeding grounds for many species.

Underground, the region has several aquifers crucial for drinking water supply and agriculture. Particularly, the karst systems within the limestone formations of the Dordogne and Lot-et-Garonne regions serve as important water reservoirs.

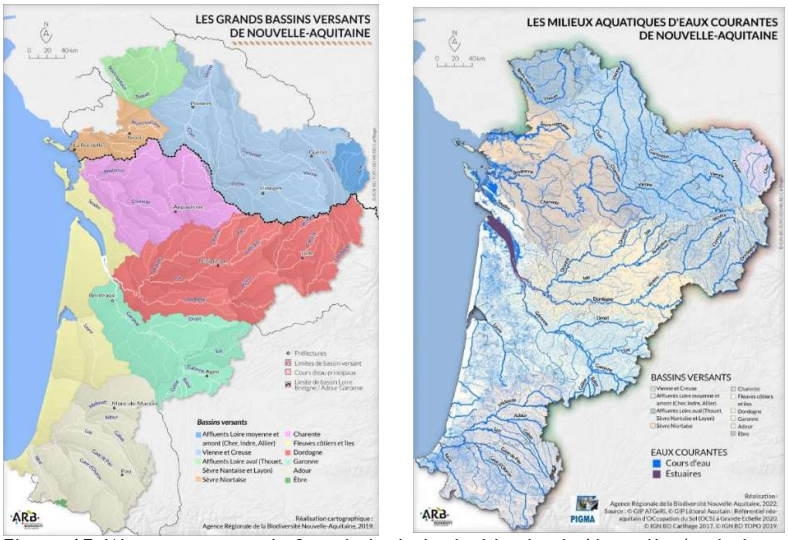


Figure 13: Water resources. Left main hydrological basins in Nouvelle-Aquitaine region. Right: Aquatic environments of running waters .Agence Régionale de la Biodiversité Nouvelle-Aquitaine (biodiversite-nouvelle-aquitaine.fr), image hydrology : Les milieux d'eaux courantes de Nouvelle-Aquitaine en 2020 (biodiversite-nouvelle-aquitaine.fr)

Source: Réseau hydrographique de la région | DREAL Nouvelle-Aquitaine (developpement-durable.gouv.fr) ; Synthese-AcclimaTerra-EN-1.pdf chapter 6

In France, water resources are managed on an integrated river basin basis. Hydrographic basins are delimited by surface water divides. The missions of the water agencies are to help local authorities, industrialists, farmers, fishing and nature protection associations to finance, support and promote their projects and initiatives to improve health, the quality of life, the preservation of water resources and biodiversity.

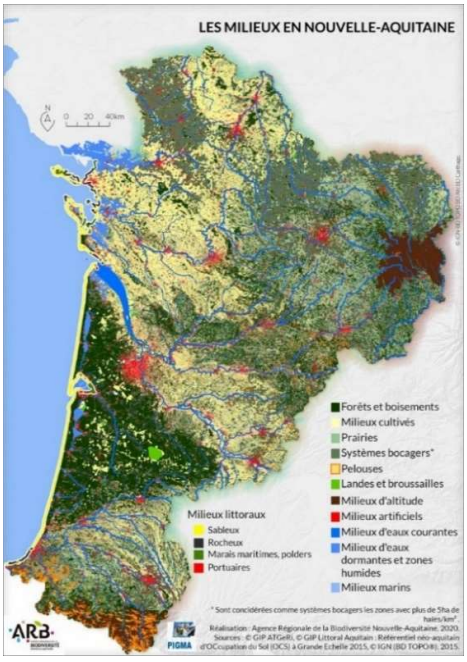
With more than 20,000 km², the hydrographical network of the Nouvelle-Aquitaine region is dense and diversified. Flows vary but are marked by severe low-water periods over much of the region. This diversity is reflected in the size and, above all, how the rivers function.

Freshwater withdrawals in Nouvelle-Aquitaine amounted to 1.5 billion m^3 in 2015. The share of volume for drinking water is 34 %. Agricultural uses represent 46 % of the withdrawn volumes. Irrigation withdrawals represent 65 % of groundwater (compared to around 35 % for France). The industrial sector takes 12 % of the total volume (nowadays decreasing). Energy production takes 8 % of the volume withdrawn.

The results of hydro-climatic expertise converge on the diagnosis of tension concerning surface and groundwater availability in the Nouvelle-Aquitaine region under the impact of temperature rise (air and water), an increasing frequency of extreme events (including low water levels that are more severe in intensity and duration), an uncertain variation in annual rainfall, and an overall increase in evapotranspiration. Facing variation in flow rates (-20 to -50 % during low water periods), significant consequences are to be anticipated, such as the evolution of aquatic biodiversity and plant growth, along with recreational users satisfaction. Beyond these regional trends, worrying localised trends emerge: the Pyrenean rivers are experiencing an aggravation of low water levels and undergoing strong modifications of flows' global cyclicity linked to the variability of seasonal rainfall / snowfall ratios; the Dordogne regime is effectively supported by the management of its large upstream dams by EDF (French Electricity company), but in its upstream portion (Limousin), many small rivers contributing to low flows are suffering dreadful assaults; as for the Charente river, the complex measurement of flows evolution must take into account management requests and the hydrogeological functioning of underground complexes.

5.3 Nature

The diversity of the region's relief and rock formations explains the richness of its geological heritage. Geology, pedology, hydrology and climate determine the natural environments and



habitats in a given area. In addition to these natural factors, mankind plays a major role in shaping and organising them, influencing habitat and species distribution (Source: SRB-NA-Strategie-action-Complet-bd-96dpi.pdf; biodiversite-nouvelle-aquitaine.fr).

Figure 14: Nouvelle-Aquitaine landscapes. Source: Les milieux de Nouvelle-Aquitaine en 2015 (biodiversite-nouvelle-aquitaine.fr)

In Nouvelle-Aquitaine, habitats that shape the landscapes are extremely varied: forests, open-land agricultural and non-agricultural landscapes, sometimes associated with a network of hedgerows, numerous aquatic and wetland habitats, coastal and marine environments, high altitude habitats and Pyreneans species, urbanised environments, etc.

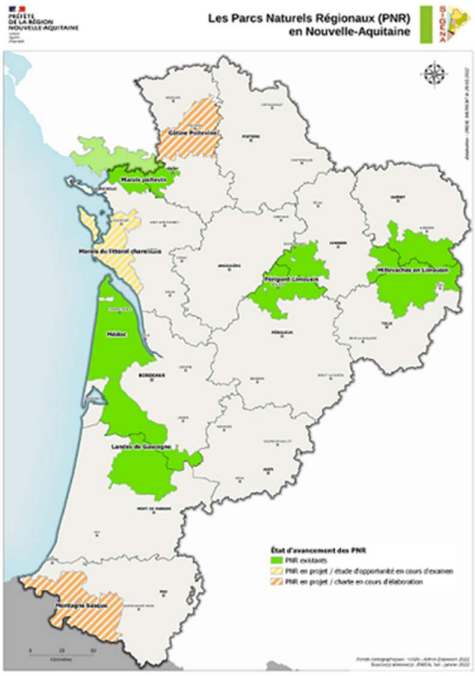


Figure 15: Regional Natural Parcs in Nouvelle-Aquitaine. Source: Parcs Naturels Régionaux (PNR) | DREAL Nouvelle-Aquitaine (developpement-durable.gouv.fr)

Many habitats overlap, for example forests and wetlands, and are interconnected, contributing to ecological continuity at various spatial scales overtime, habitats overlap has resulted in habitat mosaics. Nowadays many habitats are species-rich and sustain a valuable biodiversity. Habitat mosaics are constantly changing as a result of human activity (changes in habitat management or eco-pastoral practices, urbanisation, etc.) and environmental factors (topographical changes, coastal erosion, climate change, etc.). Over time, these changes generate spatial modifications, such as the surface of wetlands or natural grasslands which have declined significantly. Few areas have not been affected by humans; therefore, the degree of naturalness varies and is often very limited. Natural habitats can be found in the summits of the Pyrenees, ancient forests, underground cavities such as chasms and steep valleys carved out of granite. Peat bogs, some marshes, salt marshes, coastal lagoons, estuaries and sand dunes are natural areas sustaining a number of protected species.

A large number of important natural habitats for nature conservation can be found in Nouvelle-Aquitaine: grey dunes, peat bogs and low marshes, alluvial meadows, sea caves, alpine rivers,

etc. Among the most remarkable are the natural habitats of European importance (Designated by the Habitats and Bird Directives) (which are among the rarest or most threatened in Europe. The Region has a strong responsibility in terms of conservation due to their European rarity and/or their ecological interest. This is the reason why since 2023 it has taken a step forward by leading Natura 2000 within its territory. Each type of natural habitat consists of a specific flora and fauna linked to the physical and biological conditions that characterise the environment and give it a functional ecological value. The conservation status of these natural habitats is assessed according to various criteria (range, surface area, ecological structure and functioning, evolution, etc.) and carried out at the level of biogeographical regions (Atlantic, Atlantic marine, continental and alpine in Nouvelle-Aquitaine). The results are generally poor.

The great diversity of the region's natural landscape and habitats generates a rich variety of animal, plant and fungal species: 3,248 species of flora have been recorded among which, 79 % are indigenous to Nouvelle-Aquitaine. The fauna is very diverse with 11,449 animal species recorded, including at least 177 introduced species (that can cause a threat to indigenous fauna). The species diversity in the region is very high compared to mainland France. The region's rivers are also home to 7 species of migratory fish with high conservation concerns, including the European sturgeon, European eel, shad and lamprey.

The Nouvelle-Aquitaine is home to a number of localised endemic species, such as the Gaston's Gremil and the Pyrenean Desman, the Thyme-leaved Toadflax and the ocellated lizard along the south Atlantic coast, the European mink and the European pond turtle which are almost extinct in South France and to a lesser extent the Thébault's Beetle in Limousin.

Certain species of wild fauna and flora are targeted by conservation programmes called National Action Plans (PNA) for the Nouvelle-Aquitaine region 35 species are in PNAs. These PNAs are tools designed to ensure the conservation of threatened or endemic species of fauna and flora present in the region. Nouvelle-Aquitaine is also France's richest region for domestic breeds, with 60 breeds from 14 animals. 27 traditional breeds are threatened to disappear. There is also a huge diversity of local plants with 2,000 varieties among which 17 varieties of fruits, are not sufficiently exploited in the agri-food industry. This richness is called “cultivated biodiversity”.

80 % of wild plants in Europe depend on pollinators (bees, bumblebees, butterflies, hoverflies, etc.). Nearly 9,800 species are involved in pollination in France. Organic matter is recycled by decomposers, who follow one another in a complementary way. Saprophytic fungi, for example, account for up to 80 % of living organisms in forest soils, decomposing 90 % of the organic matter. Within ecosystems, predators play a role in regulating prey and limiting the spread of disease.

The Nouvelle-Aquitaine region has shown a strong commitment to biodiversity by adopting the Regional Biodiversity Strategy (SRB) in 2022. Established for 10 years, the SRB is the collective roadmap co-piloted by the Region and the State, in close partnership with the water agencies. Its aim is to build shared strategic objectives and a common framework for action to restore biodiversity.

5.4 Key insights Natural System

There is a lot of information available on the natural system of Nouvelle-Aquitaine, which explains the regional geological story of millions of years. Tectonic forces, sedimentation, and erosion have left their marks. Mountain ranges—such as the Pyrenees in the south and lesser-known ones—contribute to the region's varied topography. These geological processes have influenced soil formation, resulting in a patchwork of soil types across the area. Together with the water system, Nouvelle-Aquitaine became a very biodiverse place with a broad diversity of nature and habitats.

Human activities have significantly changed the present-day landscape. Currently, resource extraction and pollution resulting from current human activities put pressure on the natural system. The current land use is unsustainable, now and in the future. Additionally, climate change also has significant threats by rising temperatures, altered precipitation patterns, and extreme weather events disrupt the balance within ecosystems.

To address this, a transformation in the utilization of natural resources is necessary. However, given the significant diversity of Nouvelle-Aquitaine's natural system, it's crucial to recognize that this diversity also influences which solutions are suitable for specific contexts. Trade-offs exist, and integrated approaches aligned with the natural system's conditions at each location are essential to mitigate the impacts of climate change and achieve sustainable regional transformation.

6 Understanding the Region: The Social System

6.1 Policies and Strategies

Conditions for an integrated regional approach on climate adaptation:

- Multilevel alignment of policies and responsibilities between National – Regional – Department – Municipal
- Connection and integration of various policy fields – climate, rural development, agriculture, bio-economy, soil, water, regional development, spatial planning

Responsibilities

Within France and Nouvelle Aquitaine, the competencies between the different governmental levels are divided as follows:

- The local levels (cities and urban areas) act on current affairs in their sectors. They mostly intervene in the urban policy, the housing policy, the environment, the waste, the city transport and the management of elementary schools.
- The Departments mostly act on social aspects (childhood, disabled people, elders, precariousness), infrastructures (local roads) and the management of secondary schools.
- The Regions mostly act on economic development, territory planning, transport outside of cities, professional training and the management of high schools.

- The three local governments share responsibilities for sport, tourism, culture, ecological transition and popular education.
- The State mainly acts on national security, the health system, the social policy, the education policy, universities management, children protection, the national infrastructures, assistance to economic structures in difficulties, territory planning, the national housing policy and nature protection

Policy Frameworks

National level

France's roadmap to fight climate change: Low-Carbon National Strategy, PPE for Long-term Program on Energy and PNACC for National Plan for Adaptation to Climate Change. These are all national policies on climate change, which set a framework for regional and local policies.

Regional level

The Region creates and manages the SRADDET, the Regional Scheme on Planning, Sustainable Development and Territorial Equality. It fixes the global strategy for planning policies in the territory and sets objectives on a range of subjects (air pollution, carbon emissions, transport, housing...). It also has a roadmap, Néo Terra, which applies to all its policies, to ensure that climate change is considered.

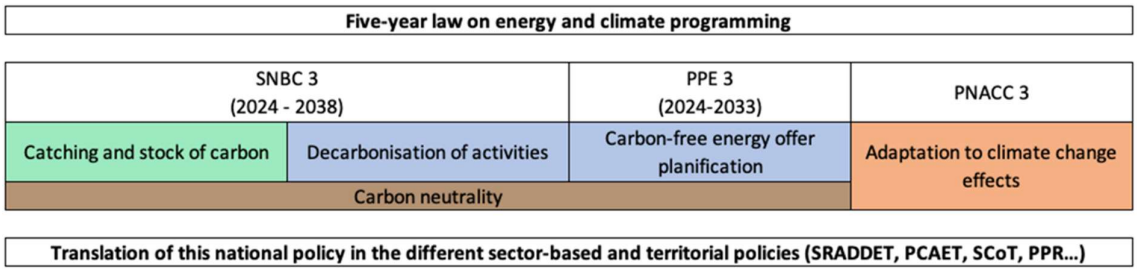


Figure 16: France's roadmap to fight climate change, adapted from *Étude sur... L'adaptation au changement climatique en Nouvelle-Aquitaine*, DREAL Nouvelle-Aquitaine, 2022.

Local level

Concerning environmental policies, the local governments are given a global framework by the State to act in their territories. At the local level, the PCAET (territorial Air Energy Climate Plan) and the PLUi (Local Urbanism Plan) must be coherent with the SRADDET (Regional scheme of planning sustainable development and territorial equality), established by the Regions. The SRADDET must also respect the national Environmental code, the Grenelle I and II and the PNACC (National plan for adaptation to climate change). On a more local level, three main strategies can be quoted:

The Plan for Territorial Coherence (SCoT) coordinates all the territory planning policies to preserve air quality and natural resources as well as to act against climate change and for climate adaptation, to reduce greenhouse gases, to preserve fossil resources, control the energy and its production from renewable resources.

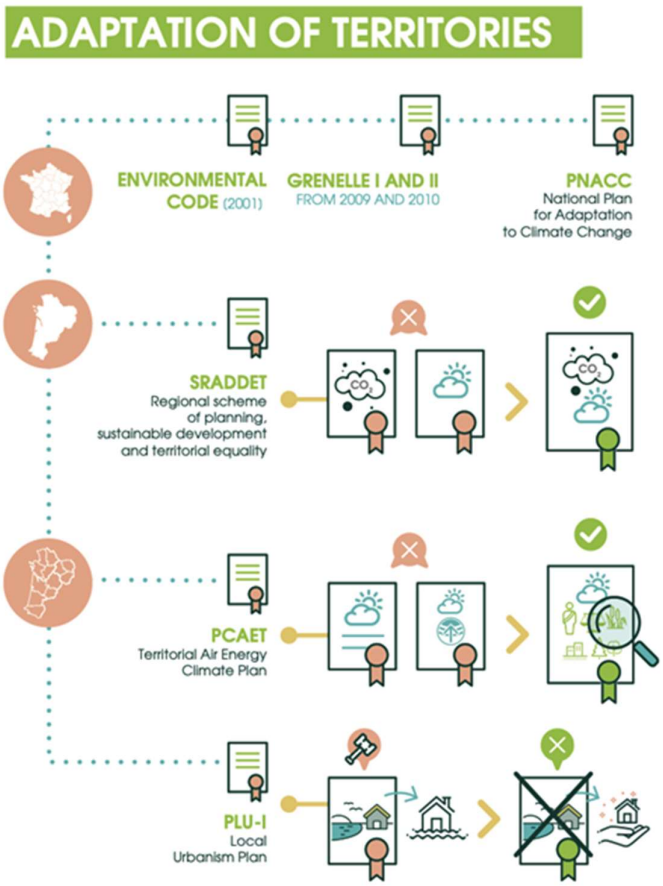


Figure 17: The Adaptation Multi level policy Framework. AcclimaTerra 2018

The Local Urbanism Plan (PLUi) implements a regulation on the use of lands for a length of 10 to 15 years. It contains a "Projet d'Aménagement et de Développement Durable" (PADD, meaning a planning and sustainable development project). The PADD structures the rules about the use of lands and the natural space preservation against urban spreading. The French urbanism code also gives the urban areas a zero net artificialisation objective, that could be reached by 2030 with the right urbanism policy.

The Territorial Plan for Climate, Energy and Air Quality (PCAET) is mandatory in all the administrative city areas with more than 20,000 inhabitants. It contains a territorial diagnosis, a strategy and a plan of action. It does not only aim to mitigate climate change and air pollution but also to adapt the territory to its effects. The PCAET defines a plan for six years to reduce greenhouse gas (GHG) emissions, improve air quality and optimize energy consumption. It must also include a plan for the adaptation to climate change.

The local strategies mainly focus on mitigation rather than adaptation (DREAL, 2022). The PNACC advocates NbS whenever it is possible in the actions. France also benefits from the European program LIFE Artisan, locally led by the OFB (French Office for Biodiversity), on NbS and territory resilience and adaptation.

In Nouvelle-Aquitaine, a main line of the Regional Strategy on Biodiversity (SRB) includes the appeal to NbS.

Other policies
There are many other relevant policies for dealing with climate adaptation:

- The Local Plan for Housing (PLH). It is made at the urban areas level, in cooperation with the State services, the cities, the SCoT leader and the social landlord. Amongst other objectives, the PLH fights against urban spreading and so against the artificialization of lands. It also contains actions for making thrifty buildings, through renovation, or new buildings. Eventually, it can act on the quality of life by influencing the way buildings are made and so their resilience to climate impacts.
- The Departmental Plan for Housing (PDH). It harmonizes the different PLH of the Department territory and creates a monitoring team on housing. It covers a larger territory, including communities where the is no PLH or SCoT.
- The Protection and Valorization Plan (PSMV). It can replace the PLUi on the territory it covers, that is to say, all or part of the protective remarkable heritage spot. By protecting the area, it acts in favor of a better environment.
- The Regional Strategy for Biodiversity (SRB) is built at the regional level. It contains 5 orientations, 20 objectives and 49 actions in favour of biodiversity in the region. It respects the national strategy for biodiversity and the regional environmental roadmap Néo Terra. Some of the actions directly refer to NbS.
- The green and blue infrastructure policy (TVB) ensures ecological continuities to preserve biodiversity and is integrated into the territory planning so that urban development actions take it into account.
- The Regional Forest and Wood Program (PRFB) is adapted from the National Forest and Wood Program (SNFB) and acts for a maximum of 10 years on a number of elements concerning the forests. For instance, it draws up economic, environmental and social priorities per forest massif, criteria the forest sustainable management as well as objectives. It acts for the forest's resilience and is built by the regional commission on forest and wood.

Water

Two agencies are managing the two watersheds which are for a part of the Nouvelle-Aquitaine territory (Adour-Garonne and Loire-Bretagne basins). Both have a strategy for adaptation. In addition, there are many policies on water:

- The Water environment management and flood prevention (GEMAPI) is established at a city or urban area level. It was created for the cities to have better control and to manage better the waterways as well as to preserve biodiversity.
- The development and water management plan (SAGE) is a local plan, adapted from a national one (SDAGE) which manages the uses of water (agriculture, drinking water, production) and the aquatic environment. It doesn't cover a city or area perimeter but it is defined at the catchment basin or water table level. It fixes objectives for water quality and quantity and includes a development and sustainable management plan (PAGD) as well as rules for the territory.

- The Territory project for water management (PTGE) is also established at the catchment basin's level. It aims to reunite all the territory players to fix a global project to preserve and protect the water. It aims to find a balance between water needs and resources and promotes an abstemiousness in the use of water.
- The Plan for drinking water supply (SDEP) determines the places that will be served by the supply network at the city or urban area level.
- The Master plan for rainwater management (SGEP or SDGEP) highlights the main stakes for the local governments and shows whether some building work is needed to manage the rainwater.
- The Action program on flood prevention (PAPI) is made to prevent flood risks and is held by the urban area government. It allows a global view of the flood risks in a specific territory.
- The Management of flood risks plan (PGRI) is made at the scale of the watershed and fixes the main objectives of flood risk management and specific objectives for the territories that are particularly at risk.
- The Regional Water Strategy. This water policy will be implemented in close collaboration with the Adour-Garonne and Loire-Bretagne water agencies. In addition to the Region's involvement in the implementation of actions to preserve water resources (quality and quantity) in the catchment areas, the Region will work with partners to improve knowledge, disseminate it and ensure that actions are consistent throughout Nouvelle-Aquitaine. Source: Stratégie régionale de l'eau (nouvelle-aquitaine.fr)

Figure 18: Overview of relevant policies to climate adaptation, adapted from Étude sur... L'adaptation au changement climatique en Nouvelle-Aquitaine, DREAL Nouvelle-Aquitaine, 2022.

Circular bio-economy

France has had a roadmap on the circular economy since 2015 with several objectives to complete some of the Sustainable Development Goals. These objectives concern resource consumption, waste reduction, recycling, reducing greenhouse gas emissions and creating employment. The no-waste law for a circular economy (2020) continues the work and aims to leave the disposable system, to better inform consumers, to fight against waste, to fight planned obsolescence and to produce better.

In Nouvelle-Aquitaine, the Regional plan for prevention and waste management fixes priorities reducing the 22 billion tons of waste produced on the territory each year.

The urban areas, when they have more than 20,000 inhabitants, must have a PCAET. These plans have a mandatory part concerning waste management. The actions can be about reducing, reusing and recycling the community's waste. The urban areas are also the ones in charge of collecting waste. Through this policy, they can impact the type of items that can be recycled or the amount of time they collect the waste to encourage people to throw less away, or even decide to stop collecting at the citizen's door but put collecting points in town. They can also build a circular economy strategy and work as a support for the Region's plan by working with local players.

Regional Risk management

There are various plans regarding risks:

- The Natural flood prevention plan (PPRI) acts on natural flood risks by working on soil use and occupation through planning. With this plan, zones at risk are identified and some prohibitions (to build for example) can be taken if the danger for inhabitants is acknowledged. The PPRI are taken by the local prefect, in coordination with local governments.
- The Foreseeable natural risks plan (PPRN) regulates soil utilization according to the natural risks (flood, earthquake…) on a specific territory.
- The Technological risks prevention plan (PPRT) is elaborated by the local State representant. It defines a perimeter of risk around some industrial plants presenting potential dangers for the population. In this perimeter, the plan acts on urban policy and can impose restrictions as far as expropriation.
- The Natural sensitive spaces (ENS) are created by the Department to preserve some natural spaces because of their ecosystem or to be there in case of floods, for instance. It regulates the public access to this environment and prevents it from urbanization. The Safeguard of the communes and/or inter-communities plan (PICS). In case of a risk or a crisis, this plan organizes solidarity and local response.

Food

The territorial food projects (PAT) are held by the local governments to unite the local players around agricultural, food and environmental transition. It aims to create local and resilient food systems.

6.2 Governance and Networks

Relevant underly concept on organizational aspects of transformative change is the Quadruple helix, which is referring to engage and align and to create an interplay between the four domains:

- Public sector
- Private sector
- Knowledge partners
- Civil society

Collaboration among partners often starts with representation of the different domains and stakes. For visioning, design and implement Nature Based Solutions, people and organizations will become partners in mission-driven innovation. The partners bring together their various resources, such as financials, knowledge, capacities and creativity, in order to be able to deal with the challenges and to collaborate on the mission-driven innovation or transformative journey. Also relevant is to connect strategic and operational levels. To be able to put the mission and solutions into practice.

In the baseline we describe the current partner network, the representation of the four domains, and the interplay among the various partners.

1.1.4 Public sector

Important for the French regions are the *National Public Frameworks*, as Paris directives and directions are leading the regions. The National government decides about the global strategies, with regard to the National Law. National government is also influential to many of the regional actors, and to their strategies.

Within the region, the public sector is organizing territorial planning, which includes the environment, climate, energy and air quality. The public sector is actively preserving the fragile ecosystem, which has the standard of Parc Regionaux.

Local governments oversee the territory planning:

- The Region: SRADDET has 80 objectives, including n°62 on the definition and enforcement of local adaptation strategies, through risk anticipation. In addition, it adopted in 2019 its regional scheme on energy and environmental transition NéoTerra. NéoTerra is built on the conclusions of the two reports on regional biodiversity and climate Ecobiose and AcclimaTerra. It aims to accompany public and private actors on their transition by 2030

- The Department (an administrative area): has a major role in social and sanitary policies, but also in the territory planning with its house policy.
  It lead local public structures called "services départementaux d'incendie et de secours" (SDIS), which can be translated as local services for first aid and fires. They fight against the vulnerabilities by acting as first aid and mobilizing firefighters when a fire occurs.

- The urban areas and towns are the main local actors for the adaptation to climate change. 31 cities in Nouvelle-Aquitaine are listed as particularly vulnerable to coastal erosion. They manage the urban policy as well as the housing and management of flooding risks. To do so, they must implement mandatory strategies (PLUi and SCoT for the territory planning, PCAET for energy and climate transition and air quality, and PPR, to prevent risk).

- 5 Natural Regional Parcs (PNR) cover 15 % of the Nouvelle-Aquitaine territory. They are financed and managed by the Region and the State. Their main missions are to operate the social and economic development, protect natural, historical and cultural heritage, participate the territory planning, welcome and inform the public about the environmental and cultural stakes experiment with new forms of public and collective actions.
    - PNR Landes de Gascogne (forest landscape)
    - PNR Marais-Poitevin (coastal landscape / wetland)
    - PNR Périgord-Limousin (rural landscape)
    - PNR Millevaches en Limousin (rural and forest landscapes)
    - PNR Médoc (coastal and forest landscapes, wetlands)

- State services in the regions oversee several policies: water, biodiversity, territory planning, housing, natural & technological risks, management of crises and curbing vulnerabilities.
- Other public structures: the Public Agency on Ecological Transition (ADEME, which has a regional unit), the Regional Agency on Environmental and Climate Evaluation (AREC), the public expertise structure on ecological transition and territories (Cerema, which has a unit in the south-west of France), the public structure on real-estate, the water agencies (two in Nouvelle-Aquitaine), the national organisation on forest, the regional organisation on biodiversity and the regional observatories. They all work on adaptation to climate change and their missions often include subjects such as nature-based solutions, water supply and quality, flooding prevention…
- On forest, the ONF has an adaptation strategy. However, a major part of the park is private in Nouvelle-Aquitaine, so it is not managed by the ONF (which possesses less than 11 % of the regional forests).
- On biodiversity, the ARB NA (regional agency) works on adaptation plans and supports local actors.
- On water, two water agencies have an administrative territory in Nouvelle-Aquitaine: Agence de l'eau Adour Garonne and agence de l'eau Loire et Bretagne. They are dimensioned regarding the watersheds, so their administrative areas are different from the Region. They both have an adaptation strategy for their watershed, especially to deal with low water periods.
- On coast erosion, the coastal conservatory leads a LIFE project called Adapto, which explores adaptative coastal management. https://www.lifeadapto.eu/adapto--a-life-project.html. The GIP Littoral also gathers a group of players to work on coastal erosion.
- On wetlands conservation, the Forum des Marais Atlantiques is a structure driving a network of wetlands administrators in the Atlantic region of the country. It works to

increase general knowledge on wetlands, to support the administrators in their projects and to drive a community with all the stakeholders.

- On global environmental policies, ADEME does consciousness-raising work and supports the communities through training and providing tools. What's more, Cerema drives the Carnot Clim-Adapt Institute which works on several public-private projects of adaptation to climate change and publishes several guides on the subject. AREC, the regional agency on energy and climate, drives studies, supports the local governments in their strategy and provides them with indicators. The regional observatory on energy and greenhouse gases is driven by AREC. Eventually, the French Parliament conducted special missions on several subjects to understand them better. It can be about any social subject but some of them concern the environmental policies. At the beginning of 2023, a French deputy, from Nouvelle-Aquitaine, returned her conclusion on the adaptation of forest policy to climate change.

Regional observatories

Regional observatory on health and environment (ORSE) works to share and value knowledge on environmental health and provides tools, data and help in the development of policies to reduce the environmental impact on health.

Regional observatory on risks (ORRNA): watches the natural, technological and sanitary risks in the Region and shares the knowledge.

Regional observatory on energy and greenhouse gases (OREGES): acts to share data and information on the consumption and production of energy and on greenhouse gas emissions.

Regional observatory on the coast: gathers experts to work on sustainable management of the coast.

The Pyrenees Observatory (OPCC) is a cross-border territorial cooperation initiative of the Pyrenees Working Community (CTP), launched in 2010 on climate change. The members of the CTP, and therefore of the OPCC, are the Principality of Andorra and the French Regions of Nouvelle-Aquitaine and Occitanie, as well as the Spanish autonomous communities of Aragon, Catalonia, Euskadi and Navarre. The platform on good practices for the water in southwest France works at the watershed ladder and provides resources to implement adaptation to climate change solutions, particularly NbS policies.

1.1.5 Knowledge

The Region works out a scheme for higher education, research and innovation whilst the State is responsible for the building and the functioning of universities. In Nouvelle-Aquitaine, this scheme (SRESRI) has five ambitions: to improve the scientific potential of the Region, to fight territorial inequalities, to structure networks of researchers, to develop regional innovation and to help citizens understand better sciences.

There are 13 research networks in Nouvelle-Aquitaine since 2020. At least five of them are centered on environmental issues. Biosena works on biodiversity and ecosystem services, Futurs-ACT works on anticipation of climate change in the territories, Naïades works on water, Tesna on energy transition and RIVAGES on coastal vulnerabilities due to climate change.

The knowledge domain is actively involved by a scientific committee, actively exchanging knowledge about climate change within the region. Different expertise are participating, for

example on climate, water and energy transition (R3). AcclimaTerra is to be seen as an intermediate between the knowledge domain of universities and knowledge institutes and the regional agenda and public partners on climate change.

AcclimaTerra is a group of scientists, which produced two reports on climate change in the region and produced several guides on particular topics (water and agriculture, renewable energies…). Its work provides a concrete vision of the impacts of climate change Nouvelle-Aquitaine is going to experiment in the future. It also raises people and local administrations' awareness of climate change. With Ecobiose, a group of scientists who worked on biodiversity in the region and published a report in 2020, the work of AcclimaTerra is used by the Nouvelle-Aquitaine Region for its Néo Terra plan.

The Nouvelle-Aquitaine Region also finances several research groups on specific topics. Some of them work on topics linked to ecological transition and provide knowledge to implement adaptation to climate change. For example, Futurs-ACT works on the anticipation of the impacts of climate change in the region and RIVAGES works on the risk and vulnerabilities of the coast and its adaptation to climate change.

Some of the natural spaces have a scientific council. For example, the Gironde estuary has a council since it became mandatory for three estuaries in France in 2008. It can be consulted by the regional Prefect on some projects and can decide to give its opinion and recommendation when it thinks it is discerning.

1.1.6 Private sector

In the regions, the Chambers of Commerce develop support and tools for the companies wanting to commit themselves to the ecological transition.

Through the "France Relance" system, the French government creates a financial incentive for companies to adopt sustainable actions. The State also develops several specific programs depending on the sector. For instance, there are programs to help the transport sector to adopt more sustainable behavior, like the EVE program. The French Organization for Biodiversity (OFB) also created a label for the companies having a positive impact on nature.

The companies themselves can act on their energy consumption, transport, buildings, etc. They often establish a plan with their CSR strategy (Corporate Social Responsibility), which includes actions for the environment impacted by the activities but also actions concerning social concerns.

Several unions of the impacted economic sectors work on the adaptation to climate change. For instance, the regional center of forest property provides training to its members on the subject. The agricultural chamber also finances studies to provide knowledge and tools to the field in Nouvelle-Aquitaine.

The private sector's engagement in public strategies elaboration and public planning processes consists of a mix of organizations actively involved in climate change, quality of life and

biodiversity. Some of them are expert on adaptation to climate change and provide their expertise on several projects. This is the case of Solagro for instance. The associations and the enterprises support the public collective strategies often with for example design studies, for example for the PCAET (and PLUi).

Given the complexity of the interactions and the holistic approach to environmental health, research must take place within an interdisciplinary framework, i.e., interaction and cooperation between several disciplines around environmental health, ensuring that each discipline goes beyond its respective perimeter and that the results of work carried out together are not simply a juxtaposition of disciplines. This interdisciplinary approach fosters innovation and creativity, emerging from the interstices between disciplines.

1.1.7 Civil Society

A number of associations (non-exhaustive examples), representing a specific interest are present in the regio:

- AdACC (les Ateliers de l'Adaptation au Changement Climatique): this association called Workshops on adaptation to climate change raises awareness with its serious game to work on the projects that can be made and avoid the "wrong adaptation" projects.
- The Permanent Centre for Environment Initiative (CPIE) exists in several territories of France and Nouvelle-Aquitaine and mainly works on consciousness-raising. However, some of its local branches develop actions of adaptation, like the CPIE of the Basque country, which worked with the urban area on coastal erosion.
- The social action centers PEP can also develop some projects such as the one in Pyrénées Atlantique, which develop a new building adapted to climate change for disabled workers.
- The International Office for Water (OiEau) also supports the regional actors in implementing adaptation to climate change projects. Thus, it manages the other European projects on adaptation to climate change NATALIE.
- Clim'Adapt is an association that promotes adaptation to climate change solutions.
- The Natural Spaces Conservatories (CEN) and the Sepanso also work for the adaptation to climate change.
- France Nature Environment (FNE) can be mentioned as well as an active organisation. Founded in 2016, FNE defends environmental interests from consultation procedures to legal action and proposes concrete solutions to make a success of the ecological transition.
- Water Family (Adour - Loire) raises awareness about the ecology and water resources
- Regional Fishing Federation. Fishing federations are committed to protecting and restoring the aquatic environment on a daily basis.

Since 1999, each area with more the 50,000 inhabitants must have a development council composed of volunteers involved in local life. It advises on territory policies (urbanism, transport, sustainability…). The CESER (https://ceser-nouvelle-aquitaine.fr/) covers all the region. Then, in all the areas concerned, different councils exist as well.

1.1.8 NBRACER partners

In the Nouvelle-Aquitaine region, seven partners are grant beneficiaries: The Nouvelle-Aquitaine Region as a public entity, AcclimaTerra a regional climate change committee, Bordeaux INP a research institution, MEOSS a private company specialized in the creation of services based on satellite imagery and cartographic data, Sorbonne Université a research institution, Parc Naturel Régional Marais Poitevin a Regional Nature Parc and SMEAG Joint Syndicate for the Study and Development of the Garonne River.

6.3 Social system and just transition

Within the baseline study relevant data and information on the regional social structures was gathered . Within the concept of just transitions, two forms of justice were distinguished:

- Procedural justice – having voices heard: inclusion of all segments of the public in the strengthening of resilience
- Distributive justice - leave no one behind: focus on the most vulnerable people include impacts on future generations

On January 1st, 2021, 6,069,400 people lived in the Nouvelle-Aquitaine region, representing 9 % of the national population. Between 2015 and 2021, the population growth was in average of 0.4 % per year, slightly more than in France (+0.3 %). Demographic growth is seen mainly in the coastal departments, due to their strong appeal. Fertility is lower than the national average, and the region's ageing index ranks second after Corsica (112 people aged 65 or over for every 100 under 20) (Insee 2024).

Poverty has many consequences explaining the vulnerability of this social group. For instance, they cannot always renovate their house to use less energy or have access to natural spaces. The main impact of climate change on them is sanitary: due to a bigger exposition to extreme temperatures or air pollution, for example, their health is more damaged (increasing of chronicle health issues, cancer…) compared to the average home.

Another population whose health is at risk with climate change is the elder people. In that sense, it is important to note that the Nouvelle-Aquitaine is in the 1/3rd European region where the population is the oldest (SRADDET diagnosis).

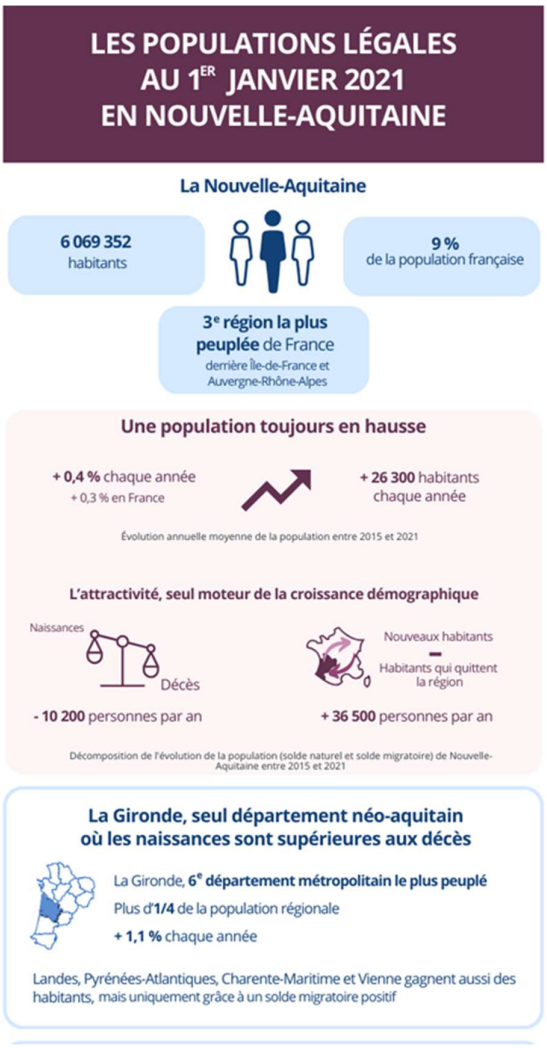


Figure 19: overview Nouvelle-Aquitaine Demography . Source: La population de Nouvelle-Aquitaine poursuit sa progression - Insee Flash Nouvelle-Aquitaine - 107

The Region is deploying an innovative strategy (ACTE - stratégie régionale pour l'accompagnement au changement en faveur des transitions environnementales) that specifically targets young people and key players to support changes in behaviour and practices in order to make a success of the ecological and energy transitions. ACTE aims to promote environmental change, tackling all areas of transition, anchoring change in the long term and, above all, moving beyond a purely individual approach. The aim of this strategy is to support changes in behaviour and practices.

Also, Néo Terra Roadmap (see section below) has social objectives:

- Mobilisation of youth
- 2030: all inhabitants of Nouvelle-Aquitaine are engaged
- co-creation with the next generation
- reconcile an environmental development based on solidarity

The Observatory in ex Poitou-Charente since 2015 Is a space of discussion on public policies, with room for reflection and interrogation for the citizens regarding climate policies (AcclimaTerra, 2018)

For the main local strategy, a public survey is mandatory and the length of it is written in the law (PCAET, SRADDET, PLUi…). However, a survey led by the Public Agency on Ecological Transition ADEME in 2012 shows that these public surveys struggle to mobilise more than around 50 people at the intercommunity ladder. In addition, the participants are in majority already aware of climate change and its effects. They tend to be more inclined to act. Moreover, the subjects introduced to public opinion are often depoliticised (Aulagnier, A., Compagnon, D., Mazeaud, A., & Smith, A. (2024) and no real alternative emerges from it in general (ADEME, 2012). There is also some mistrust from the civil society since some major public surveys in the region have been ignored by the French government (on highway or high-speed train projects). (AcclimaTerra)

6.4 Economy and regional development

Regional development

The Regional Scheme for Economic Development, Innovation and Internationalisation (SREII) is elaborated by the Region, which has the economic development competencies since the 2015 law. The scheme gives a framework to the financial help to local companies which can be organised by the Region itself or delegated to local governments if the Region decides so. The scheme also establishes priorities for territorial attractiveness and well as social economic development. It holds environmental objectives for 2030 too, like having a carbon-free territory and becoming an eco-friendly region.

Smart specialization

Main smart specialization (RIS3) priorities in Nouvelle-Aquitaine include Advanced Materials, ASD sectors, Chemistry, Health & Silver economy, Blue Growth, Agro innovation, Forests industries, Photonics, Geosciences. Main characteristics of the Region:

- First French region on agriculture, 85000 farmers, viticulture
- Agro-innovation, forest industries; water storage and carbon sequestration
- Other industries: advanced materials, geoscience, energies, mobilities ..

New Directions for the regions have been identified in 2022 : positioning of Nouvelle-Aquitaine as the first *Region "Eco-responsible"* in France.

- Accelerating the transitions in services which strengthen the economic competition and the regional comparative advantages
- Responsable innovations to become sovereign
- Humanities and planetary boundaries at the core of the development

Néo Terra (see section below) objectives:

- Transform the risks in opportunities
- 100 % Sustainable production
- Circular economy
- Innovation (technological, social, organizational)

6.5 Innovation

Underlying concepts of Innovation are the Innovation pipeline or the Transformative Adaptation Journey, with aspects and phases of Ideation and visioning, Exploration, piloting, testing and demonstration.

Also, innovative ways of working, collaborating on missions and the innovation facilities as Meeting places, Living Lab, Cluster organization (education, research, collaboration, business support, profiling) are relevant to implement the mission on Climate Adaptation.

Within the Nouvelle-Aquitaine region regarding the Mission on Climate Adaptation several initiatives are being taken, as there are two relevant large programs (Néo Terra and Life Artisan) as well as the planning and implementation of NbS projects.

Programs

Néo Terra Roadmap
On 9 July 2019, the elected representatives of Nouvelle-Aquitaine met in a plenary session on environmental and climate transition, adopted the regional roadmap dedicated to the energy and ecological transition: *Néo Terra*. The objective is to accompany the transition effort in terms of energy, ecology and agriculture by 2030.

Nouvelle-Aquitaine is one of the French regions most affected by climate change: temperatures have risen by 1.4°C over the 20th century, extreme weather phenomena are becoming more frequent (floods, storms, erosion, drought, etc.).

Faced with this observation, the Region has been engaged since 2010 in an ambitious transition process, thanks in particular to expert work which now enables it to identify precisely all the risks which its territory will face in the coming decades via diagnoses.

To move from diagnosis to action and transform risks into opportunities, the Region defined its roadmap, Néo Terra, based on major principles and precise objectives. And, co-constructed as a tool for collective intelligence and action, Néo Terra sets out 11 ambitions to accelerate change and accompany this essential transformation throughout the territory. Néo Terra is a strong policy example, carried out by researchers for 10 years (more than 450 researchers).

Néo Terra has become a strong marker, internal to the Region but also on the territory. The roadmap was built in consultation with the sectors, with a strong desire to embark, to support, without ever stigmatizing. As the leading agricultural region in Europe, the Region paid particular attention to the dialogue with the agricultural sectors which resulted in the approval of the roadmap by the Regional Chamber of Agriculture. To materialize this dynamic and promote the initiatives, a website dedicated to the approach and the actors involved has been developed: www.neo-terra.fr

The Néo Terra road map sets an ambition on making the Nouvelle-Aquitaine an aiming region for zero waste by 2030, the Region is adopting a "zero plastic pollution" plan, with three objectives: zero single-use plastic, with the development of materials or solutions to replace plastic; zero plastic in landfill sites, with the development of recycling; and zero plastic in the environment, to prevent leaks into nature.

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Life Artisan
National NbS project focused on capacity-building projects aimed at mainstreaming good practices and creating a favorable framework for the emergence of local climate adaptation projects focusing on ecosystems.

Background: The French strategy for climate change adaptation (2006) is implemented operationally through national plans, in line with the EU strategy on adaptation to climate change. The national plans target the effective adaptation, by 2050, to a regional climate in continental France and overseas territories consistent with a worldwide increase in temperatures of 1.5 °C to 2 °C compared to the XIXth century, in response to the multiple impacts of climate change (e.g. flooding, heat waves, water scarcity, shoreline erosion). The assessment of the first national plan for climate change adaptation (2011-2015) highlighted the relevance of the targeted environmental issues, but also the weak points in the strategy and the governance of the plan, such as a lack of consistency with other policies, insufficient coordination between the various governance levels, and difficulties in mobilising economic stakeholders. In order to overcome these gaps and shortcomings, the second plan (2018-2022) is putting forward the mainstreaming of nature-based adaptation solutions as a strategic and cross-cutting principle. These measures (green solutions) respond to all thematic objectives of the plan and have catalysing effects on the implementation of grey solutions (i.e. those using civil-engineering techniques and non-renewable resources) and soft solutions (based on changes in behaviour and forms of governance).

The overall ambition of the LIFE IP ARTISAN project is to increase the resilience of the country to climate change, by reinforcing French national adaptation to the impacts of climate change. The project will contribute to the achievement of objectives set in the second national climate adaptation plan and future plans. To this end, the project will seek to generalise the use of nature-based solutions wherever appropriate by 2030. LIFE IP ARTISAN is a capacity building project aimed at mainstreaming good practices and creating a favorable framework for the emergence of local climate adaptation projects focusing on ecosystems. The complementary actions will make it possible to fund new local projects and to improve coordination among the funding parties to enhance overall consistency. For this cross-cutting topic, an integrated framework is required to coordinate the work of the funding parties in financing either climate change or biodiversity policies. Life Artisan is a National Project, focusing on establishing regional networks. Region Nouvelle-Aquitaine is actively connecting to Life Artisan. In addition to the LIFE IP budget itself, the project will facilitate the coordinated use of 3.8 billion EUR of complementary funding from ERDF, EAFRD, and national funds (from water agencies especially).

Funding

There are also several funding opportunities for Climate Adaptation. In addition to the European financial systems (FEADER, LIFE, HORIZON…), the local governments can benefit from several financial support from the State and/or other public structures:

- ÉcoQuartier plan (or eco-district) to help cities conceiving and building eco-districts, adapted to climate change.

- Biodiversity funds are used to incite the territories to take action to accomplish the national plan for biodiversity, including NbS projects to restore ecosystems.
- Green funds are a global plan to help the local governments in their environmental policy. It includes parts for the adaptation to climate change, such as support on coastal policies.
- Cities' renaturation plan has been made to help urban areas adapt themselves to climate change, particularly through NbS.
- Mountain future plan support mountain areas to adapt to climate change.
- State's France Relance plan and the Regional Scheme for Economic Development, Innovation and Internationalisation (SREII) both bring financial support to the private sector to develop environmental policies, including on adaptation to climate change.

6.6 Key insights Social System

Main findings from the social system:

- Climate adaptation is driven by public sector; well-aligned policies, many public agencies and services for the implementation
- Formal and institutionalised setting; clear responsibilities
- Strong knowledge base, involved universities (Bordeaux and Sorbonne de Paris); much knowledge on the territory available, role of the observatories
- projects on implementing Nature Based Solutions and programs (Néo Terra) on new directions are evolving
- limited interplay between the domains of public sector, private sector, knowledge and civil society
- growing awareness of the importance of social aspects, as justice, health and educational aspects, but still very limited involvement and representation of civil society
- new economic directions have been set in regional development frameworks, but the private sector is rarely involved in NbS programs and projects. Also challenging private sector in new directions is still limited. Is still mainly public issue.

7 Connecting Natural and Social System - Nature-based Solutions

7.1 Examples of NbS initiatives

The Nouvelle-Aquitaine region is a very large territory with a wide variety of regional challenges in terms of mitigating and adapting to climate change as well as facing the erosion of biodiversity. Multiple studies together with the AcclimaTerra and Ecobiose reports, show that this part of the country is going to be highly affected by the increase in average temperatures. This carries along some major concerns as droughts, wildfires, water management issues to name a few. In 2019 the Nouvelle-Aquitaine Region has embarked on an ambitious development of its public policies through Néo Terra, its regional roadmap. Having been updated and strengthened in November 2023, this roadmap commits Nouvelle-Aquitaine to active ecological planning. Thus, placing environmental and social transitions at the heart of its objectives, this regional roadmap sets out six ambitions aimed at transforming the Nouvelle-Aquitaine and contributing to a greener, more sustainable and inclusive world. The first ambition states to ”rebuilding natural resources for the future”.

Regarding these challenges, Nature-based Solutions (NbS) have a crucial role to play, as they stand at the crossroads where the inseparable issues of technological innovation, biomimicry, the fight against climate change, adaptation to climate change, and the preservation and restoration of biodiversity all meet.

The NBRACER project will allow on the one hand to respond to water management in both of the two site demonstrators and on the other hand, the creation of a NbS portfolio with examples from every country in the consortium will empower regions on their capacity to act.

The first demonstrator is working on the artificial recharge of the Garonne River water table. This project is carried on by the SMEAG partner. The project itself (RAMAGE - Annual recharge and alluvial maintenance of the Garonne at low water level) started in 2019 and NBRACER will help to find new infiltration points as well as to perform infiltration tests at a larger scale. The second one aims on maintaining water levels in the Marais Poitevin by dynamically slowing the flow, to optimise groundwater recharge (PNR Marais Poitevin). The implication of the multiple stakeholders is a key factor in achieving the goals.

The inputs on the portfolio with NbS examples in the Nouvelle-Aquitaine, were not followed or carried within the NBRACER project. It is also important to mention that the given information was already available mostly on the ARB NA and Néo Terra websites. Nevertheless, these examples show that this region is already using NbS as primary solution in some sectors or

town, and part of the NBRACER project is to aware people on the benefits that NbS can bring.

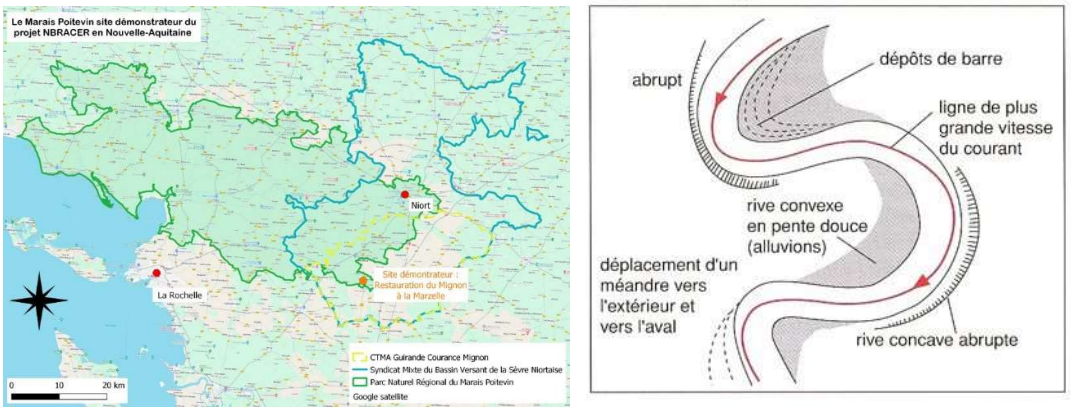

Figure 20: NbS Demonstrator in the Marais Poitevin: Left: area occupied by the Region Natural parc. Right: Restoration Morphologique that is being performed in some of the sites.

On regional resilience amongst all the Nouvelle-Aquitaine's PCAET, only 4 % of all their actions concern the adaptation to climate change. However, some popular actions contribute to it (water management, new agricultural practices, help for thermal insulation…) (DREAL). In 2021, the French research centre CEARC (Cultures, Environments, Arctic, Representations, Climate) analyzed all the French PCAET within the framework of the LIFE ARTISAN project. It discovered that, as the number of actions concerning nature-based solutions is growing, there is a lack of operationality, precision and vision in them (DREAL).

On readiness level for NbS, the French Biodiversity Observatory (OFB) has studied all the French SDAGE (The national development and water management plan) in 2023 and found out that, globally speaking, the NbS is not a common notion in France. They are mainly mobilized in the LIFE Artisan project. However, it observed an increase in the actions using NbS.

In Nouvelle-Aquitaine, according to the regional research network on biodiversity Biosena (2022), NbS are indeed getting more used by project holders. Moreover, in the regional strategy for biodiversity 2023-2032 (SRB), there is a main line on NbS so it can be expected to gain ground in the biodiversity and climate policies.

In readiness for a systemic approach, AcclimaTerra has made two complete reports on climate change in Nouvelle-Aquitaine. The last one, published in 2018, gives a bigger part than the former one to social sciences. Indeed, with the uncertainty we have for future hazards due to climate change, the researchers agreed to consider the social-economic part as one of the main points of their report. In its roadmap Néo Terra, the Region adopts a systemic approach with mainlines on agriculture, housing, natural resources but also health, solidarity and economy. In reality, the policies are still quite made and enforced in silo, but efforts are made in the planning documents and there is hope for a better systemic approach if they are properly applied.

8 Key insights and conclusion

Clear public policies and responsibilities, aligned between national and local level

The policies and strategies on dealing with (aspects of) climate change are available within France and within the Region of Nouvelle-Aquitaine. Within France, there is a clear connection between the different levels and scales of government. National level is leading and gives direction to the regions, departments and the local communities. Regions are relatively strong and well organized level of government. Next to the alignment of the different scales also alignment with the various sectors and facets are present, as there are strategies policies, as well responsible public bodies, implementing on water, soil, biodiversity, agriculture and forestry, coastal management and spatial planning.

Formal and institutionalized landscape; public sector driven, planning and implementation

Within Nouvelle-Aquitaine, and also in other parts of France, the public sector is responsible for and active in implementing measures and projects. Climate and environmental policies and implementation are mainly implemented by public sector-organizations themselves. There is a large public sector which is responsible for the frameworks and policies, but has also responsibility for the implementation, by agencies and technical service providers, as part of the public sector. The Region of Nouvelle-Aquitaine is actively leading the local government action in their territories. Local governments have the opportunity to collaborate on environmental subjects through cooperation contracts. These are often made between main urban areas and the surrounding rural areas to collaborate on subjects such as transport or sustainable energy production. Some governmental structures also involve players in the local ecological transition. For example, the different Chambers (of commerce, of craft industry) often have a "sustainability club" and organize events on subjects related to the environment and the role the local stakeholders can have.

Further partners in this field are the knowledge partners as the universities of Bordeaux and Paris, but also various specialized research institutes and observatories. Much knowledge and information on the natural system and the trends and developments are available. Also at public sector agencies, much knowledge of the natural system is available. Next to this a growing attention is observed for more integrated approaches, incorporating society and working with development pathways. AcclimaTerra is actively valorizing knowledge and applying scientific concepts for regional sustainable development, in collaboration with various universities and research groups, and is developing directions, and giving advice and support to the transformation. AcclimaTerra and also Ecobiose bring their expertise to the public debate through their publications or events.

There is also a growing awareness of the social aspects of climate change and of the role of society within mission-driven approaches, which is mentioned in Néo Terra Roadmap. But the involvement of civil society within some planning instruments is not yet leading to large involvements. An active quadruple helix interplay on climate change and environmental issues is not usual, but changes in the involvement of the private sector and civil society are in place.

New directions

The Nouvelle-Aquitaine Region is aware of key elements of EU Mission; mentioned in Néo Terra

- building new economy, mission driven innovation
- Eco-production central, durable economy, circular economy
- involvement of citizens (and role of the next generation, alignment with educational programs. School projects)

New directions should focus on identifying, creating and mobilizing, initiatives for the transformative journey.

- Néo Terra: objective is to accompany the transition, vision and ambition document, knowledge driven, but connected to the region, public sector, regional projects implemented by public agencies. Also, much knowledge driven.
- Life Artisan, focus on capacity building for emergence of climate adaptation projects and mainstreaming

Further challenge will be to manage the transformative adaptation journey, to integrate policies, strategies and initiatives at regional level, and to find the comparative advantages of the region, relevant to strengthen the profiles.

Next steps

Directions: for optimizing governance, the quadruple helix interplay and implementation

- Management of the systemic approach – integrated framework
- Strengthen the connections among quadruple helix partners– intensify the interplay
- Support initiatives and practices: ideation, piloting to full implementation
- fostering bottom-up initiatives

AcclimaTerra can be seen as a driver for change, but mobilizing and strengthening capacities and collaborations, from the various domains, and between the various organizations, will be critical.

Annex 5: Baseline Cantabria

NBRACER
Nature Based Solutions
for Atlantic Regional Climate Resilience

Regional Baseline report

Cantabria

Wageningen Research

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Nature Based Solutions
for Atlantic Regional Climate Resilience

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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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1 A regional baseline

1.1 Aim of the Regional Baseline

The aim of this regional baseline is to collect and share the regional information and to discuss the current situation among partners in the regions involved in NBRACER. By creating a baseline first insight on the current physical and social-economic context will be developed, relevant to deal with climate change, to plan and implement Nature Based Solutions (NBS) and to start the Transformative Adaptation Journey in each Demonstration region towards a climate resilient society.

The regional baseline comprises a collection of general regional information both qualitative and quantitative data. The baseline adopts a systemic approach to comprehend the intricate relationship between the natural system and the human/social system. Within this framework, three key components are delineated: the natural system, the social system, and the connection between these two systems within the key community services. Through this systemic approach, a clearer understanding of resilience-building mechanisms and pathways can be attained.

The baseline will give direction to region's specializations, unique characteristics, as well as its strengths and weaknesses concerning Nature-Based Solutions (NBS). The baseline will facilitate a common understanding, to support the joint sense-making for future visions and pathways.

1.2 Key concepts

Climate change can be approached in different ways. Therefore, it is important to describe the conceptual approaches that are underlying the NBRACER project and the analysis of information that has been collected for this baseline report. While many studies have been using an impact or risk-based approach, NBRACER is focussing on a systems-based approach to foster resilience. Key concepts related to this approach are:

- Systemic approach and key community systems
- The concept of regional transformation adaptation journey
- The transformational governance; concepts of collaboration and inclusion

1.1.1 Systemic approach and key community systems

The baseline adopts a systemic approach to comprehend the challenges that climate change poses on the region. The systemic approach is focussed to better understand the intricate relationship between the natural system and the social system. This approach starts from the Sustainable Development Goal's wedding cake that illustrates how economies and societies are connected with the natural system and in order to have a well-functioning economy and society, they should be well embedded in the underlying natural system (Figure 1).

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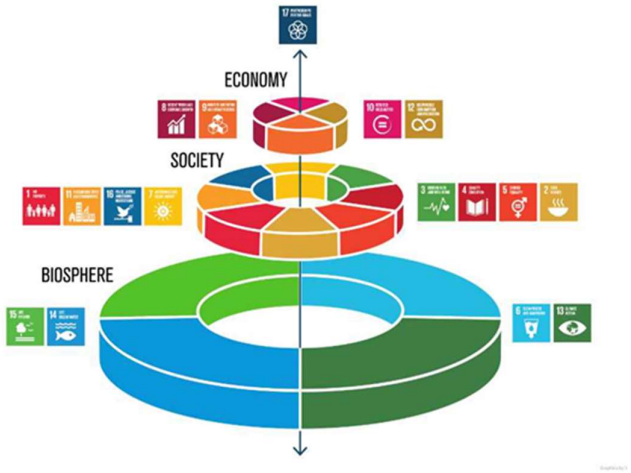

Figure 1: Wedding Cake of sustainable development goals (SDG) (Source: United Nations)

In the baseline, we aim to analyse the different parts of the natural and social systems and their connection. This will help to move away from the environmental or sectoral approach only, that is often used in climate change assessments that considers nature separate from society and economy. Instead, it promotes a more systemic approach that explicitly focuses on the interrelationship between natural and social systems. Nature-based solutions inherently have the potential to strengthen this connection sustainably by leveraging the natural system's capabilities to address societal issues.

Within this approach, three key components are delineated: the natural system, the social system, and the connection between these two systems that includes the governance that is in place to ensure natural and human systems are in balance. Approaching climate change in a systemic way enhances a better understanding of the systems issues that lead to climate change impacts and provides a better understanding on how systems could change in order to regain a balance between the natural and social systems given the context of the climate changes.

Related to this systemic approach are the key community systems that play a dominant role in the European Mission on Adaptation (European Commission, 2021). Key community systems are systems that meet basic needs for society but might be impacted by climate change. The EU distinct 5 Key Community Systems: the land use and food system, water management system, critical infrastructure system, the health and wellbeing system and the local economic system. The Mission Climate Adaptation is focussing on using the ecosystems and nature-based solutions in order to protect the key community systems from the negative impacts of climate change. The ecosystem is crucial for our wellbeing and ensures that we are ecologically connected, that nature is restored and that ecosystem services are delivered.

Furthermore, the baseline also summarizes the available information on climate change risks and assesses the related vulnerabilities of the key community systems due to climate change. To safeguard our wellbeing, it would be needed to assess the needs for transformation to ensure that the key community systems keep on meeting basic needs.

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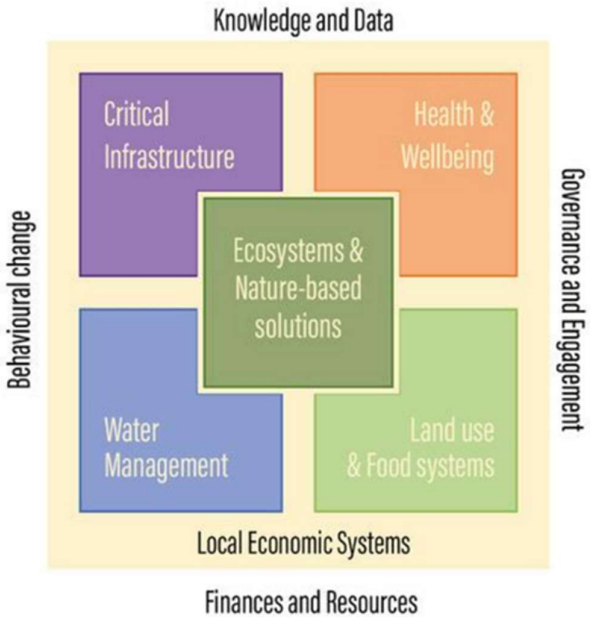

Figure 2: Key Community Systems (EU Mission of Climate Adaptation)

1.1.2 Regional Transformative Adaptation Journey

As NBRACER aims for systemic transformation at the regional level, we are relying on the Transformative Adaptation Journey (also used in Pathways2Resilience) in order to bring forward the regional transformation. This approach is originally based on the adaptation policy cycle but is extended with elements that would enhance the collaboration between public, private, knowledge and societal partners.

The first phase of the Transformative Adaptation Journey - *preparing the ground* – focuses on understanding what's already being done in the broader policy, social, environmental, and economic contexts, understanding who are the key actors and institutions needed to involve, understanding the socio-economic context and available resources, and providing evidence to determine regional priorities and opportunities for sustainable, climate-resilient regional development. Also, climate risks and opportunities for prosperity need to be assessed. At the end of this phase, regions will have a comprehensive baseline covering, among others, risk assessments, adaptive capacity needs, a stakeholder map and a monitoring framework that will act as a solid foundation for the journey. (Source Climate KIC, DesirMED).

The next step in the regional adaptation journey involves co-developing a *shared vision* with stakeholders. Active engagement is essential for creating commitment and ownership of the process and vision. This co-created vision will be a tool for mobilizing change and holding regional stakeholders accountable. It must be holistic, combining scientific insights with community priorities to foster a sustainable and equitable future. Public-private partnerships will be key to mobilizing resources and driving large-scale innovation. Ultimately, the vision must be dynamic, evolving with climate changes and lessons learned, and calls for courage,

collaboration, and commitment from all sectors to protect our planet for future generations. (DesirMED)

Next step is developing *adaptation pathways* for climate adaptation and resilience gather interventions across multiple levers of change in a portfolio of actions, each of them contributing to progress towards the desired pathway, that will coincide with action & investment plans. While implementing the plans, it is aimed to closely monitor progress on the systemic change and to evaluate, learn and adjust actions if needed. In this way, building resilience via transformation becomes an iterative process, a journey, where all relevant regional stakeholders take part.

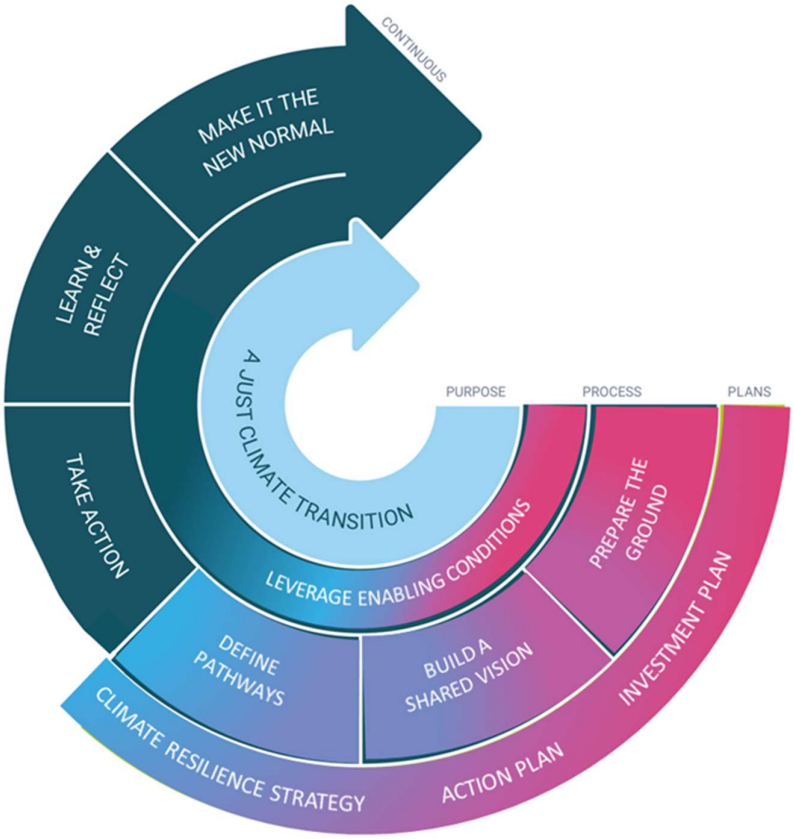

Figure 3: Transformative Adaption Journey (Climate KIC, P2R)

1.1.3 Collaborative and inclusive approach

The European Mission on Adaptation acknowledges the need to involve organisations beyond the conventional public actors, when it comes to building resilience. It is crucial that private partners, knowledge partners and society (*quadruple helix*) are involved in the regional transformation adaptation journey. This means that these partners need to be mobilized and engaged in the various phases of the transformational process and start with collaborating on directions and solutions to cope with climate change, and to create dynamics and initiatives within the specific regional context (*Smart Specialization*).

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The European Strategy on Climate Adaptation (2021) also promotes the principle of *just resilience* or *just transition,* indicating that adaptation processes have to be inclusive in order to avoid the risk that adaptation measures put an uneven burden on some groups and that marginalised groups are not well included in the planning and decision-making processes. Therefore, it is crucial to better understand who in the region might be unequally affected due to climate change and to ensure that they are well engaged in the development and implementation of adaptation measures to ensure that these measures meet their needs. It would be needed to explore vulnerable groups in the regional context and identify groups that are left behind.

1.3 Process of constructing the Regional Baseline

To create the regional baseline, the required information topics were defined and listed. As mentioned earlier, the baseline examines both the natural system and the social system, emphasizing their interconnections and key community services. For each component, we specified the necessary information to obtain the desired insights for the baseline. More detailed information about this systemic approach and its individual components will be presented in the upcoming chapter.

To gather this information, we distributed a document to the region that could be filled out, based on the list of required information topics. The region, possessing valuable insights into local conditions, significantly enriched our understanding of vulnerabilities, challenges, and opportunities. This collaborative knowledge-sharing formed the bedrock of our regional baseline.

Additionally, Wageningen Research supplemented this information with relevant online sources. We meticulously reviewed existing reports, data, and materials to enhance the insights shared by the regions. Our goal was to create an initial overview of the region's current state — a snapshot that captures its unique characteristics, risks, and adaptive potential.

The baseline serves as a starting point. During the regional workshop, we collected additional information and incorporated it into the baseline as needed. Our aim is to align with your perspective and regional expertise, ensuring that the baseline evolves dynamically throughout the NBRACER project.

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2 Situating Cantabria

The region Cantabria, located in the north of Spain, is bordered by the Bay of Biscay to the north, the Basque Country to the east, Castilla y León to the south, and Asturias to the west. The region's climate is heavily influenced by the Atlantic Ocean, resulting in high annual precipitation and lush vegetation. Therefore, the region is also known for the 'green Spain'.

Figure 4: Location of Cantabria in northern Spain (Britannica, 2025)

Cantabria is characterized by its diverse landscapes, ranging from the coastal areas to the Cantabrian Mountains. The average altitude is approximately 500 meters with the highest peak of 2618 meter. The region has well-formed and productive floodplain valleys in the lowlands of the river catchment. Due to this landscape and the oceanic climate, a variety of agricultural activities can take place in this region, with cattle husbandry being particularly prominent.

Coastal

The coast of Cantabria is approximately 211 km long. It is an abrupt coast that alternates exposed systems (cliffs, beaches) and more sheltered locations (estuaries and bays). The coast in Cantabria can be divided in four different systems: rocky shores, estuaries and dune systems and coastal cliffs. Within each system, different habitats can be distinguished. These habitats are formed by different species that are adapted to specific flooding conditions (e.g. permanently submerged, intertidal). Coastal habitats and biodiversity withing Sites of Community Importance in Cantabria are identified, mapped and their conservation status assessed and publicly available (https://rednatura2000cantabria.ihcantabria.com/).

Rural

The land cover gradient in the region characterizes the legacy of human management and land use practices for the last 400 years. The eastern part of the region, has been kept deforested for stockbreeding through the combined use of fire and cattle grazing. Consequently, they are

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dominated by a mixture of shrubs with a predominance of dry heathland communities and extensive pastureland. Only some isolated patches of eurosiberian forest (mainly oak, birches and beeches) remain on steep hillslopes. In contrast, the western part of the region has not experienced relevant deforestation processes and presents mature eurosiberian forest but also mediterranean vegetation in lowlands (mainly holm oak and Pyrenean oak). Here, the presence of brown bear and Cantabrian capercaillie evidences a better state of landscape conservation, in opposition to the eastern extreme.

Urban

Cantabria has a long history of human settlements, resulted in a rich cultural and historical identity. Nowadays, the population is concentrated along the coast. More than one-third of its residents living in Santander, the capital of Cantabria, being the financial and commercial hub of the region. The city has a moderate number of green spaces with tree cover, frequent but generally small in size. The built environment is characterized with low-rise buildings (only 7 buildings above 45 metres) in the central part of the city, which gradually decrease in height and density until there is a transition to single-family housing systems towards the outer part of the city. Many of the latter have an associated agricultural-pastoral use.

The Urban network scattered throughout the territory, with lower population density in mountain areas and higher concentrations in the valley bottoms and coastal areas. Only Santander and Torrelavega, both on the coastal area, have more than 50,000 inhabitants (around 170,000 and 50,000 inhabitants respectively).

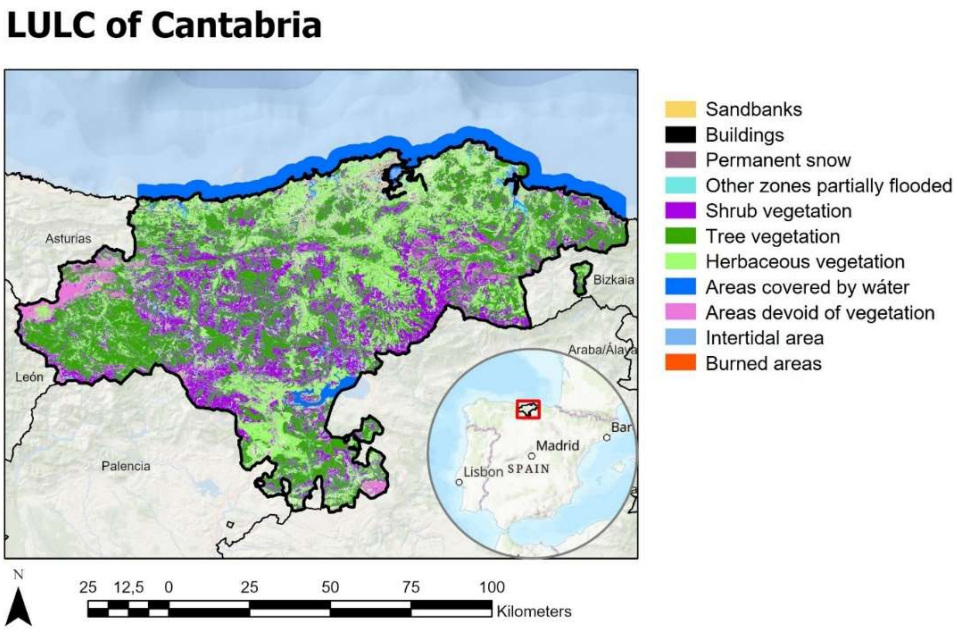

Figure 5: Interconnectedness between the various landscapes (Source: Mapas Cantabria)

Cantabria's landscape is made up of a mosaic of mountain habitats (forests, meadows and rocky areas), fluvial habitats (rivers, riparian forests and floodplains composed mainly of pastures), and coastal habitats (beaches, estuaries, rocky coastal areas, etc.). The rural, coastal and urban systems are highly interconnected, producing a smooth gradient of naturalness-agricultural-pastoral and fishing anthropic uses that leads to a more relevant urban use only in the central area of the cities.

The climate of this area is humid oceanic temperate, which together with the relief, produces short and steep rivers with great erosive power and frequent floods of varying magnitude. The rivers connect the rural and montainous landscape with the coastal landscape through valleys of the middle areas and, ultimately, the estuaries. In the Bay of Santander, the three landscapes converge: the rural landscape of the Miera basin, the Cubas estuary and Santander city. The mountainous morphology of the territory has conditioned the settlement and the more intensive uses towards the valley bottoms and the coastal area. Main change in the Cantabria landscape is laid in abandonment of traditional uses in mountain areas and urbanisation in coastal areas.

Principal climate change challenges

Cantabria is suffering different climate risks related to extreme weather events (heatwaves, flooding and droughts) that lead to different impacts from local to catchment scale (e.g., soil erosion, water impairment episodes, large wildfires, loss of agriculture production). Moreover, sea level rise and ocean storms threaten key urban areas, where most of the population in the region lives.

Cantabria well-known for its:

- Unic cultural and historical identiy.
- Special climate conditions and green landscapes
- Long history of human settlement
- Mountains
- Beaches

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3 Understanding the region: the Natural System

3.1 The regional landscape

The landscape of Cantabria is known for its diverse geography, from coastal areas, floodplain valleys, and rugged mountains. The contemporary topography of Cantabria owes much of its formation to geological processes and climatic influences over millennia. The region is characterized by the Cantabrian Mountains, which rise sharply from the coast, creating a dramatic contrast between the sea and the highlands.

During the last Ice Ages, glacial activity played a significant role in shaping the landscape. The glaciers carved out deep valleys and left behind a variety of geological features. In the Picos de Europa, part of the Cantabrian Mountains, the glacial cover extended over the high peaks, creating cirques and U-shaped valleys that are still visible today. These glacial advances and retreats have sculpted the landscape into its current form.

As the glaciers retreated at the end of the last Ice Age, meltwater carved out deep valleys and deposited sediments, forming fertile plains and river valleys. The rivers, such as the Ebro and the Deva, have continued to shape the landscape by eroding rock and depositing alluvial sediments, creating rich agricultural land. The formation of karst landscapes, including caves and sinkholes, also occurred during this period as water dissolved the limestone bedrock.

3.2 The soil system

In the areas around Cantabria, you mainly find limestone and sandstone, along with other rocks like conglomerate (a rock made of compressed stones), quartzite, shale, slate, and gypsum. These rocks are very old and date back to the time of the dinosaurs. These rocks are even older and mostly consist of slate, schists, and quartzites, which change into metamorphic rocks further west towards the Galician plateaus.

Cantabria has various soil types depending on the kind of rocks in the ground. We can divide these soils into two parts, with a boundary roughly around the city of Oviedo:

- Humid Ranker (Western Asturias): In western Asturias, where the ground has a lot of sandstone, quartzite, gneiss, and granite, you find a soil type called 'Humid Ranker.' These soils are usually gray and have a layer of humus (a type of organic material). They form through the slow breakdown of rocks, with little washing away of substances.

- Dark Calcareous Forest Soils (Eastern Asturias and Western Santander): In eastern Asturias and western Santander, the soil changes due to more limestone in the ground. This leads to dark soils with a lot of humus. These soils have a thin top layer, with a sticky clay layer underneath. They are very fertile, but the clay can prevent water from draining well.

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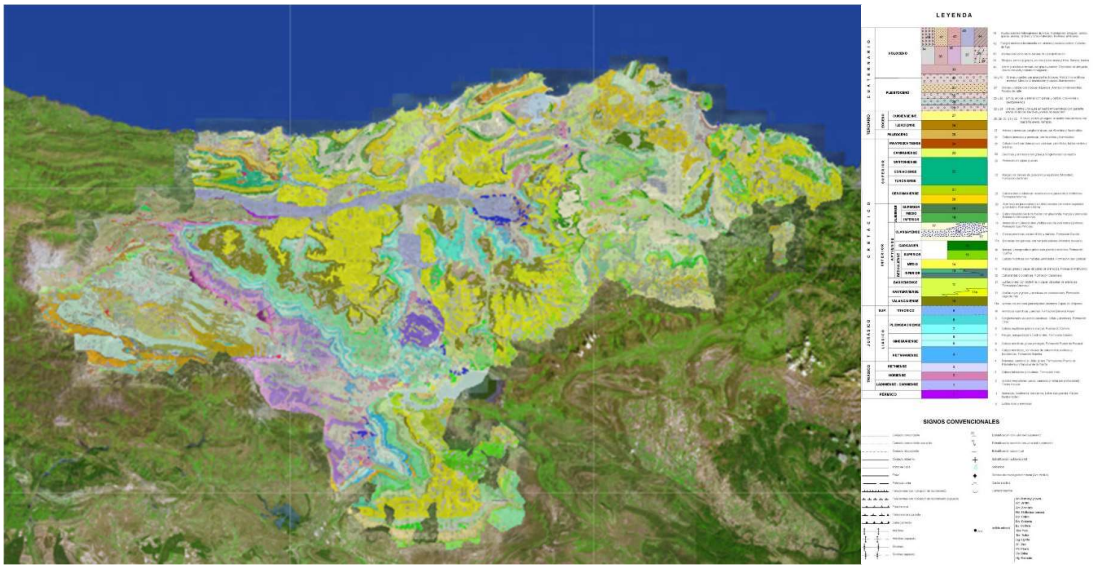

Figure 6: The soil system of Cantabria (Source: Mapas Cantabria)

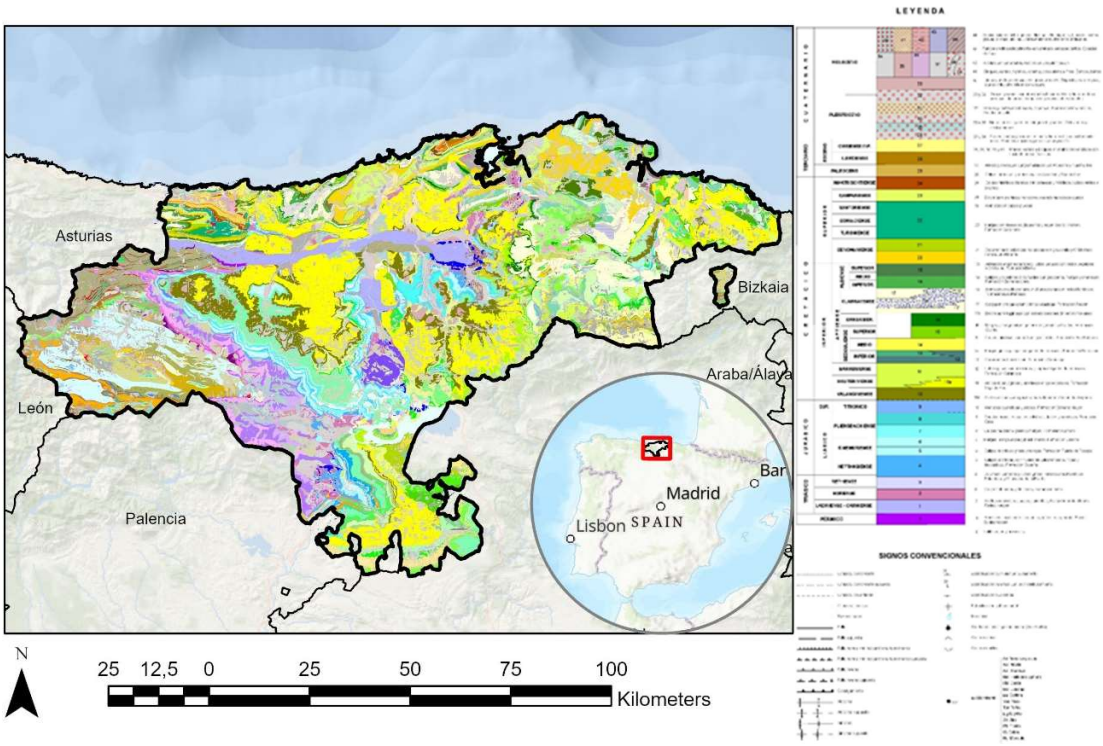

Figure 7: The geology map of Cantabria (Source: Mapas Cantabria)

In many parts of Cantabria, especially where there is limestone, you find a unique landscape known as 'karst.' This landscape is created by the dissolving of limestone by water, leading to the formation of caves, sinkholes, and rock shelters. This gives the landscape a unique, often bumpy appearance. Especially around Posada de Llanes in Asturias, you see a lot of these karst features. Here, some rivers even disappear underground, only to reappear later.

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The coastal area of Cantabria has flat hill ridges that generally don't exceed 300 meters in height and don't extend far inland. Further inland, you find higher mountains with peaks ranging from 800 to 850 meters. Behind these mountains lies a narrow valley where rivers flow through. The mountains of the Picos de Europa, with peaks over 2600 meters, create an impressive landscape with deep gorges (see figure 8).

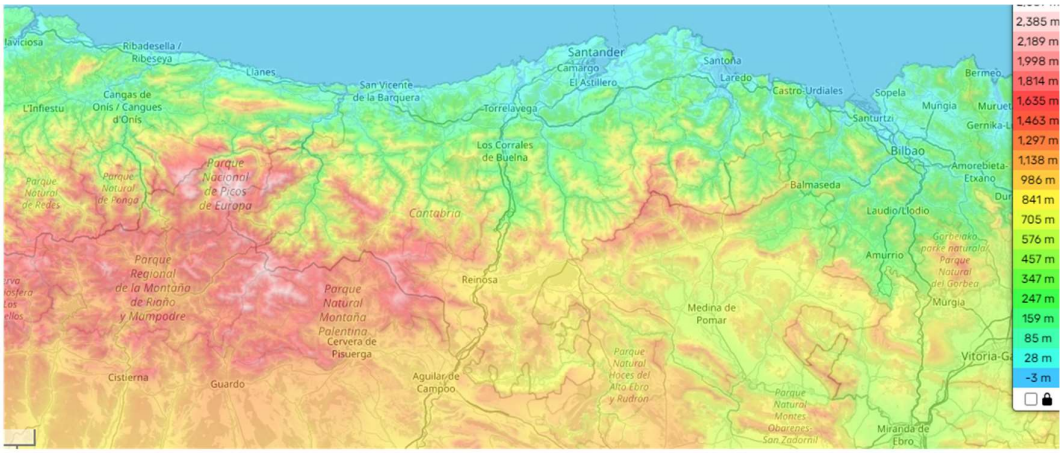

Figure 8: The elevation map of Cantabria and the wider region (Source: Cantabria topographic map, elevation, terrain)

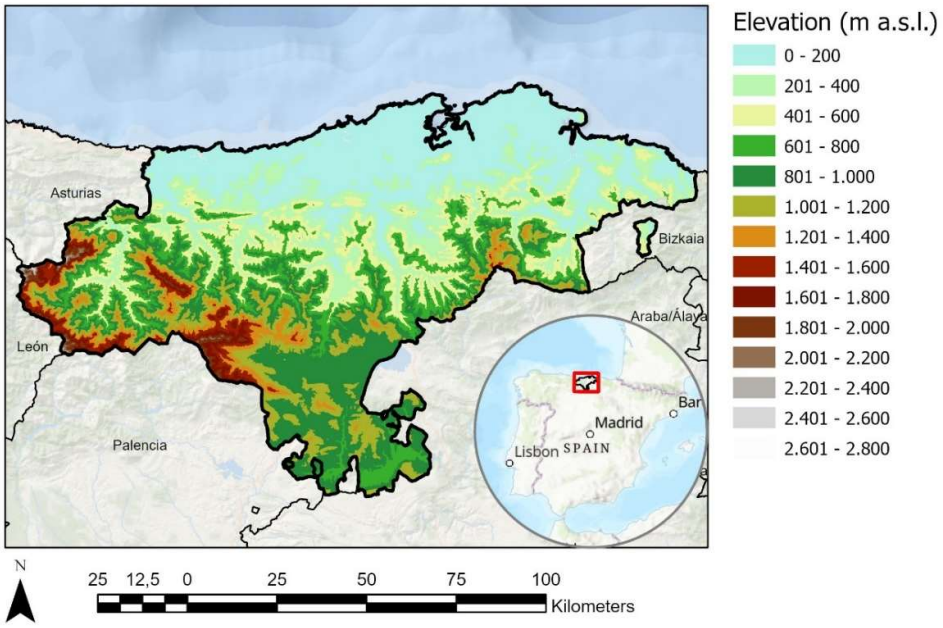

Figure 9: The topography map of Cantabria (source: Mapas Cantabria)

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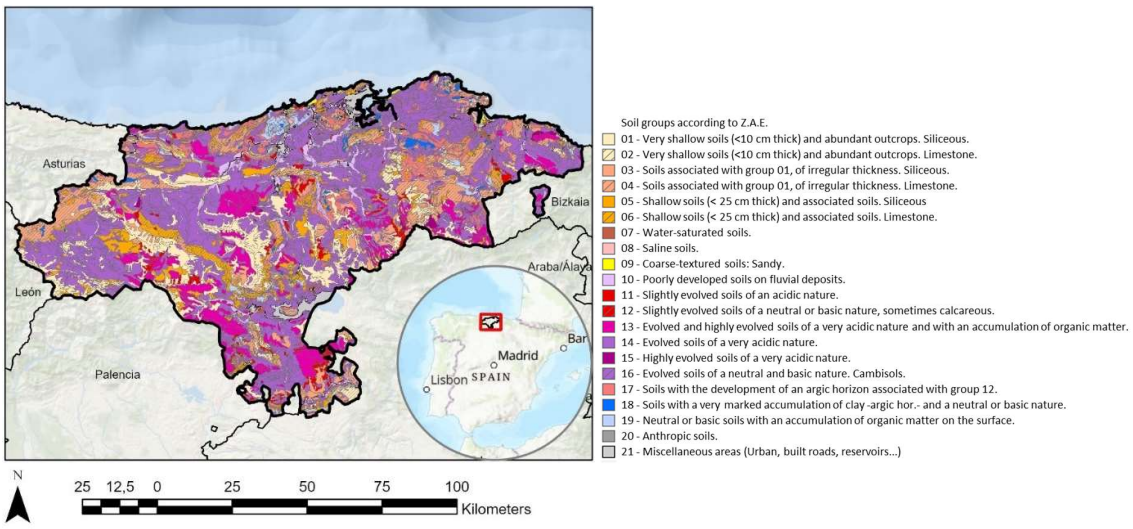

Figure 10: The soil and edaphology map of Cantabria (Source: Mapas Cantabria)

3.3 The water system

Cantabria is characterized by a dense network of rivers and streams, many of which are short but swift, owing to the region's mountainous terrain. The most significant rivers include the Ebro, Pas, Saja-Besaya, and Nansa, among others. These rivers generally flow from south to north, starting in the Cantabrian Mountains and emptying into the Cantabrian Sea. The Ebro, although primarily associated with other regions, has its source in Cantabria and is one of the most important rivers in Spain but flows into the Mediterranean Sea. Only the Camesa River, belonging to the Duero basin, flows into the Atlantic Ocean.

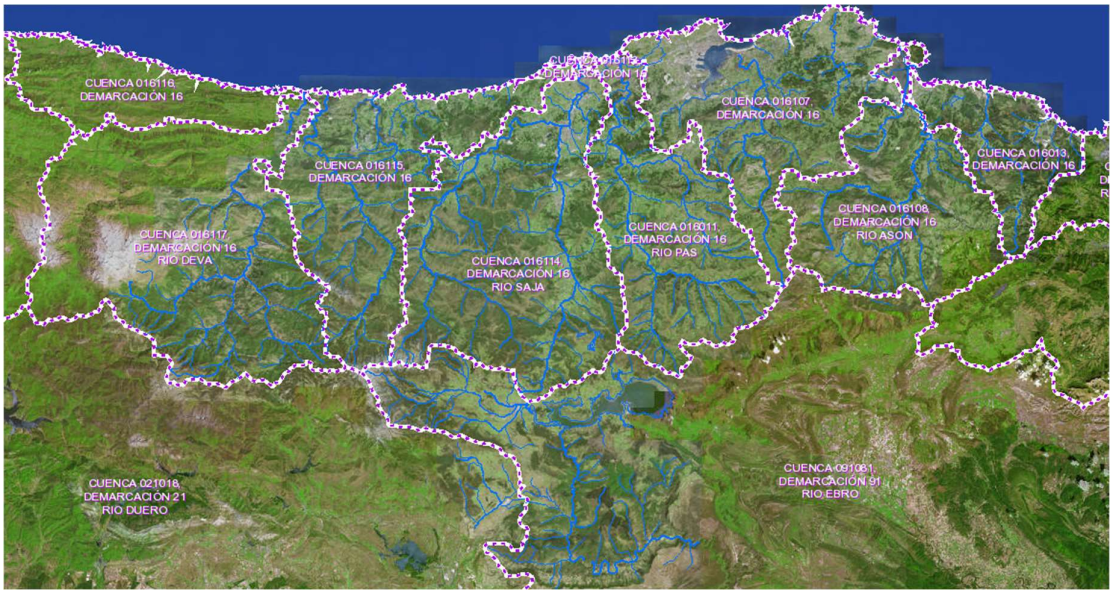

Figure 11: The water system of Cantabria (Source: Mapas Cantabria)

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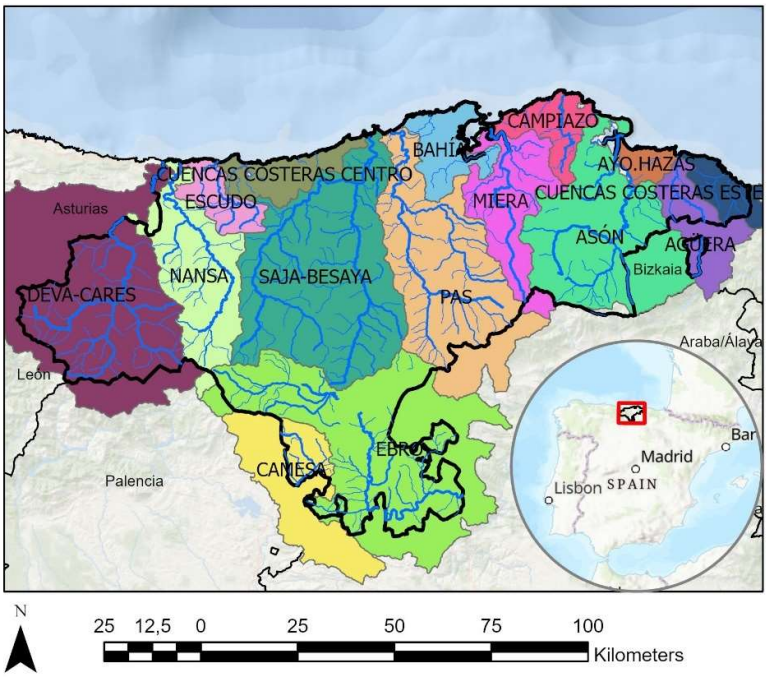

Figure 12: Rivers and watersheds of Cantabria (Source: Mapas Cantabria)

Cantabria has few natural lakes, but several artificial reservoirs have been constructed to manage water supply, control flooding, and generate hydroelectric power. Notable reservoirs include the Embalse del Ebro, one of the largest in northern Spain, which plays a crucial role in water regulation for both Cantabria and neighbouring regions. Other reservoirs, such as the Alsa and Cieza, also contribute to the region's water management.

The coastal area of Cantabria features several estuaries and marshlands, formed by the confluence of rivers and the sea. These areas are ecologically significant, providing habitats for a variety of bird species and serving as natural filters for water. Notable wetlands include the Oyambre Natural Park and the Santoña, Victoria, and Joyel Marshes Natural Park. These wetlands are not only important for biodiversity but also play a role in flood control and water purification.

In Cantabria, rain is the main source of freshwater, thanks to the region's temperate oceanic climate, which brings substantial rainfall year-round. Additionally, meltwater from snow in the higher altitudes of the Cantabrian Mountains and the Picos de Europa contributes significantly to the area's freshwater resources, especially during the spring and early summer months.

Cantabria's karstic geology significantly influences its groundwater system. The region's limestone formations, particularly in the Picos de Europa and other mountainous areas, have created extensive underground aquifers. These aquifers are crucial for providing drinking water, especially in areas where surface water may be scarce. The karstic nature also leads to phenomena like underground rivers and springs, contributing to the region's water resources.

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3.4 The nature system

Due to the divers' landscape structures, a wide diversity of nature can be found in Cantabria. Cantabria is renowned for its diverse and striking natural landscapes, which reflect a unique blend of wild, untouched areas and landscapes shaped by centuries of human activity. The region's most prominent feature is its mountainous terrain, particularly the Cantabrian Mountains and the Picos de Europa. These rugged peaks and deep valleys, reaching over 2600 meters in elevation, are home to alpine meadows and forests.

The vegetation in Cantabria varies significantly between the eastern and western parts of the region. In the eastern area, historical deforestation for stockbreeding, has led to landscapes dominated by shrubs, dry heathland communities, and extensive pasturelands. Despite this, some isolated patches of Eurosiberian forest, including oak, birch, and beech trees, remain on steep hillslopes. In contrast, the western part of Cantabria has experienced less deforestation and features mature Eurosiberian forests along with Mediterranean vegetation in the lowlands, such as holm oak and Pyrenean oak. This better-preserved landscape supports species like the brown bear and Cantabrian capercaillie, indicating a higher level of conservation.

The abundant rainfall in Cantabria supports a network of rivers and streams that flow from the mountains to the coast, nurturing rich aquatic ecosystems that include trout and salmon. The region also boasts significant wetlands and estuaries, such as the Santoña, Victoria, and Joyel Marshes Natural Park, which are crucial for migratory birds and other wildlife.

The Cantabrian coastline extends for about 200 kilometers and features a variety of coastal systems. These include rocky shores with rugged outcrops and tidal pools, estuaries and dune systems that support species adapted to fluctuating flooding conditions, and dramatic coastal cliffs that provide nesting sites for seabirds. Each of these coastal systems hosts unique habitats suited to specific environmental conditions, such as permanently submerged or intertidal zones.

Cantabria features several national parcs and special conservation areas. Picos de Europa National Park is famous for its mountains, deep gorges, and biodiversity, home to species like the Cantabrian brown bear and golden eagle. Santoña, Victoria, and Joyel Marshes Natural Park is a vital wetland area located along the northern coast of Cantabria. This park supports a wide range of bird species, including migratory waterfowl, and is crucial for the conservation of aquatic plants and marshland ecosystems. Dunas de Liencres Natural Park has a dynamic dune systems and coastal habitats, supporting diverse coastal flora and fauna. Monte Hijedo Natural Park preserves ancient forests and wildlife, including roe deer. Cabárceno Natural Park, a former mining area, now houses a variety of global wildlife in large enclosures. These different parks play an important role in conserving Cantabria's diverse ecosystems and offers visitors unique natural experiences.

Cantabria is renowned for its rich biodiversity and varied ecosystems, including lush forests, wetlands, coastal areas, and mountainous regions. However, human activities have also a big influence on the ecosystems nowadays and how they function.

Cantabria's ecosystems are increasingly impacted by climate change, presenting several challenges. Shifts in temperature and precipitation patterns can disrupt the delicate balance of local ecosystems, affecting plant and animal species adapted to specific climatic conditions. Increased rainfall can lead to soil erosion and habitat degradation, especially in areas where deforestation has occurred. Conversely, reduced rainfall and warmer temperatures may strain aquatic ecosystems, alter river flow patterns, and elevate wildfire risks in forested regions. These climate-induced changes can result in shifts in species distributions, a decline in biodiversity, and disruptions to essential ecological processes.

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For forestry and biodiversity, species associated with cooler and wetter conditions, such as beech forests, are particularly vulnerable and may become confined to microclimatic refuges. In contrast, Atlantic holm oak forests are likely to expand. Mountain rivers and lakes are also highly susceptible to these changes.

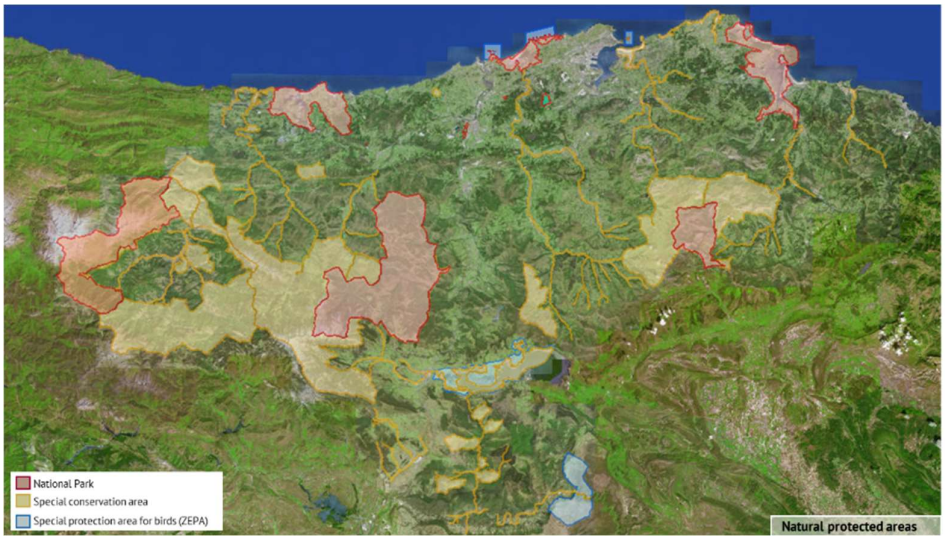

Figure 13: Nature conservation areas of Cantabria (Source: Mapas Cantabria)

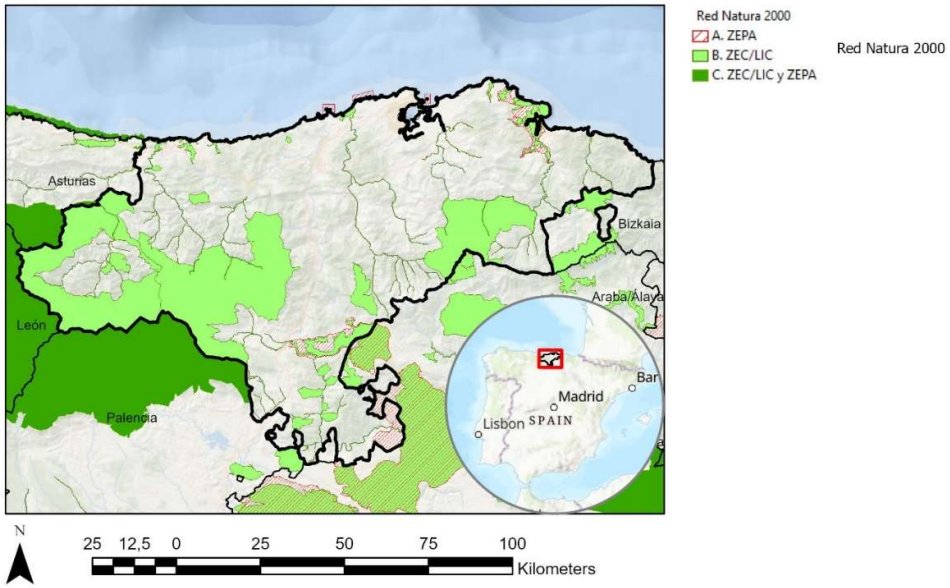

Figure 14: Red natura 2000 in Cantabria (Source: Mapas Cantabria)

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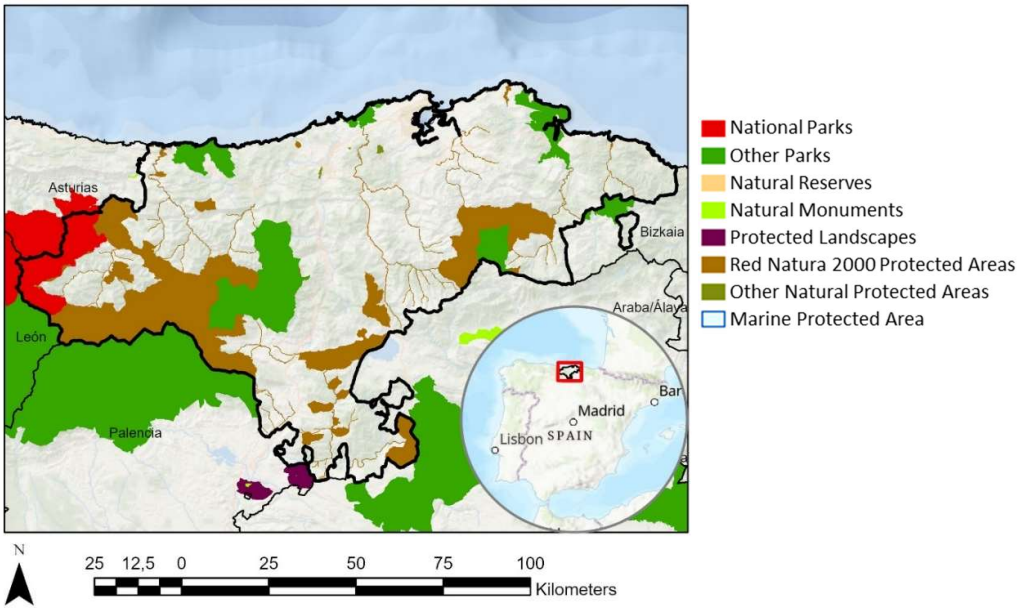

Figure 15: Protected Natural Areas Cantabria (Source: Mapas Cantabria)

3.5 Dynamics in the natural system

Cantabria's weather is characterized by high humidity throughout the year, with maximum precipitation concentrated in winter and spring.

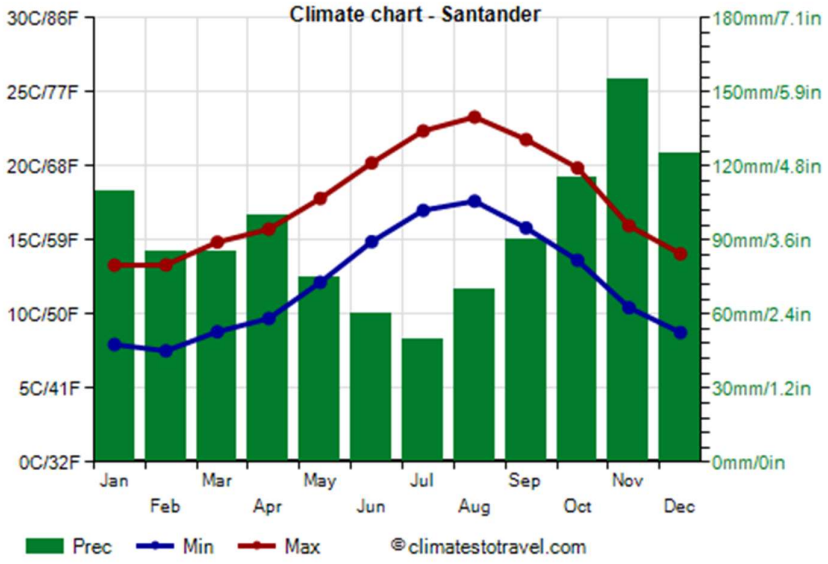

Table 1: Climate chart for Santander, showing monthly average precipitation (green bars) and minimum and maximum temperatures (blue and red lines) (Source: Climates to travel)

Winters are generally mild in the coastal areas, with temperatures rarely dropping below freezing. However, the region does experience significant rainfall during this season, which can lead to increased runoff and soil erosion. The combination of mild temperatures and high precipitation supports lush vegetation growth, particularly in the coastal and lowland areas.

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In the more mountainous parts, temperatures become lower. Snow events are a bit more frequent in inland hilly areas. In the mountainous peaks, heavy snowfalls can occur.

In spring (March-May), temperatures rise gradually, promoting the growth of vegetation. The increased rainfall during this period, which can lead to flooding in low-lying areas, as well as the transport of sediment downstream.

Summer in Cantabria is characterized by moderate temperatures and continued high humidity. While the region does not typically experience extreme heat, the combination of warm temperatures and high humidity can lead to increased evapotranspiration, which may dry out soils, particularly in areas with poor water retention. Summer thunderstorms are common and can result in localized flooding and soil erosion.

Autumn brings cooler temperatures and increased rainfall, which can saturate soils and lead to surface runoff and river flooding.

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4 Understanding the Region: Social System

4.1 Policies and strategies

In the overview of policies below, it is becoming clear that there has been a growing attention to climate change the recent years, and to climate adaptation, as well at National level, as at regional level. The frameworks are existing and within Cantabria many organizations have been participating in the policy making process. Actually the plans are being revised due to new agreements on CoP25. Also additional policies and planning activities are being taken place actually, with a focus on territory and environmental (forest, water basin management), as well as urban planning. Also interest in concepts and policies on circular and bioeconomy is growing. In this overview limited reference is given to the connection with regional policies on economics, as regional and rural development and agricultural policies.

Main policies at National Level

- National Climate Change Adaptation Plan 2021-2030
- National Strategy for Green Infrastructure and Ecological Connectivity and Restoration
- National Hydrological Plan
- Western Cantabrian Hydrographic Demarcation Hydrological Plan
- Plan for the Implementation and Adaptive Management of the Ecological Flow Regime in Rivers
- Flood Risk Management Plans
- Special Action Plain in Situations of Alert and Eventual Drought of the Western Cantabrian River Basin District

Main policy instruments at the regional level:

- Cantabria's Climate Change Action Strategy 2018-2030 (2018); (https://www.cambioclimaticocantabria.es/documents/3528731/3528777/Estrategia+Cambio+Clim%C3%A1tico+2018-2030.pdf/5c61b11b-af55-97bc-58bd-ae68979089ab)
- The Declaration of Climate Emergency (2019) aimed to commit actions to fight climate change at the regional level, adopt measures to mitigate its effects and promote strategies in the field of the economy that contribute to those same ends, established some objectives:
- To review the Cantabria Climate Change Action Strategy 2018-2030, adapting its objectives to the commitments made by Spain in this area after COP25 (in contracting phase)
- To develop the "Circular Economy and Bioeconomy Strategy of Cantabria" (in design)
- To set up the "Advisory Council on Climate Change, Circular Economy and Bioeconomy of Cantabria" (constituted in 2019)

Other regional instruments and strategies contributing to the pathway to climate resilience:

- Regional Strategic Plan for the Management and Control of Invasive Alien Species
- Strategic Plan for the Prevention and Fight against Forest Fires in Cantabria ›

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- Cantabria Forest Plan.
- Strategic Environmental Plan for the Saja-Besaya Basin 2030. Action Plan 2022-2024.
- Law on Territorial Planning and Urban Planning of Cantabria
- Cantabria Environmental Audit Plan 2021-2027
- Regional Territorial Planning Plan of Cantabria (in approval phase)
- Cantabria's Green and Blue Infrastructure Strategy (design in process)

Local level

- General Urban Development Plan
- Climate Emergency Declaration of Santander
- Urban Adaptation Action Plans

Regarding Nature and Nature Based Solutions, the focus is on protection of valuable ecosystems. Various organizations and policies are in place; the Government of Cantabria oversees environmental protection through regional regulations and conservation programs. The regional Ministry of the Environment and the Environmental Agency of Cantabria are key players in developing and implementing conservation strategies. Nationally, the Spanish Ministry for the Ecological Transition and the Spanish Biodiversity Foundation contribute to broader conservation efforts. Additionally, Cantabria is part of the Natura 2000 network, which includes Sites of Community Importance (SCIs) and Special Protection Areas (SPAs) designated to conserve valuable habitats and species. Local environmental organizations and conservation groups also actively work to safeguard Cantabria's natural heritage through education, advocacy, and hands-on conservation projects.

4.2 Governance

The governance of Climate Adaptation in Spain / Cantabria region is characterized by top-down policies and responsibilities. In this paragraph we describe the governance from the four domains of interest: public sector, private sector, knowledge and civil society.

Public sector

Main actor in Climate Adaptation (and Nature Based Solutions) is the government. From the description of the current policy frameworks and the figure below, it is to be seen that there is alignment and connection between the governmental levels: national, regional and local on climate policies. Also the responsibilities are clear. The National government is responsible for coastal and fluvial areas. The regional government is responsible for rural development, environment and climate change. Cantabria consists of 102 municipalities. Half of the population is living in the city of Santander. City of Santander is much involved in NBRACER project team, while they are very active in greening the city to deal with effects of climate adaptation (heat, heavy rainfall) and applying Nature Based Solutions, together with civil society and citizens. Also Cantabria consist of 7 catchment areas, relevant to adapt to the effects of climate change, in case of heavy rainfall and flooding. Interesting an relevant for collaborative approach is the connection with the Business Forum and the existence of an Advisory Council. The Advisory Council on Climate Change, Circular Economy and Bioeconomy of Cantabria (constituted in 2019), has advised to involve all municipalities, stakeholders and

communities – "leave no one behind", in order to arrive to system change at regional level. Important will be to identify the needs of the people and to building trust. Managing this network of municipalities and communities is still challenging.

Currently the following public bodies are involved in regional governance:

National Public authorities (Coastal and fluvial areas), Regional Ministries and DGs (Rural Development, Environment and Climate Change, Urban and Spatial Planning, Water and Ports), Municipalities, aggregation of Municipalities, Chamber of Commerce of Cantabria (Environment Business Forum), Cantabria Climate Change and Environment Advisory Council.

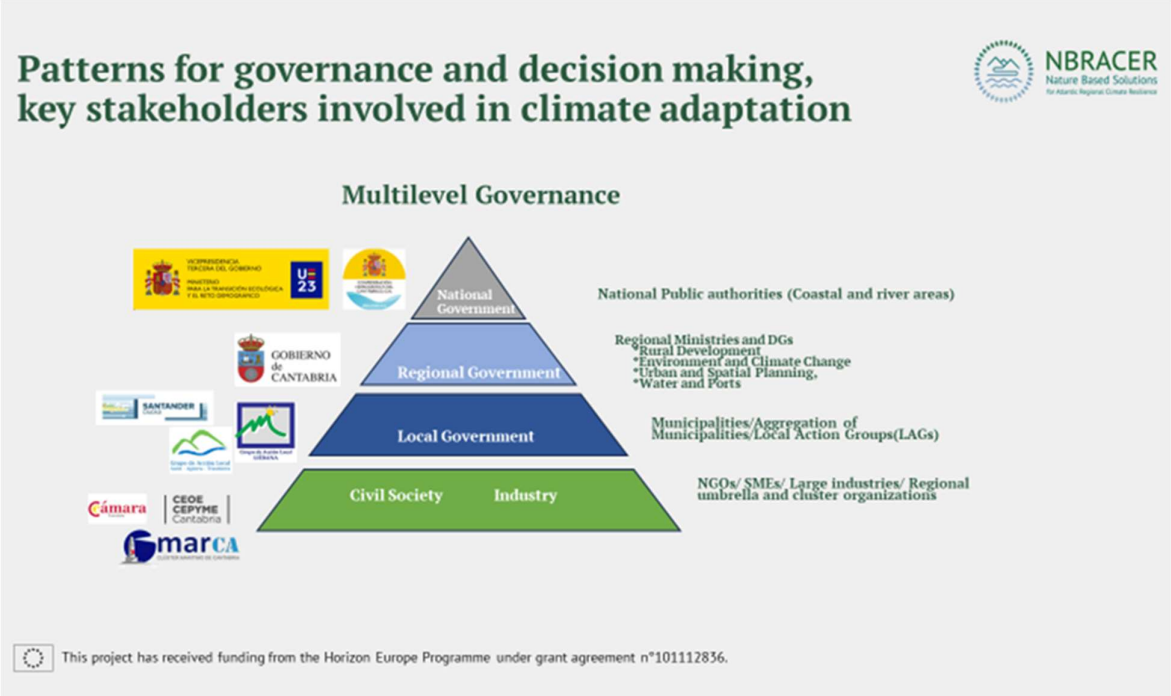


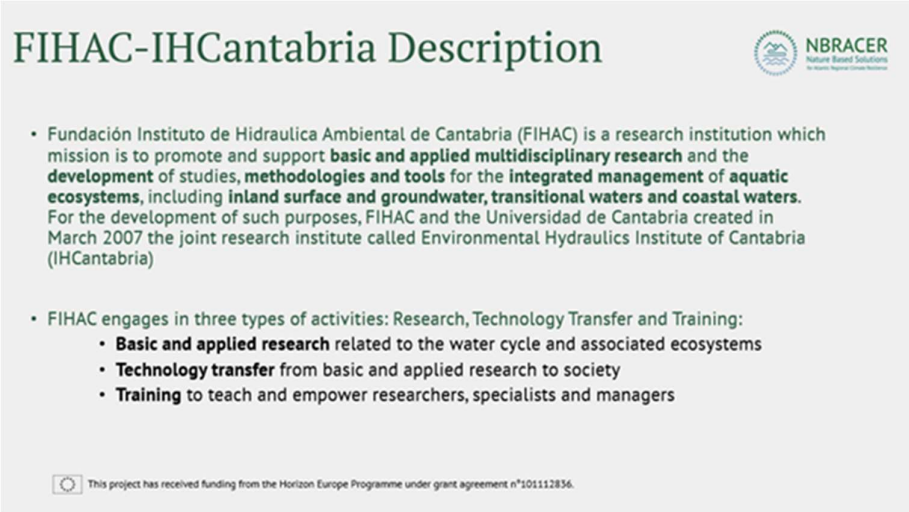
Figure 16: The regional governance on Climate adaptation

Knowledge partners

Next to the public sector also knowledge partners are active in climate change research, but they seems to be missing in the above scheme of Regional governance on decision making on Climate Change and managing the policy implementation process. These organizations have no formal role in the governance.

But the regional knowledge institutes have valuable data, knowledge and insights on the region, which are very useful in developing regional approaches and in designing and implementing Nature Based Solutions. Various knowledge institutes and researchers are actively involved in setting up local and regional projects, pilots and demonstrators to apply nature based solutions in the region, mainly in rural areas. These knowledge partners are also involved in the NBRACER Transformative Adaptation Journey, as well from climate change research, research on environment, water and hydrologics (IHC, FIHAC), both focusing on applied research and service development. Also RedCambera is involved from more societal

perspective, responsible for the participation process, which started with creation of an overview of perceptions on climate change and NBS.



4.3 Economy and private sector

Characteristics and numbers

GDP per capita: 26167€; Unemployment rate: 7.5%.

Cantabria is a region with a low export orientation: despite the intense progress in recent years, the weight of exports of goods in the regional GDP is below the Spanish average. In 2022, Cantabria exported goods worth 3510 million €, which represents 0.9% of Spanish exports. The main export sectors are iron and steel (16.8% of the total), chemical products (15.7%) and electrical appliances (12.1%). The total gross value added registered in Cantabria reached 12868 million € in 2019, of which 9027.9 million euros corresponded to the services sector, representing 70.2% of the total. It is followed by industry (20.8%), the construction sector (7.5%) and the agricultural sector (1.6%). Investment in research and development in Cantabria in 2022 was 0.9% of GDP, while the Spanish average is 1.4%.

Regional development and Innovation

From OECD and Vanguard[1] the following information on regional innovation will be relevant:

> *Innovation is a key aspect of regional competition. It is the main factor in order to close the gap between scientific progress and regional development. Innovation allows companies, and the industrial sector to be more competitive, increasing their benefits and creating a more advanced socio-economic ecosystem. Research and Innovation have to work together in order to create open innovation systems focused in all actors within the regional innovation: academia, companies, research centers, and public administration.*

Cantabria economy has been historically based on agriculture, fishing, and small-scale industry. Cantabria faces a number of challenges that affect its industrial transition capacity. If it could overcome them or mitigate their impact on the region, Cantabria will be better able to advance in its development aims. The most significant challenges are:

- The lack of an innovation culture.
- A lack of awareness – particularly among smaller businesses – of the potential benefits in engaging with the 'green' and digital transitions, particularly with respect to renewable energy.
- A skills shortage to engage in the green and digital transitions.
- A small and potentially shrinking workforce given the isolation of rural areas in Cantabria and the outward migration of youth.
- Limited capacity of smaller companies to engage with potential funding sources for innovation due to limited knowledge and resources.

Cantabria's agri-food sector accounts for only 0.7% of the region's total industry research and development (R&D) expenditure. The sector is accustomed to receiving European Union funds as well as grants and subsidies from the regional government, so there is little incentive to innovate in order to boost competitiveness, for example by considering new production processes. Instead, small agri-food companies tend to focus on their own operations and may miss opportunities to collaborate and share knowledge that could contribute to production, product or market innovation, for example.

There is a small and potentially shrinking workforce, given the isolation of rural areas in Cantabria, and the outward migration of youth Cantabria is both a coastal and mountainous region. Agri-food companies are located both on the coast (e.g. fisheries and canning businesses) and in more remote, mountainous or rural areas (e.g. beverage and dairy producers). This makes Cantabria's industrial transition challenges particularly place-based within the region itself, and more isolated areas could be left behind. Sparsely populated areas make it difficult to provide services and can lack sufficient infrastructure and job opportunities to retain people, especially younger generations. Moreover, many businesses in mountainous and rural areas are small family businesses that offer low pay and have difficult working conditions (e.g. long days, limited possibility for holidays, seasonal employment, etc.). The result is that young

[1] (From Vanguard website: https://www.s3vanguardinitiative.eu/members/cantabria and OECD (2023): Cantabria's High Impact Action: Social Inclusion in the Primary Industries In-depth assessment.)

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people are often reluctant to take over their family's business, preferring to move to urban areas or other regions.

Cantabrian Regional Government's Innovation Directorate developed a repository of agri-food companies it could potentially support to help advance Cantabria's industrial transition. The Regional Government identified companies with the potential to develop innovative sustainability, digitalisation or social projects in the agri-food sector to test solutions for Cantabria's industrial transition challenges.

Regional Smart specialization

Priorities 2014-2020:

- Agri-food specialised in high quality products
    - Agri-food specialised on dairy products
    - fisheries: semi-preserved fish products (anchovy), canned tuna and aquaculture and fishery products;
    - development of ICT systems for improving production control.
- Maritime Engineering
    - Blue economy related to off-shore energy, submarine mining, marine leisure resorts;
    - services for off-shore infrastructure, altitude aquaculture, resource control and prediction of coastal phenomena.
- Further, technology, 3d printing, manufacturing.

Priorities 2021-2027: five sectoral priorities of Cantabria's S3. These sectors are:

- industrial digitalisation;
- the health system;
- the blue economy;
- the agri-food sector;
- the culture industry/sustainable tourism.

Connections with developing innovative solutions and service to deal with Climate Change have not been made very explicitly, but for agrifood, blue economy sectors there should be opportunities for this region. Also challenges for Tourism and for health system are relevant.

Main potential network partners:

- The Directorates General for Fisheries and Food, for Industry, Energy and Mining, and for Social Policy
- The Cantabria Rural Development Network, a non-profit association with a strong network in the rural business environment
- The Santander International Entrepreneurship Centre (CISE)
- Other stakeholders included local governments, the Cantabria Chamber of Commerce, regional business associations, regional trade unions, the University of Cantabria and regional scientific and technology centres.
- Sodercan: Regional Development Agency: Mission To actively promote the strengthening of the industrial base of Cantabria:

    - To cultivate entrepreneurial talent and the creation of companies
    - To attract external investment
    - To support the development of competitive companies
    - To support the transformation of companies in mature markets experiencing difficulties competing on a global stage
    - To support the creation of the Knowledge Society and engagement with Public Entities
- Cluster:
    - SEA OF INNOVATION; Sea of Innovation Cantabria Cluster was designed to integrate all players within the marine energy sector of Cantabria, creating a national and international centre of excellence, connecting researchers, industry and leading companies to further research, development and innovation in the service of the economic, social and technological advancement of marine energy.
- Main challenges Sodercan (spokesman Abaitua):
    - Sustainability in regional innovation strategy (which is already part of it)
    - Reach out to civil society organizations and citizens
    - Involve politics, long term policies

4.4 Society

Demographical information

From the concept of social justice, identification of the most vulnerable groups with regards to climate change is relevant. Regarding rising temperature and heatwaves, elderlies have a higher vulnerability. Also, people living in cities are more vulnerable to warming as cities concentrate larger urbanized areas, lower vegetated and leisure areas and a lower percentage of permeable soils. Yet, some rural areas (Liébana, Ebro) are more vulnerable as the climate of these areas are dryer and warmer. Vulnerability to coastal erosion and flooding are people living in the coast. Particularly the coastal touristic sector is vulnerable as sea level rise directly threats touristic infrastructures and beaches (e.g. in Cantabria, 40% of the beaches are expected to disappear with sea level rise, according to the Cantabria Regional Strategy against Climate Change 2018-2030). On the other hand, valley bottom inhabitants in the lower reaches of rivers are more exposed to river flooding.

Cantabria's demographic challenges include a shrinking workforce due to the isolation of rural areas and outward migration of youth. The region's industrial base is distributed across both coastal and mountainous areas, making the transition to sustainable industry particularly complex. Sparsely populated areas struggle with providing services and job opportunities, leading to further depopulation, especially among younger generations. Many local businesses in mountainous and rural areas are small family enterprises that offer limited pay and difficult working conditions, which deters young people from continuing in these roles, preferring instead to move to urban areas or other regions (OECD, 2022).

Civil society engagement

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The Cantabria Regional Strategy against Climate Change 2018-2030 includes actions to increase civil society engagement and behavioral change, such as: the development and dissemination by social actors of the Sustainable Development and Education for development strategies, awareness campaigns for general society or capacity building in climate change for technicians working in regional administrations.

Engagement of the society in rural area through dissemination and outreach projects leaded by scientific institutions that include activities to co-design adaptation strategies. For instance:

- Citizens science and participation strategy development for climate adaptation by Red Camberra
- life ADAPTABLUES: e.g. Highschool contest on climate change adaptation strategies. https://escapadelcc.unican.es/
- Escape Climate Change project by University of Cantabria e.g. (https://escapadelcc.unican.es/)
- Cultural aspects, values and identity in relation to climate change and nature - information about the role of landscape in people's life: Some scientific projects carried out by IHCantabria (e.g. ZOSTECO, MARBEFES) demonstrate that coastal landscapes, such as estuaries, and coastal habitats (e.g. seagrass meadows) support cultural and aesthetic services for the people that live and use coastal areas.

4.5 Key insights Social System

Key findings and main characteristics:

- Cantabria is a varied and diversified landscape, with 7 catchment areas. There is a variety of networks of partners and distributed responsibilities.
- The approach on climate change adaptation is to a large extend public sector driven. Policies at the different levels are set or are in development. The region is responsible for climate policy implementation and rural development. The region consists of 102 municipalities, which makes it very challenging to involve all communities;
- The National government is responsible for coastal management.
- The current approach is strengthened by a strong regional knowledge base. The regional knowledge institutes have a good understanding of the region, foremost of the characteristics of the natural system. The Cantabria approach is much knowledge driven. The interactions are mainly research – policy exchange
- Within the region currently there is limited private sector involvement in Climate adaptation; strengthening awareness of climate change and Nature Based Solution in agricultural sector and the industries and the regional risks and challenges, can contribute to the creation of an innovation culture and ecosystem
- There is attention to citizens involvement in science and knowledge partner RedCambera is working on strengthening the participation on NBS within the region. Within the city of Santander, civil society and citizens are invited to get involved in NBS – greening the city.
- Coordination and management of the regional approach on climate adaptation, which is to be seen as a Transformative Adaptation Journey, is a challenge for

Cantabria, due to the limited interplay between the domains, the varied landscape and networks, and the somewhat formal and topdown Mode of governance. But, many partners and initiatives are active without being connected to the larger network. And the participatory process on climate change adaptation and Nature Based Solutions has started.

Directions

- search for coordination mechanism; management of the implementation of the Climate policies and the design and implementation of Nature Based Solutions, within and between the different landscapes and entities.
- strengthen quadruple helix interplay in designing and implementation of NBS in the region; mobilize the private sector and the civil society and stimulate the collaborative approach.
- search for specific regional opportunities in dealing with climate change and design and implementation of NBS. Connecting the coastal with rural areas and with the urban areas along the coastline. Mobilize the blue economy and the marine and coastal partners and clusters, next to the smart industries and the agri(food) production partners, in developing innovative solutions, new business opportunities

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5 Regional climate risks & Key community systems

5.1 Regional climate risks

Cantabria faces a range of climate-related risks that pose significant challenges to its food system, water management, infrastructure, and ecosystems. These climate risks include heat waves, flooding, droughts, and wildfires, each affecting distinct areas and systems within the region.

Heat Waves: Urban Impacts

Heat waves affect Cantabria and all Spanish regions. In response, Cantabria declared a climate emergency, aligning with the Spanish government's 2020 declaration to combat climate change. Urban areas, particularly the capital city of Santander, are especially impacted by rising temperatures. To mitigate these effects, initiatives such as the establishment of urban tiny forests using the Miyawaki method have been implemented. This approach involves planting dense, native forests in small urban spaces to enhance biodiversity and reduce heat (Urban Tiny Forest, n.d.). Additionally, restoration projects like the reclamation of the Marisma del Conde area in Ría de Cubas (Santander Bay) highlight the importance of integrating ecological restoration with urban resilience strategies (ihcantabria, 2024).

Flooding in Coastal and Valley Areas

Cantabria is highly vulnerable to flooding caused by sea-level rise, fluvial overflow, heavy rainfall, and seasonal changes. Coastal regions and low-lying valleys are particularly at risk. Rising sea levels exacerbate erosion and inundation in coastal zones, while storm events and fluvial flooding intensify the erosion of catchment areas and disrupt local ecosystems.

Wildfires in Mountainous Regions

Mountainous areas face an increased risk of wildfires due to drier climatic conditions and human activities. These fires are further intensified by rising temperatures and prolonged droughts, threatening both natural ecosystems and human settlements.

Risk Assessment and Mitigation

A public call for a comprehensive risk assessment is planned for 2024–2025 to address these challenges. Key climate hazards identified include:

- Flooding: Increased coastal and river flooding, erosion, and habitat disruption due to heavier and more frequent rainfall events.
- Erosion: Accelerated loss of soil in mountainous and coastal regions, particularly during storms.
- Droughts: Reduced water supply during summer months, especially in urban centers along the coast where tourism drives up demand.
- Temperature Extremes: Rising air and water temperatures, particularly impacting river ecosystems and inland areas.
- Wildfires: Heightened wildfire risks driven by drier conditions and human activity.

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These interconnected risks highlight the urgency of adopting adaptive strategies to safeguard Cantabria's natural and built environments. Efforts must focus on enhancing infrastructure resilience, conserving ecosystems, and promoting sustainable land-use practices to mitigate the escalating impacts of climate change.

5.2 Climate change and the Food system

In relation to the primary sector, over the course of this century, all the Maritime agro-climates in Cantabria will disappear, which will strongly reduce agroclimatic diversity. In addition, there will be a significant decrease in the productivity of pastures, both semi-natural and artificial, which will produce more vulnerability in the productivity of the livestock sector in general.

Regarding the agricultural sector, the maritime agro-climates of Cantabria are expected to disappear over this century, leading to a reduction in agroclimatic diversity. Additionally, a significant decline in the productivity of both semi-natural and artificial pastures will heighten the vulnerability of the livestock sector. Effective conservation strategies must address these climate-induced impacts to protect Cantabria's natural heritage and agricultural productivity.

5.3 Climate change and Water management

Cantabria boasts an extensive network of rivers, streams, coastal and maritime areas, and artificial lakes. As discussed in Chapter 4, the region's primary source of freshwater is rainfall, thanks to its temperate oceanic climate that provides abundant precipitation year-round. Additionally, meltwater from snow in the higher altitudes of the Cantabrian Mountains and the Picos de Europa significantly boosts the area's freshwater supply. Moreover, groundwater is also a crucial source of freshwater, supporting drinking water needs, economic activities, and natural ecosystems.

Water management in Cantabria is organized by various government agencies and organizations that work together. The regional government of Cantabria is responsible for developing policies and regulations related to water management. The Confederación Hidrográfica del Cantábrico is responsible for managing the river basins in northern Spain, including Cantabria. They handle the planning and implementation of water management programs, including the management of rivers and reservoirs. Municipalities are responsible for managing urban water, including drinking water supply and wastewater management. Furthermore, various environmental organizations in Cantabria work to protect water resources and promote sustainable water use.

Cantabria's temperate oceanic climate, marked by significant rainfall and mild temperatures, plays a crucial role in its water management system. However, climate change poses additional pressures, leading to various climate-related risks.

More extreme precipitation events can result in flooding and overflows in reservoirs and treatment plants, necessitating robust management and infrastructure to handle the excess water. Conversely, periods of low rainfall can strain water supplies, making efficient water use and conservation measures essential. This can impact the reliability of water sources and increase the demand on reservoirs and groundwater.

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Temperature changes can also affect water quality and the efficiency of water treatment processes. Warmer temperatures may lead to higher rates of algae growth in reservoirs, complicating water purification efforts.

Cantabria's coastal regions are at high risk from coastal erosion and flooding, severely impacting tourism infrastructure. Projections suggest up to 40% of beaches could disappear due to sea-level rise, posing a significant threat to coastal communities and economies (Cantabria Regional Strategy against Climate Change, 2018).

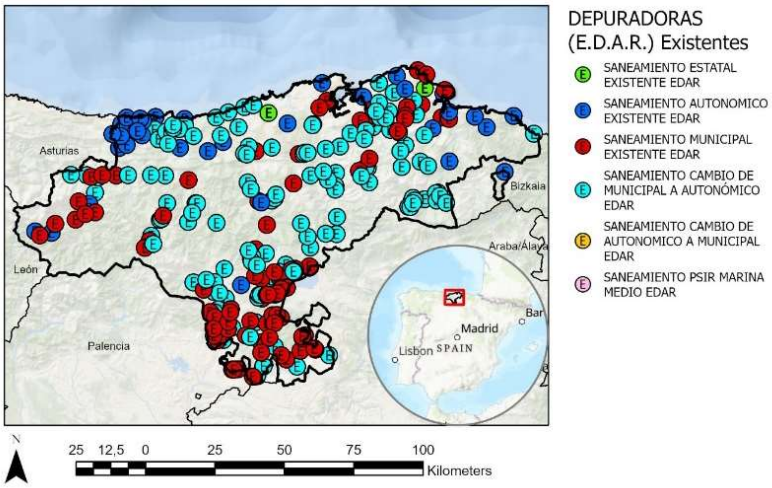

Figure 17: Existing wastewater treatment plants (EDAR) Cantabria, categorized by state, municipal, and autonomous management systems (Source: Mapas Cantabria)

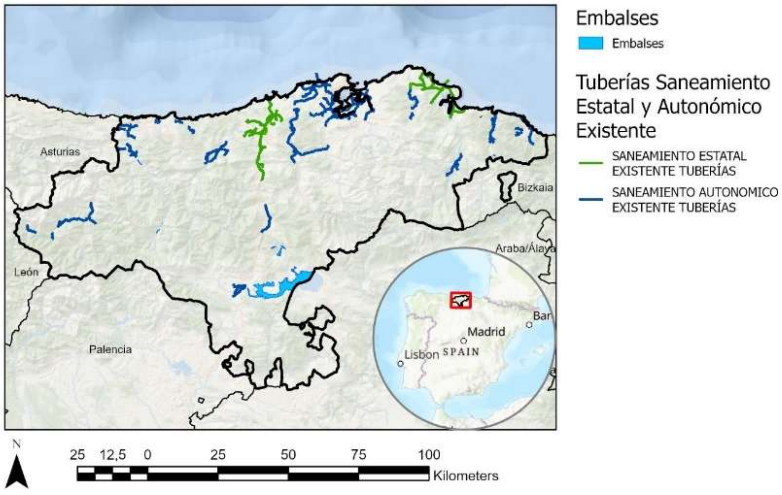

Figure 18: Reservoirs and Existing State and Autonomous Sanitation pipelines Cantabria (Source: Mapas Cantabria)

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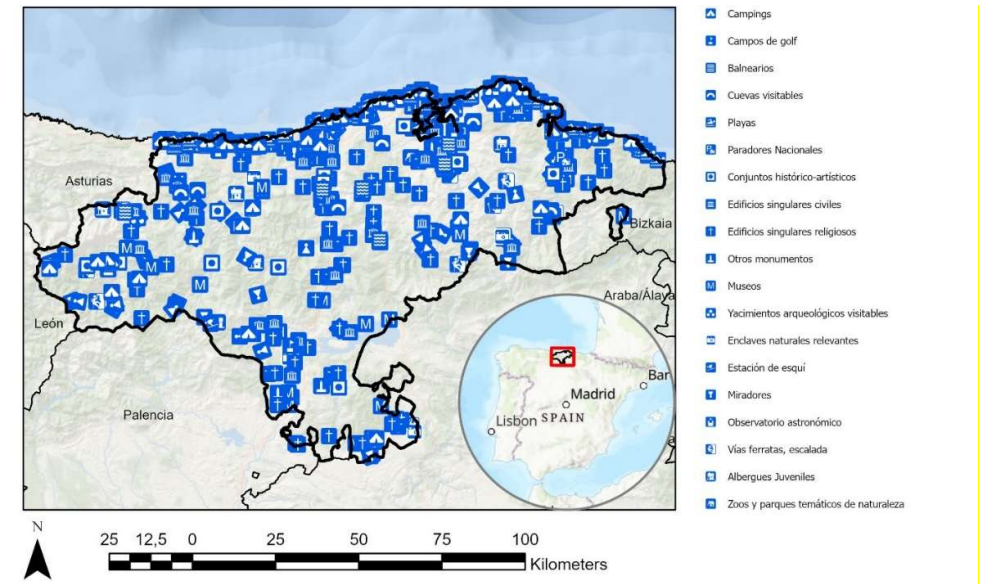

Figure 19: Map of leisure, sports, and tourism infrastructure in Cantabria, showing campsites, golf courses, beaches, museums, and other attractions (Source: Mapas Cantabria)

5.4 Climate change and infrastructure

Transportation and Road Infrastructure

The mountainous terrain in Cantabria continues to challenge transportation connectivity, particularly in rural and isolated areas. While major urban centers like Santander are accessible, many smaller towns remain poorly connected, with limited rail and road networks. Critical routes like the Autovía A-8 connect the region to major cities but do not adequately serve interior regions, affecting trade and accessibility (Gobierno de Cantabria, 2024).

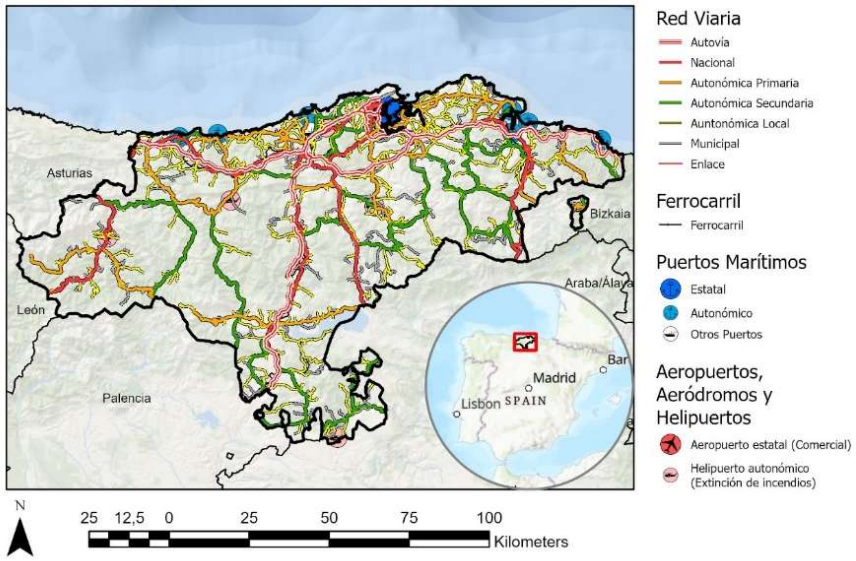

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Figure 20: Map of transport infrastructure in Cantabria, including road networks, railways, ports, and airports (Source: Mapas Cantabria)

Energy Infrastructure

Cantabria relies on hydrological energy production and distribution systems, which are essential for sustaining the region's resilience to climate impacts. However, these systems are also vulnerable to changing weather patterns and resource availability, requiring ongoing adaptation efforts (Gobierno de Cantabria, 2024).

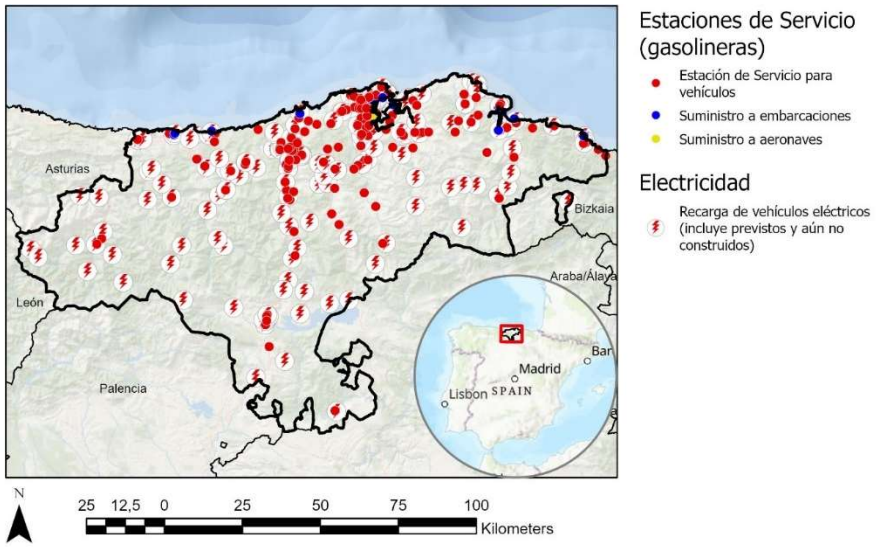

Figure 21: Map of energy infrastructure in Cantabria, showing fuel stations and electric vehicle charging points (Source: Mapas Cantabria)

Telecommunication Infrastructure

Recent investments have focused on improving broadband access in rural areas, a vital step to reduce isolation and support local economies, though challenges in remote connectivity persist (Gobierno de Cantabria, 2024).

Climate risks and impacts on infrastructure

Cantabria's geography also makes it vulnerable to natural hazards such as landslides, floods, and severe weather, which can disrupt roads and transport, further complicating connectivity in the region (PLOS Climate, 2023).

1. Coastal and Flood Risks: Cantabria's coastal infrastructure, including ports, roads, and tourist facilities, is highly vulnerable to sea-level rise, coastal erosion, and increased flooding. Projections indicate that sea-level rise could result in the disappearance of around 40% of beaches by 2030, directly threatening coastal infrastructure and impacting tourism (IFCA, 2019). Increased storm frequency and intensity also pose risks to ports and other coastal facilities, potentially disrupting trade and tourism (IFCA, 2019).

2. Water Infrastructure: Climate change, in increasing droughts and changing precipitation patterns, impact water availability and quality, especially during dry

periods when coastal populations experience heightened demand. Efforts to improve water transfer capacity between river basins are critical to mitigate these impacts, ensuring a stable supply even in times of drought (PLOS Climate, 2023).

3. Transportation Infrastructure: Cantabria's transportation infrastructure, particularly roads and rail, is vulnerable to landslides, flooding, and extreme weather events. The mountainous terrain further complicates these vulnerabilities, with rural and isolated areas being the most affected. Disruptions to transport infrastructure can lead to significant economic impacts, hindering access to essential services and exacerbating isolation in rural communities (PLOS Climate, 2023).

4. Energy Infrastructure: The region's energy infrastructure, including hydropower facilities, is susceptible to changes in water flow due to altered rainfall patterns and prolonged droughts. This can reduce hydropower output and affect energy supply stability. Additionally, increased temperatures can elevate the demand for cooling, placing additional strain on energy systems (SpringerLink, 2023).

In recent years, Cantabria has made significant strides in infrastructure development, supported by investments from the regional government, the Spanish national government, and the European Union. Projects like the Palencia-Santander high-speed railway aim to improve connections to central Spain, potentially alleviating some of the region's historical isolation (Gobierno de Cantabria, 2024). Furthermore, Cantabria has collaborated with neighbouring Asturias to enhance emergency and rescue operations in mountainous areas such as the Picos de Europa, which are prone to frequent rescue operations due to their rugged terrain (Gobierno de Cantabria, 2024).

5.5 Climate change and health

Spain has the highest life expectancy in the EU at 83.2 years in 2022, which is about 2 years above the EU average. Women tend to live about 5.5 years longer than men. People from low income groups have lower life expectancy, compared to people from high income groups. This difference related to environmental, social and economic factors, in particular differences in behavioural risks. Main causes of death are diseases on the circulatory system like stroke and ischaemic heart disease and cancer, in particular lung and colorectal cancer. But compared to the EU, Spanish people have rather low proportion of deaths that are related to unhealthy lifestyles. Mental health disorders are a significant burden, affecting more than one in six people in 2019. There is a socio-economic disparity in the prevalence of depression, with those in lower-income groups more likely to suffer. Spain has issued a Mental Health Strategy (2022-26) to improve care and promote community-based services.

Spain's health system provides universal health coverage, with most healthcare financed through public spending. However, out-of-pocket expenses (21%) are above the EU average (15%). The system is decentralized, with regional health authorities managing resources and services.

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Effectiveness: Spain has one of the lowest rates of preventable mortality in the EU, thanks to effective cancer screening and vaccination programs. However, regional disparities remain a challenge.

Accessibility: While access to healthcare is generally good, unmet needs have risen due to the pandemic. Efforts are underway to improve service coverage.

Resilience: Spain's health spending increased during the pandemic, and the Recovery and Resilience Plan aims to strengthen the system, focusing on digital transformation, health promotion, and addressing staff shortage.

The health system in Cantabria is integrated into Spain's decentralized national health system (SNS), which provides universal coverage to residents through general taxation. Health services in Cantabria are managed by the regional health authority, allowing for localized planning, resource allocation, and decision-making in service provision. Cantabria, like other regions, offers comprehensive services under the SNS, including primary care, specialized care, and emergency services. Challenges specific to Cantabria may include health workforce pressures, similar to broader trends across Spain, where shortages in certain medical specialties and general practitioners are prevalent, particularly in rural areas.

Cantabria's health services are part of a system that prioritizes prevention, with strong primary care structures aimed at reducing preventable hospitalizations. The region participates in Spain's broader health initiatives, such as cancer screening programs and the digital health transformation strategy.

The system faces some challenges, including the distribution of medical resources and equipment, which can vary across regions. Furthermore, out-of-pocket expenses in Cantabria may reflect the national trend, where dental care and optical services are less comprehensively covered, leading to higher personal spending on these services.

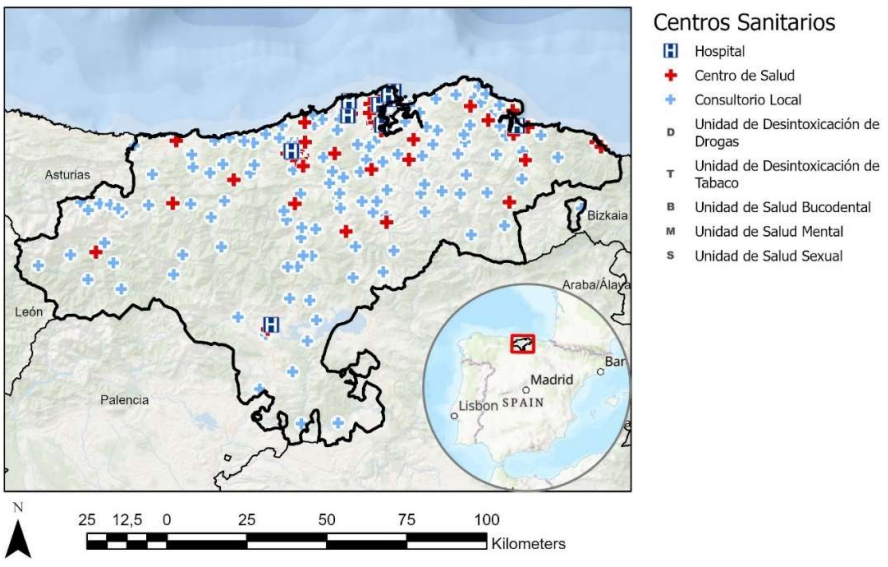

Figure 22: Map of health system infrastructure in Cantabria, showing hospitals, health centres, and specialized units (Source: Mapas Cantabria)

6 Connecting Natural and Social System

6.1 Readiness for NbS

Climate adaptation and Nature Based Solutions are still “poorly known” concepts in many regional and local administrative-technical departments. At the national level, a survey conducted in Spain on the public's perception of climate change showed that 65% of the population is completely sure that climate change is happening, with only 25% identifying it as negative. However, most people think that it could have a significant impact on their quality of life.

Some previous experiences in ‘NBS pilot actions’ implemented, but evidence of their impact on climate adaptation is still lacking. As another positive point, there are already lessons learned from some of the obstacles to the implementation of the NBS obtained in previous projects that have been worked on at regional level (e.g., the ALICE project).

Scientific-technical knowledge and public initiative to conserve and restore diverse ecosystems. Relevant initiatives have been taken by civil associations to conserve and restore the region's natural heritage. Both are facilitated by socio-ecological dynamics in the region that favour renaturalisation and are therefore favourable for the passive and/or less costly application of NBS. National and supranational funding programmes aimed at fostering climate resilience through the implementation of NBS.

6.2 Examples of Nature Based Solutions initiatives

Unless the readiness is still preliminary, Cantabria has already some experience with the design and implementation of Nature Based Solutions, which are mainly focused on management and conservation of well-preserved ecosystems (e.g., mature forests or alpine ponds and wetlands), as well as restoration of ecosystems (e.g., floodplains, afforested areas, etc.) promoted by different administrations. The following NBS examples are already taking place:

- Urban tiny forests planting (Miyawaki method) in Santander
- Restoring of a land claim area (Marisma del Conde) in Ría de Cubas (Santander Bay)
- Sustainable forest management in Eucalyptus plantations (Monte Corona)
- River profile and floodplain restoration. Project for the environmental and landscape conditioning of the Híjar and Ebro River Park and improvement of the state of the river and associated ecosystems
- Conservation of mature natural forest
- Restoring natural tidal flow in Ría de Capitán (Oyambre estuary)
- Prescribed burning in San Roque de Riomiera
- Conservation of native riparian forests along headwater streams
- Conservation of riparian buffer strips embedded in a forestry planting
- River profile and floodplain restoration. Environmental recovery of the Saja river between the Santa Lucía and Virgen de la Peña bridges (Cantabria)

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- Assisted natural regeneration of wetlands in Picos de Europa National Park (Las Salgardas, Cantabria)

Also the region has listed already the benefits of Nature based solutions for the region, which are relevant to involve and convince additional partners to collaborate on NBS in Cantabria:

> Biodiversity conservation, climate regulation, soil degradation regulation, water quality regulation, temperature regulation, C-sequestration regulation, flood regulation, soil erosion regulation, hydrological regulation, wildfire regulation, raw materials provision, aesthetic value, cultural heritage recreation/tourism and coastal erosion regulation.

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7 Key insights and conclusion

The current situation in Cantabria is very well suited for working on the objectives of the EU Mission on Climate Adaptation and the NBRACER approach of the Transformative Adaptation Journey. We concluded that Cantabria still is in early phase, but at small scale various initiative are already taking place. Also the policies are set and several 'regional planning strategies' related to 'climate adaptation' are actually in approval/design phase. However, multi-level and multi-actor governance of policy instruments related to climate adaptation requires additional coordination and management efforts which has slowed down innovation towards more systemic approaches. On the other hand, there are previous successful local/regional experiences with participatory processes related to regional/local policy instruments/strategies.

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Annex 6: Baseline Porto

NBRACER
Nature Based Solutions
for Atlantic Regional Climate Resilience

Regional Baseline report

Porto

Wageningen Environmental Research

Remco Kranendonk, Yawei Wang, Bertram de Rooij, Marlies van Ree, Ingrid Coninx

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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 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 Mission 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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1 A Regional baseline

1.1 Aim of the Regional Baseline

The aim of this regional baseline is to collect and share the regional information and to discuss the current situation among partners in the regions involved in NBRACER. By creating a baseline first insight on the current physical and social-economic context will be developed, relevant to deal with climate change, to plan and implement Nature Based Solutions (NBS) and to start the Transformative Adaptation Journey in each Demonstration region towards a climate resilient society.

The regional baseline comprises a collection of general regional information both qualitative and quantitative data. The baseline adopts a systemic approach to comprehend the intricate relationship between the natural system and the human/social system. Within this framework, three key components are delineated: the natural system, the social system, and the connection between these two systems within the key community services. Through this systemic approach, a clearer understanding of resilience-building mechanisms and pathways can be attained.

The baseline will give direction to region's specializations, unique characteristics, as well as its strengths and weaknesses concerning Nature-Based Solutions (NBS). The baseline will facilitate a common understanding, to support the joint sense-making for future visions and pathways.

1.2 Key concepts

Climate change can be approached in different ways. Therefore, it is important to describe the conceptual approaches that are underlying the NBRACER project and the analysis of information that has been collected for this baseline report. While many studies have been using an impact or risk-based approach, NBRACER is focussing on a systems-based approach to foster resilience. Key concepts related to this approach are:

- Systemic approach and key community systems
- The concept of regional transformation adaptation journey
- The transformational governance; concepts of collaboration and inclusion

1.2.1 Systemic approach and key community systems

The baseline adopts a systemic approach to comprehend the challenges that climate change poses on the region. The systemic approach is focussed to better understand the intricate relationship between the natural system and the social system. This approach starts from the Sustainable Development Goal's wedding cake that illustrates how economies and societies are connected with the natural system and in order to have a well-functioning economy and society, they should be well embedded in the underlying natural system.

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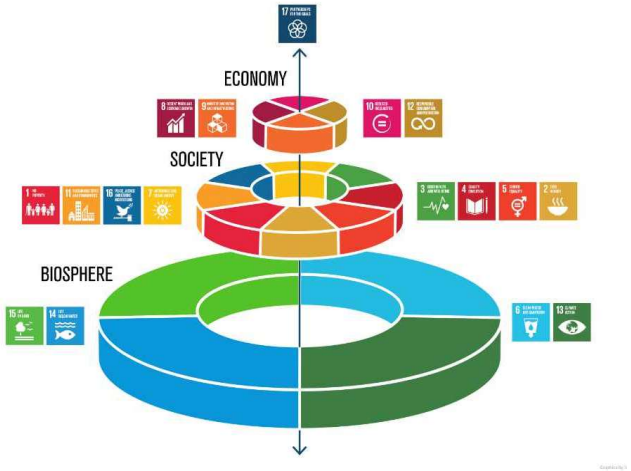

Figure 1: Wedding Cake of sustainable development goals (SDG), United Nations

In the baseline, we aim to analyse the different parts of the natural and social systems and their connection. This will help to move away from the environmental or sectoral approach only, that is often used in climate change assessments that considers nature separate from society and economy. Instead, it promotes a more systemic approach that explicitly focuses on the interrelationship between natural and social systems. Nature-based solutions inherently have the potential to strengthen this connection sustainably by leveraging the natural system's capabilities to address societal issues.

Within this approach, three key components are delineated: the natural system, the social system, and the connection between these two systems that includes the governance that is in place to ensure natural and human systems are in balance. Approaching climate change in integrated way enhance a better understanding on how to regain a balance between the natural and social systems given the context of the climate changes.

Related to this systemic approach are the key community systems that play a dominant role in the European Mission on Adaptation (European Commission, 2021). Key community systems are systems that meet basic needs for society but might be impacted by climate change. The EU distinct 5 Key Community Systems: the land use and food system, water management system, critical infrastructure system, the health and wellbeing system and the local economic system. The Mission Climate Adaptation is focussing on using the ecosystems and nature-based solutions in order to protect the key community systems to the negative impacts of climate change. The ecosystem is crucial for our wellbeing and ensure that we are ecologically connected, that nature is restored and that ecosystems services are delivered.

Furthermore, the baseline also summarize the available information on climate change risks and assess the related vulnerabilities of the key community systems due to climate change. To safeguard our wellbeing, it would be needed to assess the needs for transformation to ensure that the key community systems keep on meeting basic needs.

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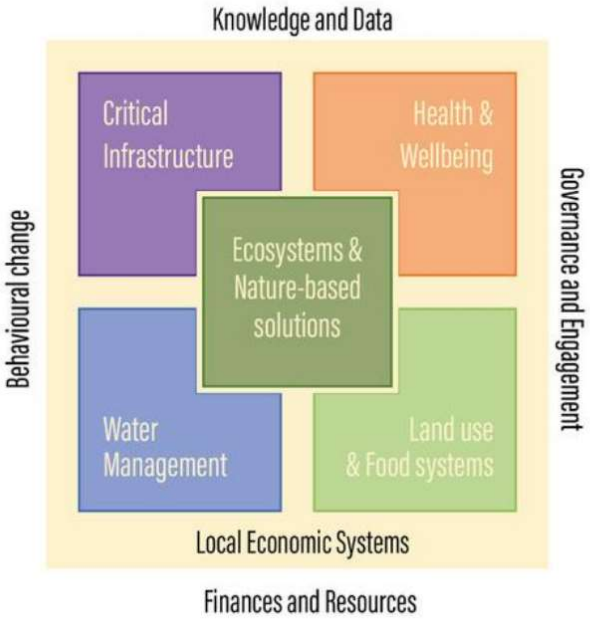

Figure 2: Key Community Systems (EU Mission of Climate Adaptation)

1.2.2 Regional transformation with the Transformative Adaptation Journey

As NBRACER aims for systemic transformation at the regional level, we are relying on the Transformative Adaptation Journey (also used in Pathways2Resilience) in order to bring forward the regional transformation. This approach is originally based on the adaptation policy cycle but is extended with elements that would enhance the collaboration between public, private, knowledge and societal partners.

The first phase of the Transformative Adaptation Journey - *preparing the ground* – is focusing on understanding what's already being done in the broader policy, social, environmental, and economic contexts, understanding who are the key actors and institutions needed to involve, understanding the socio-economic context and available resources, and providing evidence to determine regional priorities and opportunities for sustainable, climate-resilient regional development. Also climate risks and opportunities for prosperity need to be assessed. At the end of this phase, regions will have a comprehensive baseline covering, among others, risk assessments, adaptive capacity needs, a stakeholder map and a monitoring framework that will act as a solid foundation for the journey (Source Climate KIC, DesirMED).

The next step in the regional adaptation journey involves co-developing a *shared vision* with stakeholders. Active engagement is essential for creating commitment and ownership of the process and vision. This co-created vision will be a tool for mobilizing change and holding regional stakeholders accountable. It must be holistic, combining scientific insights with community priorities to foster a sustainable and equitable future. Public-private partnerships

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will be key to mobilizing resources and driving large-scale innovation. Ultimately, the vision must be dynamic, evolving with climate changes and lessons learned, and calls for courage, collaboration, and commitment from all sectors to protect our planet for future generations. (DesirMED)

Next step is developing *adaptation pathways* for climate adaptation and resilience gather interventions across multiple levers of change in a portfolio of actions, each of them contributing to progress towards the desired pathway,that will coincide with action & investments plans. While implementing the plans, it is aimed to closely monitor progress on the systemic change and to evaluate and learn and adjust actions if needed. In this way, building resilience via transformation becomes an iterative process, a journey, where all relevant regional stakeholders take part.

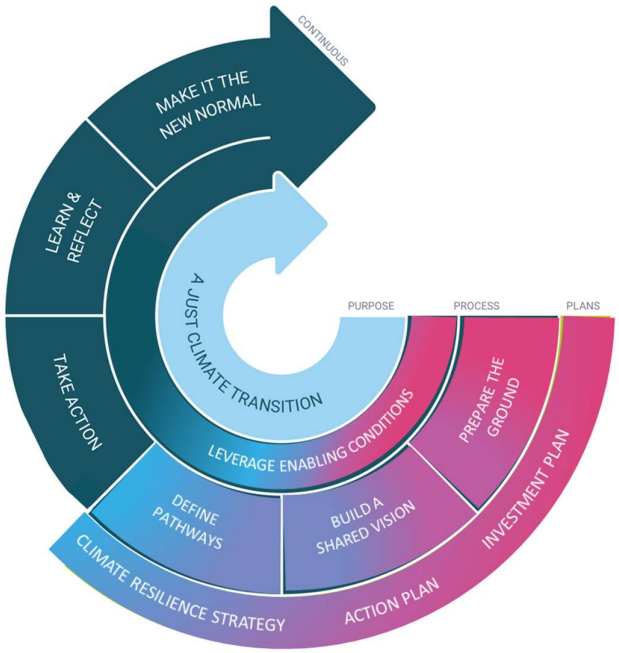

Figure 3: Transformative Adaption Journey (Climate KIC, P2R)

1.2.3 Collaborative and inclusive approach

The European Mission on Adaptation acknowledge the need to involve organisations beyond the conventional public actors, when it comes to building resilience. It is crucial that private partners, knowledge partners and society (*quadruple helix*) are involved in the regional transformation adaptation journey. This means that these partners need to be mobilized and engaged in the various phases of the transformational process and start with collaborating on directions and solutions to cope with climate change, and to create dynamics and initiatives within the specific regional context (*Smart Specialization*).

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The European Strategy on Climate Adaptation (2021) also promotes the principle of *just resilience* or *just transition,* indicating that adaptation processes have to be inclusive in order to avoid the risk that adaptation measures put an uneven burden on some groups and that marginalised groups are not well included in the planning and decision-making processes. Therefore, it is crucial to better understand who in the region might be unequally affected due to climate change and to ensure that they are well engaged in the development and implementation of adaptation measures to ensure that these measures meet their needs. Generally spoken, it is assumed that elderly, children, immigrants, single parents and poor people are more severely affected by climate change (Breil et al, 2021). However, it would be needed to explore vulnerable groups in the regional context and identify groups that are left behind.

1.3 Process of constructing the Regional Baseline

To create the regional baseline, the required information topics were defined and listed. As mentioned earlier, the baseline examines both the natural system and the social system, emphasizing their interconnections and key community services. For each component, we specified the necessary information to obtain the desired insights for the baseline. More detailed information about this systemic approach and its individual components will be presented in the upcoming chapter.

To gather this information, we distributed a document to the region that could be filled out, based on the list of required information topics. The region, possessing valuable insights into local conditions, significantly enriched our understanding of vulnerabilities, challenges, and opportunities. This collaborative knowledge-sharing formed the bedrock of our regional baseline.

Additionally, Wageningen Research supplemented this information with relevant online sources. We meticulously reviewed existing reports, data, and materials to enhance the insights shared by the regions. Our goal was to create an initial overview of the region's current state — a snapshot that captures its unique characteristics, risks, and adaptive potential.

The baseline serves as a starting point. During the regional workshop, we collected additional information and incorporated it into the baseline as needed. Our aim is to align with your perspective and regional expertise, ensuring that the baseline evolves dynamically throughout the NBRACER project.

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2 Description of the region

Porto city has a population of 231,800 (INE, 2021). The metropolitan area has around 1.8 million people (2023) making it the second-largest urban area in Portugal. The total surface area of the region is 41.42 km^2. Porto has one of the highest population densities with around 5,595 inhabitants/km^2 (INE, 2021). The municipality is administratively composed of 7 parishes.

Porto is located along the Douro River estuary in northern Portugal. The western part of its urban area extends to the coastline of the Atlantic Ocean. The historic centre of Porto was declared a World Heritage Site by UNESCO in 1996. The World Heritage Site is defined in two concentric zones; the "Protected area", and within it the "Classified area".

Porto features a warm-summer Mediterranean climate (Köppen: Csb), with influences of an oceanic climate (Cfb), common in the north of the Iberian Peninsula. As a result, its climate shares many characteristics with the warm, dry Mediterranean climates of southern Europe and the wet marine west coast climates of the North Atlantic, providing it warm, dry summers and mild, rainy winters. Cool and rainy days can, occasionally, interrupt the sunny weather. These occasional summer rainy periods may last a few days and are characterized by showers and cool temperatures around 20 °C (68 °F) in the afternoon. The annual precipitation is high and concentrated in the winter months, making Porto one of the wettest major cities of Europe. However, long periods with warmer temperatures and sunny days are frequent even during the rainiest months[1].

2.1 Urban Landscape

Porto is an urban territory made up of a diversity of areas resulting from different city formation phases, under historical characteristics and physical support. Porto's territory is, in its majority, covered by urban and industrial areas creating a total of 69% of impervious soil. The remaining area is composed by a more permeable soil scattered through the territory, such as green areas (gardens, parks), forests, farming areas and coastal areas. NBRACER implementing territory (Campanhã parish) is mostly composed by urban and industrial areas – this parish was one of the main industrial areas in Porto. Nevertheless, it has also a high number of green areas, showing some permeability (CMP, 2018a).

The city has a diverse level of slopes. Elevation is crucial to assess the influence/potential impact of climate change effects and contrasts with areas with coastal influence and areas with are more vulnerable to heavy rainfall. The municipality has a homogeneous hypsometry and an inclination oriented towards the Atlantic Ocean. (westernmost part of the city with elevations between 0 and 30m). The eastern zone is higher where it reaches maximum altitudes of 160m. The morphology of the municipality is clearly dissected by the watercourses, next to which it presents a greater slope.

[1] Climate of Porto - Wikipedia

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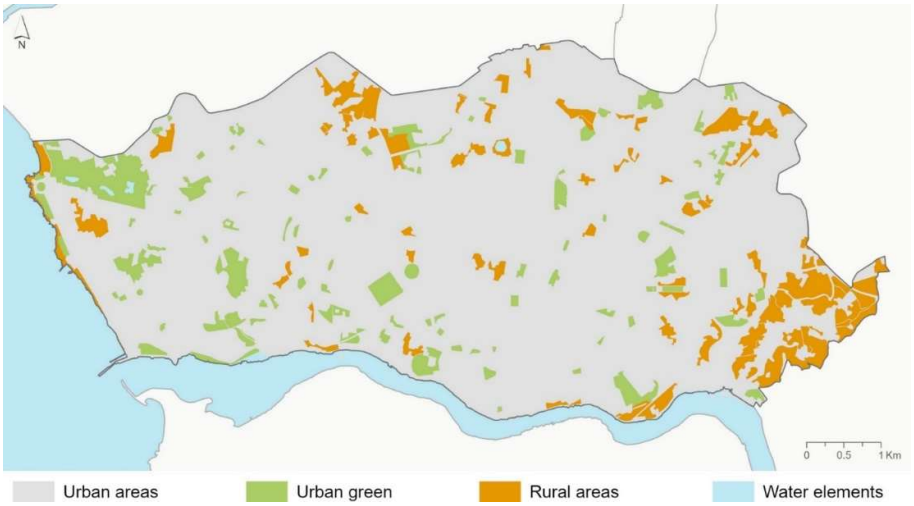

Figure 1. Porto's land use map (Source: European Union's Copernicus Land Monitoring Service, 2020)

Porto landscape is mainly composed of urban areas, with different types of occupation and morphology. The city has originated along the slopes of the river; the city has expanded gradually. This urban matrix also includes industrial, commercial and transport areas with some territorial expression. The presence of a relevant ecological structure with urban green spaces can also be noted.

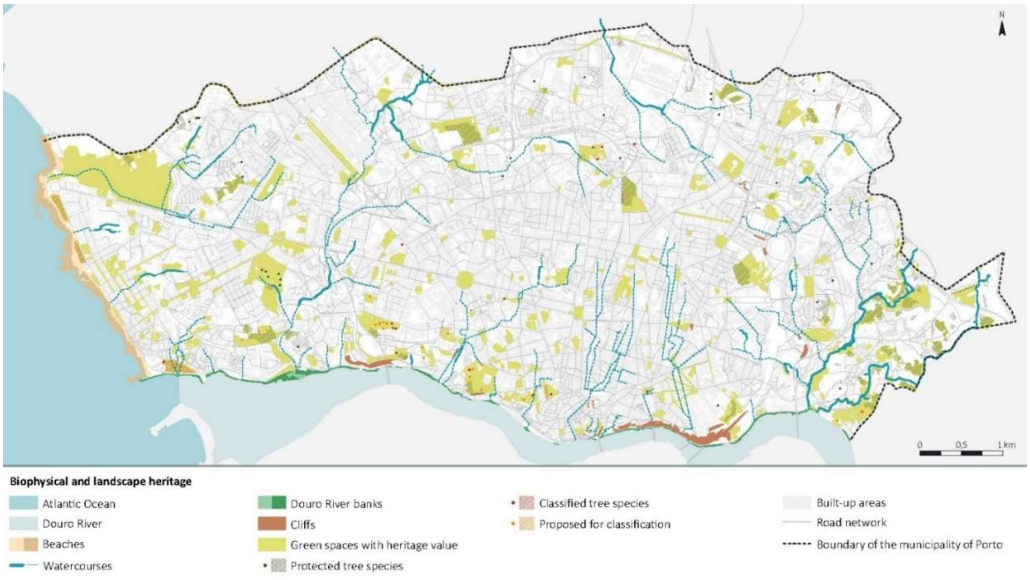

Figure 5: Biophysical and Landscape Heritage Map of Porto Municipality: Depicts key natural and built elements, including watercourses, Douro Riverbanks, cliffs, green spaces with heritage value, protected tree species, and proposed classifications, alongside urban infrastructure such as road networks and built-up areas (Source: CMP, 2020)

2.2 Rural Landscape

Porto's urban matrix still shows some rural spaces. Forestry, agricultural and pasture areas are present with greater expression in the parishes of Campanhã, Aldoar, Foz do Douro and Nevolgilde, Ramalde and Paranhos. The few rural areas that still exist in Porto have their origins

in the vast agricultural fields, pastures and forests that dominated the territory until the mid-20th century.

2.3 Coastal and Marine Landscape

Porto has an expressive Atlantic front that corresponds to the western limit of the parish of Aldoar, Foz do Douro and Nevogilde. The Douro riverside area with steep banks and hillsides, is strongly present in the city's landscape, being the southern limit of the municipality along five parishes. Regarding the eastern part of the city, it's also important to mention the Tinto and Torto riverside areas.

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3 Understanding the region: Natural system

3.1 Morphology

As referred above (2.1), Porto territory presents a homogeneous hypsometry, with altitudes between 0 and 160 m, so there is no great altimetric diversity. Porto is dominated by altitudes between 30 and 90 m (51%) and slopes below 5º (65%). In general, the territory descends smoothly from East towards West to the Atlantic Ocean to lower altitudes and flattened areas. Strongly delimiting the city, the Douro River defines an embedded valley with steep slopes (above 40º, 0.3% of the territory) in the South. In the NBRACER demonstration neighbourhood of Campanhã there are the highest altitudes, reaching 160 m, and the greater heterogeneity in terms of slopes, where flattened and moderated slopes contrast with slopes between 17º and 32º due to the influence of the Tinto and Torto rivers, tributaries of Douro River (CMP, 2018c).

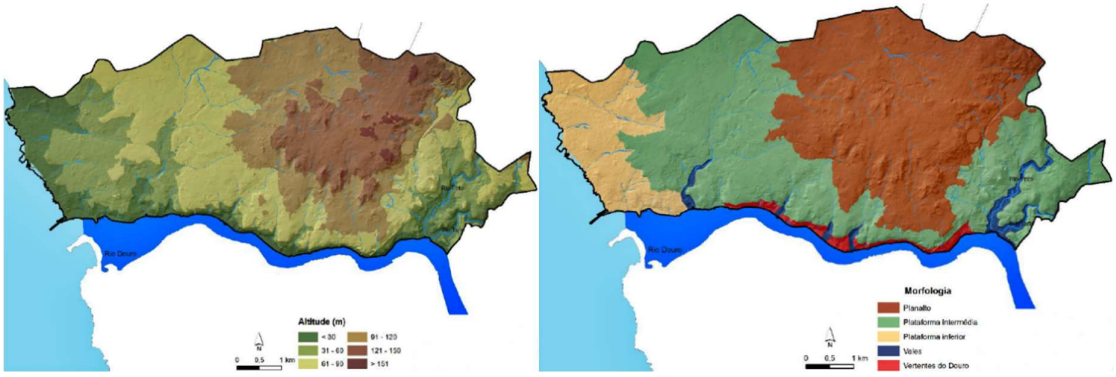


Figure 6 (a): left: Altitudinal map of Porto, the elevations across the territory ranges from 0 to 160 m, with the highest altitudes concentrated in the eastern areas near the Campanhã neighborhood. (CMP, 2018c)

(b) right: Morphological slope map of Porto, illustrating the variability in slopes across the region, with steeper slopes observed along the Douro River valley and tributaries such as Tinto and Torto rivers.

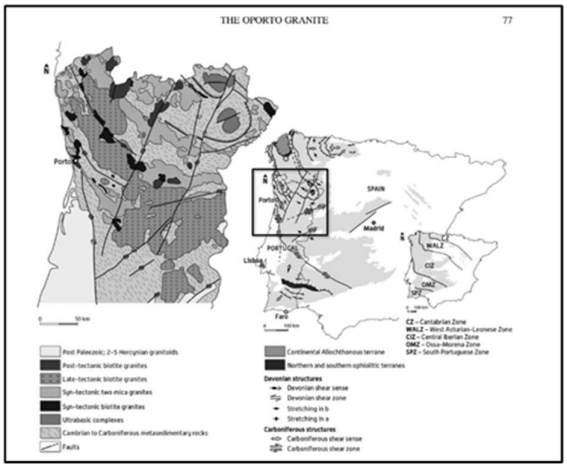
3.2 Soil

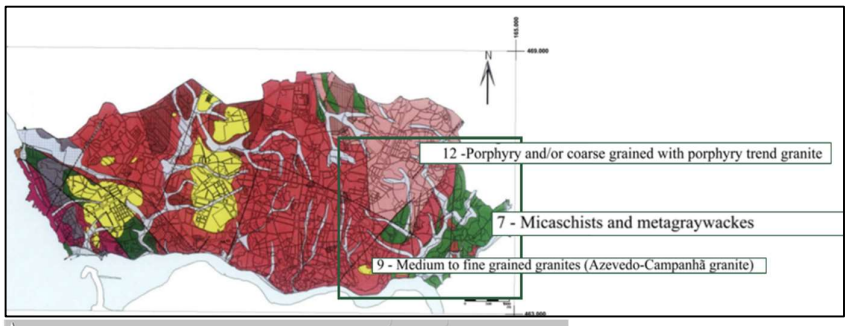
The diverse geological formations in Porto Region have a strong influence on the different soil types and landscapes.

Two notable soil types in the Porto region are granite soils and schist soils. Granite soils originate from coarse-grained igneous rock and are known for being nutrient-rich, well-drained, and acidic. These soils are typically found in areas with gentle slopes and good drainage. On the other hand, schist soils are derived from foliated metamorphic rock and are characterized by their thin, stony nature (Almeida and Begonha, 2015[2]). Commonly found on steep slopes, schist soils are nutrient-rich and have excellent drainage and water retention capacity. Bote granite soils and schist soils can be found in the neighbourhood Campanhã.

[2] Contribution of Portuguese two-mica granites to stone built heritage: the historical value of Oporto granite ANGELA ALMEIDA1 & ARLINDO BEGONHA (2015)

The diverse geological formations in the Porto region contributes significantly to the varied soil types and landscapes, shaping the region's unique agricultural and ecological characteristics.





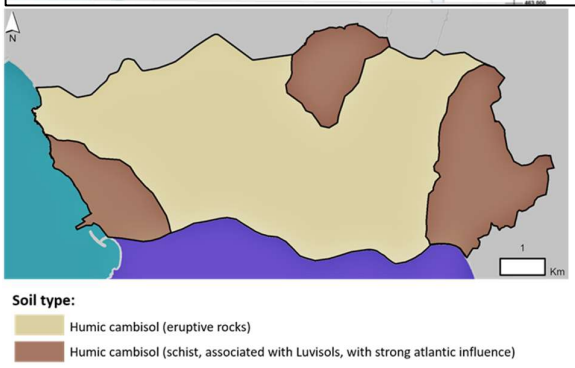


Figure 7(a) & (b): Geological map of Portugal, showing the Porto region and its surrounding lithological formations, such as porphyry granites, micaschists, and metagreywackes (Source: Almeida & Begonha, 2015)

Figure 7 (c): Soil map of Porto, categorizing regions by humic cambisols, formed either on eruptive rocks or schist, associated with Atlantic influence (Source: CMP, 2018b)

3.3 Water

Porto is situated at the mouth of the Douro River, which plays a significant role in the region's water system.

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The Douro is the third largest river of the Iberian Peninsula, encompassing Spain, Portugal, Andorra, Gibraltar, and a small part of France. It flows into the Atlantic Ocean, where tidal influences affect the water levels in the river estuary and the coastal areas.

Furthermore, the surrounded area of Porto features various smaller rivers, streams, and water sources that contribute to the local water system, providing water for drinking, agriculture, industry, and recreation.

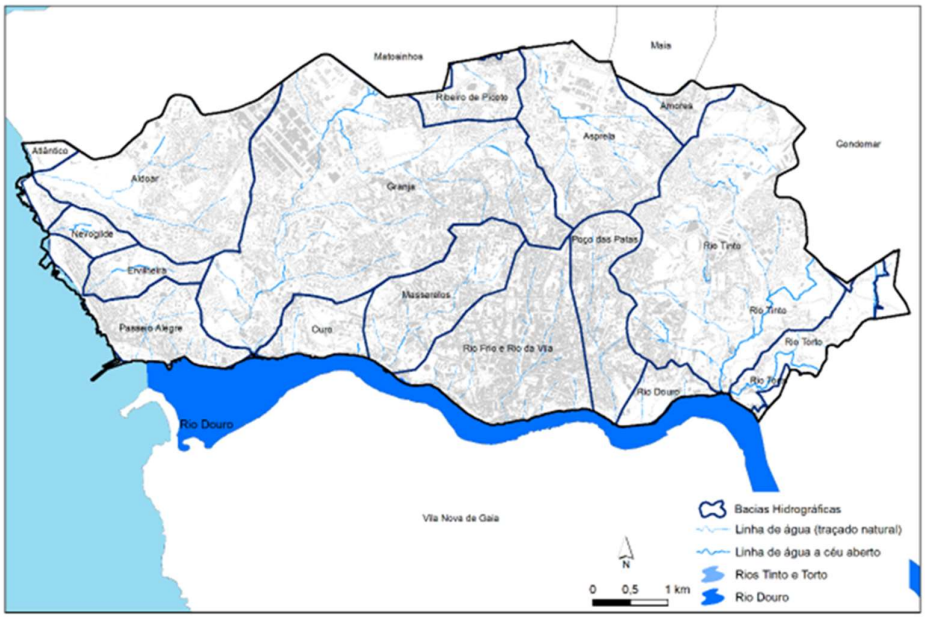

Figure 2. Porto municipality hydrographic network and river basins (CMP, 2018c)

3.4 Nature

Porto is acknowledged for its green urban scenery. The region's fertile soils and favourable climate, including abundant rainfall, create good conditions for urban green spaces.

Porto and its suburbs are renowned for their numerous green spaces and parks, with urban planning playing a significant role in maintaining and expanding these areas. Campanhã is one of the parishes with a higher proportion of green spaces, yet most of them are poor in ecosystem services. The municipality has invested in restoring these spaces, with Parque Oriental da Cidade do Porto (Oriental city park) and Parque Alameda de Cartes (Alameda de Cartes Park) being examples of this.

Connectivity between different landscapes is ensured by the Municipal Master Plan (MMP; 2021) and the Municipal Ecological Structure within the MMP. According to Farinha-Marques et al. 2018, the total area occupied by urban green spaces (permeability value) is 13.14 Km^2 around 31%. According to the same author, in 2018 Porto presented 7.9m^2 of public green spaces *per inhabitant*, and a total area of green spaces of 55.3 m^2 *per inhabitant*.

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Figure 9. Natural Spaces and Urban Green Spaces in Porto Municipality (Source: CMP, 2018b)

The city's commitment to expand green spaces is further evident in initiatives such as tree planting, extensive tree coverage, and the implementation of green roofs, all contributing to Porto's green landscape.

Figure 9 (a) top left: Satellite image showing the geographic context of Porto (Source: Google Map, retrieved on 2024) (b) top right: Map of natural spaces and urban green spaces in Porto (Source: CMP, 2018b); (c) Bottom left: Photo of Parque Oriental da Cidade do Porto (Source: author, 2024); (d) Bottom right: Land-use classification map, with overlays for protected and unprotected areas. (Source: CMP, 2018c)

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3.5 Key insights Natural System

Historically, Porto's location was tactically chosen considering factors related to the water and soil systems, ensuring strategic advantages.

The city's green spaces are strategically situated in less desirable building zones characterized by steep slopes near valleys. These areas are composed of Schist soils, prone to erosion, but the strategic placement of greenery in these locations plays a crucial role in erosion prevention.

In contrast, the parish of Campanhã appears to have been developed in a location less optimal for soil and water systems. This is likely caused by the fact that more favourable locations in the area already became occupied.

A closer look at Campanhã reveals that the built areas are predominantly concentrated in the northern part, where the terrain is more stable and flatter than in other parts of the parish.

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4 Understanding the Region: Social System

4.1 Governance

4.1.1 Responsibilities

Multilevel alignment of policies and responsibilities between National – Regional – Municipal level is an important pre-condition for an integrated approach for transformative approach on climate adaptation.

Portugal decision-making power is divided in different governmental levels, characterized by a balance between central government and local government, depending on the issues. However, it must be noted that Portugal does not have regions and therefore the central government sets several decisions with impact at the local level.

The different levels of government and their responsibilities are:

- Central government (based in Lisbon): holds the most significant decision-making power in all important matters (e.g. education, national security, justice, healthcare and infrastructure) and it's also responsible for endorsing laws and policies applicable to the entire country;
- Local authorities composed by municipalities and parishes. Municipalities have autonomy to manage local affairs, including urban planning, public services (e.g. water supply and waste management), local taxes and social services. Parishes have much more limited responsibilities, focused on community-level issues (e.g. local events and small-scale infrastructure projects).

Porto Municipality integrates Area Metropolitano Porto (AMP). The AMP is a public inter-municipal association comprising 17 municipalities, which does not hold legislative powers but serves as an expected platform of dialogue and coordination among its members to address shared challenges and common goals for region development. The municipalities within AMP retain their autonomy and decision-making powers over local matters within their jurisdictions, as referred to previously.

4.1.2 Policies and strategies

Connection and integration of various policy fields is an important pre-condition for an integrated regional approach on climate adaptation: climate, rural development, agriculture, circular economy, soil, water, regional development, spatial planning, and social policies.

Climate policies

Municipality of Porto has much relevant policies on climate change (mitigation and adaptation):

- Municipal Master Plan (2021): a new approach to sustainability, urban environment quality and citizens well-being; territory resilience and adaptation to climate change.

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- Municipal Climate Action Plan (2024), derived from the Municipal Strategy for Adaptation to Climate Change (2016), which was evaluated in 2023: 151 projects were implemented (33 ongoing) and represented a municipal investment of 234 million euros.
- Porto Climate Pact: Porto's neutrality can only be achieved with concrete actions carried out by all stakeholders, public and private. The ambition is that Porto becomes the national leader in climate action, anticipating carbon neutrality to 2030.
- EU Mission - Climate-Neutral and Smart Cities: Porto was selected by the European Commission to be part of the group of 100 Climate-neutral and Smart Cities, and as a Mission City, Porto has the ambition to be a leader, at national and European level, in climate action, anticipating carbon neutrality to 2030.
- EU Mission on Adaptation to Climate Change: Porto takes part of this mission.
- Strategic Masterplan for Porto Eastern Area: applied to areas on Campanhã parish, considers the response of urban planning to the potential effects of climate change; includes the implementation of Porto's Eco-district: a sustainable city model on environment, social and economic level.

Policies and strategies on nature-based solutions:

- The Municipal Master Plan (2021) defined the densification of the city's green structure, including: doubling the green area of public access; structured tree planting on city streets; reduced fees for operations that vacate the interior of blocks, making them permeable green spaces.
- Enhancement and Rehabilitation of Porto Watercourses Plan (PVRLA): the creation of retention basins, the increase in the permeability of the territory and the renaturalization of piped sections of watercourses are the main solutions described.
- Municipal Strategy for Adaptation to Climate Change (2016) which will be followed by the Municipal Climate Action Plan.
- More Permeable Porto (ongoing): identification of hotspots within the city related with flooding during extreme rain events and finding short-term and medium-term solutions to solve the problem.
- Porto City Tree Planting Plan 2023: improving the conditions for sustainable tree planting in public space; enhancing ecosystem functions and services generated by trees (supporting, provisioning, regulating and cultural) in streets and contribute to the adaptation of the city and its infrastructures to climate change. The document operationalizes the municipal ecological structure and defines a strategy for the future: which trees we need and which trees we can have, how and on which streets in the city.

Municipal Climate Action Plan

In view of the risks identified for the city, and maintaining the trend of worsening climatic climate effects, and their impacts, both present and future, the municipality has identified its priorities for adapting to climate change. These priorities aim to reduce exposure to climate risks, strengthen the resilience of the city's various infrastructures and facilities, reinforce the response of the different support networks for the population and improve the conditions of habitability and use of the city.

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Aware of the direction and path to follow, Porto Municipality, supported by its various planning and territorial management planning and territorial management instruments, such as the Municipal Master Plan, the Municipal Emergency and Civil Protection Plan, sectoral plans and strategies on Water Safety, Health, Afforestation, Housing, Noise, Mobility, Circular Economy, Food System, among many others, defined a set of major adaptation objectives that are intended to embody the municipality's ambition to increase the city's resilience in the various sectors and areas of activity.

The major adaptation objectives for Porto are:

1. Increasing the protection of natural risk zones and vulnerable areas
2. Promote the bioclimatic comfort of public and private buildings through the use of sustainable solutions and improved thermal efficiency
3. Increasing the resilience of public spaces through the expansion and ecological upgrading of the of the green structure in order to improve bioclimatic comfort and valorise the water lines
4. Improve the efficiency of the urban water cycle by adapting the network and the infrastructures associated with water management
5. Increasing the efficiency of the city's warning and emergency systems
6. Improve people's health and safety conditions
7. Increasing climate literacy

Adaptation targets have been set for each of these major adaptation objectives, which are monitoring and evaluation tools that are crucial to achieving the climate resilience needed for the city's future. Within each of the adaptation targets were defined actions. Adaptation actions are broken down into a programme of adaptation measures that reflect a set of municipal projects and initiatives aimed at increasing the city's climate resilience in the short and medium term.

This plan also includes climate mitigation, in line with adaptation measures. By signing up and being selected as one of the European cities to take part in the '100 climate-neutral cities by 2030' Mission, Porto has committed itself to achieving an 85 per cent emissions reduction target by 2030. Several targets were defined to achieve this mains objective, namely: emission reduction in buildings (-98%), transport (-78%) and waste (-40%); and a 140% increase for carbon capture. For this, several actions were plan under the four main domains identified: a) Porto More Green; b) Better mobility; c) Clean and efficient energy; Greater circularity.

Investment:

A large part of the investment allocated to increasing resilience and adaptation to climate change is planned and identified in the Implementation Programme and Financing Plan of Porto's Municipal Master Plan. With an overall budget of around 900 million euros over 10

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years, the MMP foresees an allocation of around 680 million euros for projects with the potential to adapt to climate change in the city.

Notwithstanding the more than 75 per cent of the investment planned in the MMP allocated to the adaptation component, the remaining 25 per cent has great added value for reinforcing investment on the mitigation side, as a result of projects to transform mobility and the city's public transport sector, which reinforces the city's great commitment to climate action. In addition to the investment provided for in the MMP with the identification of various adaptation and mitigation actions, the Municipality created a specific municipal fund to financially support the implementation of the MMP and, inherently, the implementation of the Municipal Climate Action Plan, creating financial mechanisms capable of ensuring and guaranteeing the availability of the 450 million euros needed to adapt the city by 2030.

Other policies

Spatial policy

- Municipal Master Plan (2021): a new approach to sustainability, urban environment quality and citizens well-being; territory resilience and adaptation to climate change.

Regional economic development

- Porto City Council develops relevant economic studies to support its decision-making, as well as the decisions of Porto's citizens, investors and the business community. The collected empirical and proven information is essential to better define strategies, policies and action plans: www.cm-porto.pt/economia/estudos-estrategicos
- Porto Economic Development Strategy (PULSAR): identifies the urban matrix trends for the city of Porto development and carries out a high-level diagnosis and strategic vision. This strategy identifies the priority axes and potential structuring projects with a medium to long-term time horizon, and adapts these projects to financing instruments conveyed by the Recovery and Resilience Plan and framed in the Next Generation EU and the EU Green Deal.

Biodiversity and nature

- Municipal Ecological Structure (MES): The MES represents a municipal planning figure, whose delimitation in the Municipal Master Plan has become mandatory. It is essential for territory protection, ecological conservation and environmental and landscape enhancement.
- Porto Municipality is developing a Biodiversity Strategy for the city.

Water

- Enhancement and Rehabilitation of Porto Watercourses Plan (PVRLA): this plan is part of the Municipal Climate Change Adaptation Strategy and results of the recognition of the importance of watercourses as a strategical axis for the city's sustainability and adaptation to climate change, while considering the best natural engineering practices.
- Porto Urban Drainage Master Plan: structuring the rainwater drainage system to increase its resistance to extreme weather phenomena; improve the ecological and

environmental quality of the city water bodies; contribute to the preservation of natural and marine resources and ecosystems.

- Porto Wastewater Complex Recovery: redesign and modernize wastewater treatment plants, positioning this system at the forefront of environmental sustainability.
- Gravitational Porto: redefines the areas of the water supply and distribution, using the city's topography for distribution in a 100% gravitational way. Between 2006 and 2020, total energy savings were around 2.18 million euros.

Circular bio-economy

- Circular Economy Roadmap: identify opportunities and guidelines, build a long-term vision in order to transform Porto into a circular city in 2030.

Renewable energy

- The Porto Solar project consists in the installation of photovoltaic systems on 29 rooftops of municipal buildings, 25 of which are schools in the municipal public network.

International networks

Porto Municipality also participates on several international networks to improve knowledge and share the best practices:

- Covenant of Mayors (since 2009)
- Carbon Disclosure Project (CDP): Porto's commitment to environmental and sustainability issues is also reflected in its adherence to the CDP reporting a city-wide emission inventory. In addition, it must have set a renewable energy target for the future and published a climate action plan. CDP also looks at the risk and climate vulnerability assessment made by cities, as well as the existence of a climate adaptation plan to demonstrate how it will address climate risks (CDP_city_of_Porto).
- Eurocities Network: Porto has been a member of the Eurocities Network since 1990 and has been actively involved in environmental issues and on the food working group.
- Green City Deal: a movement of European mayors committed to making cities healthier, implementing relevant EU environmental laws. By signing the Deal, cities commit to addressing five areas of environmental management: air, water, nature and biodiversity, circular economy and waste, and noise.
- Member of Ellen MacArthur Foundation (EMF): involvement as a partner of the EMF since 2018, an international organization that promotes the principles of the circular economy worldwide, involving municipalities, companies, experts, and civil society.

Climate change, vulnerability, governance aspects

The Porto partners have made an inventory of the problems and vulnerabilities regarding governance, policies and strategies on climate change and climate adaptation:

- Climate action subject to the intermittent dynamics of political cycles
- Lack of articulation and cooperation between regional and national entities
- Lag between decision/action and their consequences
- Legislation not aligned with reality

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- Lack of climate literacy

4.1.3 Governance: Quadruple helix interplay

Relevant underlying concept on organizational aspects of transformative change is the Quadruple helix, which is referring to engage, align and to create an interplay between the four domains: Public sector, Private sector, Knowledge partners and Civil society.

Collaboration among partners often starts with representation of the different domains and stakes. For visioning, design and implement Nature Based Solutions, people and organizations will become partners in mission-driven innovation. The partners bring together their various resources, such as financials, knowledge, capacities and creativity, in order to be able to deal with the challenges and to collaborate on the mission-driven innovation or transformative journey. Also relevant is to connect strategic and operational levels. To be able to put the mission and solutions into practice.

In this baseline we describe the current partner network, the representation of the four domains, and the interplay among the various partners.

Public sector

At the Municipal level the following functions and responsibilities are actively used within Climate Adaptation: planning, regulating, encouraging good practices (Environmental Index, for instance), experimenting, monitoring, demonstrating and sharing knowledge from the experiences conducted. Within NBRACER Porto is represented by the Porto Municipality. The municipality has a strong program management already active within the EU Urbinat project. The program management is able to mobilize and connect different policy sectors and instruments.

Private sector

The private sector has been active in voluntarily implementing NBS solutions in Porto (green roofs, fronts, parks and gardens) as it increases the property values. At the same time (after negotiations with the municipality) there have been parks and water courses restoration projects implemented by private developers.

Knowledge domain

The municipality has a good collaboration with Porto University, the Faculty of Sciences from University of Porto (FCUP), with active involvement of landscape architects, for example designing NBS at premises of Porto University. This Faculty holds much local knowledge on the urban ecosystem and landscapes. Participating in municipal and regional planning from research domain is taking place with know-how (for instance the Municipal Master Plan was revised after several studies from different research groups in Porto), by generating knowledge and educating the next generation professionals.

Civil Society

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Several NGOs are active on Climate Adaptation in Porto, with Green Roofs Association being a good example. Many other societal groups have been involved in the different municipality projects. For example, in the design of the URBINAT project, civil participation was at its center and resulted in a 4 hectares interstitial park connecting social housing, schools, among others services. Campanhã Parish Council is participating in NBRACER.

Other partners of Porto Municipality NBRACER network are:

- Private municipal construction company (GO Porto)
- Private municipal culture and sports company (Ágora)
- Private municipal environment company (Porto Ambiente)
- State-owned company for road and rail infrastructures (Infraestruturas de Portugal, S.A.)

4.2 Economy

Porto is the largest city in terms of economic activity of the Portuguese Northwest and its economic profile comprises activities that tend to be concentrated in the largest urban centers, such as business services, commerce, hotel industry, education, health and social support. Business services generate 43% of jobs in Porto, most of which are concentrated in administrative and support service activities, consulting, scientific research and development, and information and communication activities.

Porto's productive structure (both current positioning and the potential for the future) determined the need for a more specific analysis of eight areas of economic activity:

- Traditional: Commerce and Services, Tourism, Real Estate, ICT and Service Centers;
- Emerging: Culture and Creative Industries, Health;
- Wild-card: Blue Economy and Energy and Environment (Porto City Council, 2022).

Regional development

Porto Economic Development Strategy (PULSAR): identifies the urban matrix trends for the city of Porto development and carries out a high-level diagnosis and strategic vision. This strategy identifies the priority axes and potential structuring projects with a medium to long-term time horizon. The Motto of the development of Porto is: FROM "MORE PORTO" TOWARDS "BETTER PORTO", which may be relevant for becoming a more resilient city from a perspective of Climate Change.

This strategy has the following characteristics:

- Participatory, broad stakeholder involvement.
- Broad perspective: sustainability central, identity.
- Green economy
- Porto positions itself among the most sustainable cities (A3), actively contributing to address climate change and to the promotion of the circular economy.
- Green economy and climate transition reinforce circular economy and business activity, while implementing policies that effectively tackle climate change and reach towards carbon neutrality

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- Focused on smart specialisation and sustainable growth in value (replacing growth in volume) - immaterial values; knowledge, R&D, technology and sustainability domains with different maturity.
- Some of the defined projects are Green Porto, Digital Hub, Innovation and talent District.
- Connecting the City level with the Metropolitan region, the Region Norte and NW Iberian peninsula.

4.3 Society

Demography
Porto currently has a population of approximately 231,800 people (Censos, 2021), with a significant portion residing in the metropolitan area, which includes about 1.7 million inhabitants. The urban density in Porto is around 5,595 people per km² (Censos, 2021), making it one of the most densely populated cities in Portugal. This density is significantly higher than the national average, which is approximately 114 people per km².

Projections suggest that Porto's population may experience slight fluctuations, with a modest growth rate anticipated in the coming years due to urban revitalization initiatives and a focus on attracting new residents (Census, 2021). Notably, Porto has experienced a population decline that began in the 1980s—between 1981 and 2021, the city lost approximately 95,000 residents (Censos, 2021). However, between 2011 and 2021, there was an inflection in this downward trend, as a result of wealthier and younger people move to the surroundings of the city, the larger Porto Metropolitan area. The current policy is aiming to stop the decline and showing a tendency for population recovery.

However, it's also important to consider the city's "user" population, since a large number of residents in neighboring municipalities work, study or visit Porto - around 150,000 users per day. The numbers increase when tourists from all parts of the world became part of the equation - in 2022 there was an annual value of 4.8 million overnight stays in the city (Pordata, 2022).

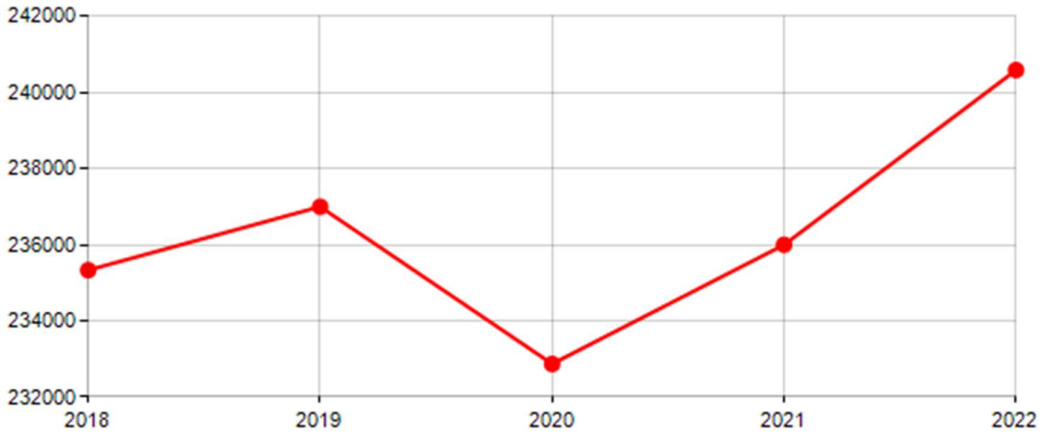

Figure 10. Population Trends in Porto (2018–2022). (Source: Urbistat, n.d. -a)

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Age

The age distribution in Porto shows a balanced demographic, though there is a noticeable trend towards an aging population. Porto is facing a major challenge: an increase in the elderly population. In 2022, 26% of the population was 65 or older. The data pointed out 227 people over 65 for every 100 people under 15 living in Porto, illustrating that Porto has a rather high dependency ratio compared to the national average.

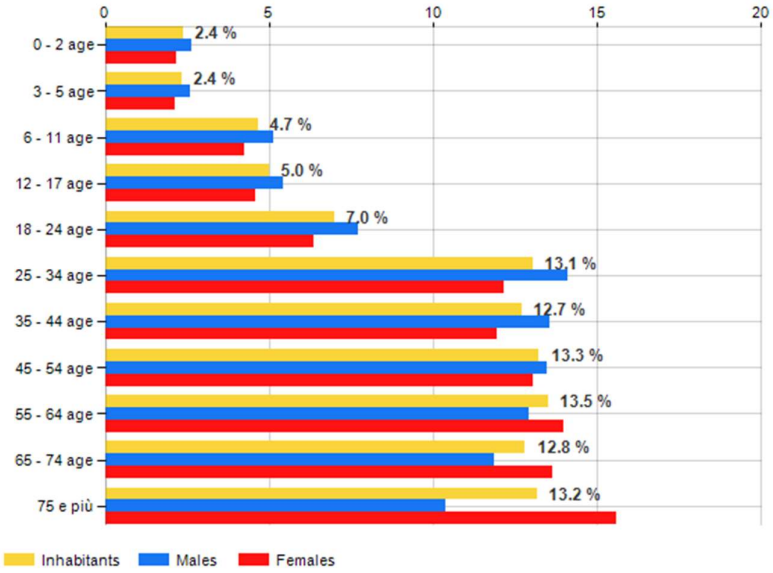

Figure 11: Urban Density in Porto (Source: Urbistat, Demographic statistics PORTUGAL)

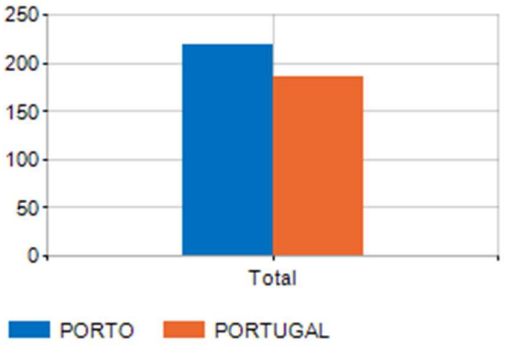

Figure 12: Comparison of total population percentages of Porto (blue) and Portugal (orange). Porto demonstrates a higher urban density and older demographic compared to the national average. (https://www.ine.pt/)

The life expectancy at birth in the city is approximately 81 years (Eurostat, 2022). Porto has a relatively younger population compared to other major Portuguese cities, with a higher proportion of individuals aged 0 to 29 (Instituto Nacional de Estatística).

Household Composition

Households in Porto primarily consists out of single persons (47.5%), followed by nuclear families, with married couples being the most common household type (34.4%) (see figure 13). There is also a significant proportion of single-parent households (14.5%), particularly among

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women. Of these single mothers, approximately 24% have one or more children, compared to single fathers, of which around 10% have children (Censos, 2021).

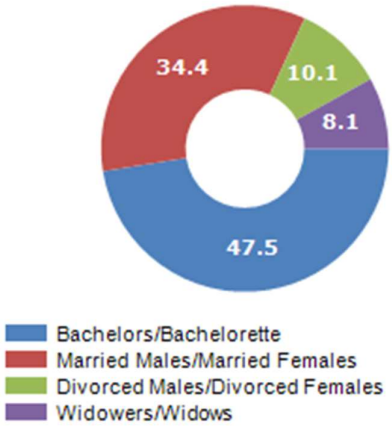

Figure 13: Household Composition in Porto (Source: Censos, 2021)

Gender
In Porto, the gender ratio is relatively balanced, with slightly more women than men (approximately 107,000 men and 110,000 women) (Instituto Nacional de Estatística, 2024). This gender distribution aligns with the national trends seen across Portugal.

Nationality
The majority of Porto's population (about 90%) is of Portuguese origin. Approximately 10% of residents are immigrants or descendants of non-Portuguese parents (Demographic statistics PORTUGAL). Recent years have seen an influx of new residents, particularly from Brazil, Angola, and the European Union, driven by job opportunities and higher education options (https://www.ine.pt/).

Income, poverty and unemployment
The average salary in Porto was around €21,500 in 2022, which is slightly lower than the national average of €22,500. Approximately 18% of the population is considered at risk of poverty, with the highest rates among individuals aged 18 to 34. Roughly 7% of children in Porto live in households receiving social assistance, with higher concentrations in certain neighborhoods. Porto has an unemployment rate of about 7.5%, which is higher than the national average of approximately 6.0% (Eurostat, June 2023).

People with Disabilities
Disability data is not comprehensively registered in Portugal. However, estimates from the National Institute of Statistics suggest that around 15% of the population may have some form of disability.

Identified vulnerable groups with regards to climate change (social justice):

The eastern part of Porto, parish of Campanhã, where NBRACER will be implemented is characterized by several demographic, social and exclusion problems:

- High percentage of social housing population characterized by low education levels, precarious jobs, high unemployment and highly dependent on social support – the eastern zone accommodates around 30% of city social housing (Quaternaire, 2019);
- High percentage of elderly population with an increase trend over time. This also explains the high number of people living alone (INE, 2021);
- Old residential building stock with poor energy efficiency - around 56% of Campanhã parish houses were built until 1970 (Quaternaire, 2019).

Main aspects of the social vulnerability to climate change

- Economically and socially vulnerable population
- Aging and isolated population
- Aged, degraded and inefficient building
- Commuting movements

Civil society engagement

Porto municipality develops diverse actions to engage civil society on city's life. A good example is URBiNAT, a recently developed project focused on a problematic area with the vulnerable groups identified, which allowed to not only improve the quality of life of the residents, but also to engage the local community on the development of public spaces. URBiNAT allowed to create a 40,000 m2 of green spaces, opening up a pedestrian and cycling channel from Corujeira Garden to Eastern Park entrance – the so-called Alameda de Cartes Park. This requalification, which was designed and implemented with the local community, encourages people to move around in safer and more pleasant spaces (Pombeiro, 2023).

4.4 Key insights Social System

Porto Municipality has a complete pallet of relevant policies on climate adaptation and on relevant other policies. Actually, the Municipal Climate Action Plan, derived from the Municipal Climate Adaptation Plan, is in its finalisation phase, with only public and political scrutiny lacking. The municipality is heavenly involved in climate adaptation and working from different policy fields within a large Program, with various capacities internally and externally. The municipality is quite autonomous in setting up and implementing the policies, but connection with National policies could be improved. The Municipality has a good collaboration with local universities. The university is involved in large program and projects and has developed a relevant knowledge base on local climate adaptation, which is also being demonstrated at their own premises.

There is much attention to the social aspects of the city as clear social problems are existing in Porto municipality. In order to keep the city liveable Porto is focusing on new social groups as city users - students, workers, tourists – while providing affordable housing, to attract talent, on one side, and to answer to social issues on the other side.

These aspects are relevant part of the Porto approach within NBRACER, with a special focus on involvement of civil society organizations and with a focus on the parish of Campanhã. Next to citizens, also private sector is being stimulated to take measures towards climate change.

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The PULSAR initiative Porto has defined Smart directions and specializations, taking into account climate change, sustainability, green objectives and values as central, instead of only economic growth:

- Sustainability and green growth: value instead of volumes
- Services economy: interplay knowledge and business partners
- Creating space for greening cities: tree planting, green roofs
- Social approach – contributing to community building, social safety, health – just transition
- Data driven – smart and digital – new tools and services for governance, planning: for risk management and for sustainable living

Directions

Relevant directions for NBRACER – embedding the project within the parish, integrating various functions, domains and solutions. Further extending the partnership an upscaling the scope:

- Connecting NBRACER demonstration to regional strategy on values and to PULSAR projects: on talent, on green economies, digital hub; focus on testing of solutions
- Connection with larger region, neighbouring municipalities
- Involvement of various knowledge disciplines
- Social services development
- Developing business opportunities for climate adaptation – new services development
- Connecting to local entrepreneurial ecosystem and innovation ecosystem
- Using or connecting to the Facilities Services Centres – interplay between knowledge and business domains; Innovation and Talent District
- Developing newly organizational forms, including education, research, collaboration, social services, business support and building a strong local profile.

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5 Regional climate risks

The main climate changes projected until the end of the XXI century for the municipality of Porto show (Pombeiro & Ribeiro, 2016):

- decrease of the mean annual precipitation, which may vary between 3% and 25%;
- decrease of the number of days with precipitation between 12 and 29 days per year;
- more frequent and intense droughts;
- rise in annual mean temperature (between 1°C and 4°C);
- increase in the number of days with very high temperatures (≥ 35°C) and of tropical nights (≥ 20°C);
- more frequent and intense heat waves;
- average sea level rise between 0.17m and 0.38m by 2050, and between 0.26m and 0.28m by the end of the XXI century;
- increase of extreme events, in particular in extreme rainfalls and more intense winter storms.

The climate in Porto is becoming hotter and drier over time. In the 1980s, the average annual temperature was 14.7°C, but today it has risen to 15.5°C. Similarly, the average annual precipitation has slightly decreased from 1285.6 mm in the 1980s to 1262.4 mm now. Despite this overall decrease, extreme rainfall events continue to occur, causing significant disruptions and financial losses to the urban population of Porto, highlighting the growing impact of climate change on the city's weather patterns and residents.

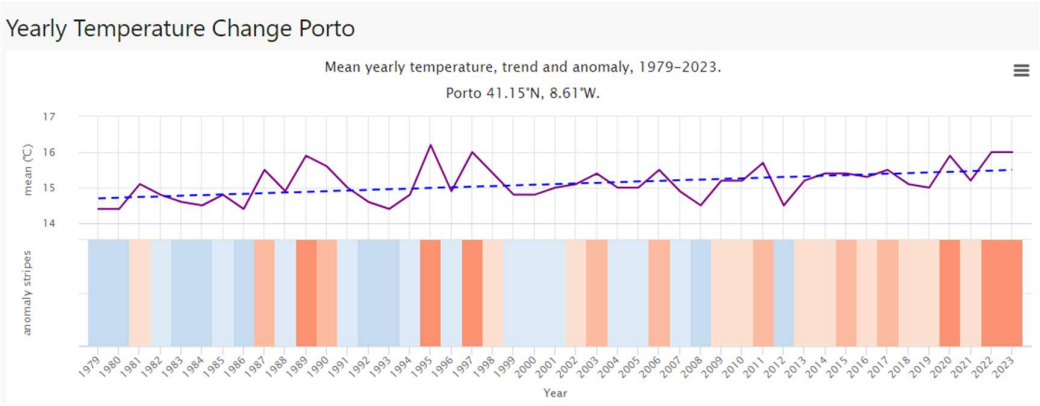

Figure 14: Yearly Temperature Change in Porto (1979-2023). The blue and red anomaly stripes indicate years with below-average and above-average temperatures, respectively, while the solid purple line shows the yearly temperature trend. The dashed line represents the long-term average temperature for the period. (Source: Meteoblue, n.d.)

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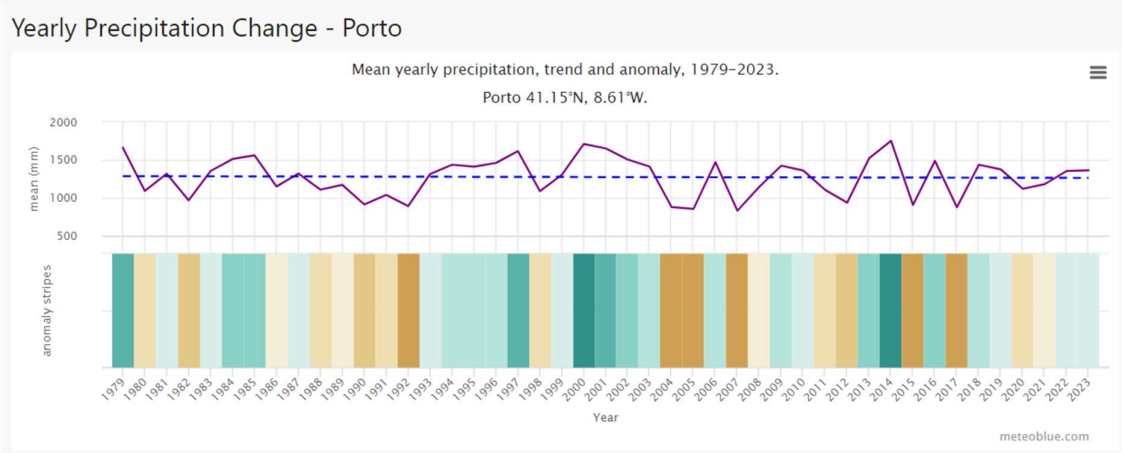

Figure 15: Yearly Precipitation Change in Porto (1979-2023). The solid purple line represents the annual precipitation trend, while the dashed line shows the long-term average precipitation. The coloured anomaly stripes below the graph indicate years with above-average (green/blue tones) and below-average (brown tones) precipitation. (Source: Meteoblue, n.d.)

Looking ahead, climate projections for Porto indicate even more drastic changes. Compared to the historical period of 1976-2005, temperatures are expected to rise by 1.3 to 2.4°C by mid-century (2041-2070) and by 1.4 to 3.9°C by the end of the century (2071-2100). Additionally, annual precipitation is projected to decrease by 3% to 25%, depending on the model.

The main risks associated with these changes include:

1. extreme heat (elevated temperatures/heatwaves);
2. extreme cold (low temperatures/cold waves);
3. storms;
4. droughts;
5. river floods (heavy rainfall);
6. urban flooding (heavy rainfall);
7. mass movements (heavy rainfall);
8. coastal gales;
9. coastal erosion;

all of which pose significant challenges to the city's infrastructure and residents (PMAC, 2024).

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Climatic events	Probability	Seriousness	Risk level			Risk trend
			Present	Medium term (2041/2070)	Long term (2071/2100)	
Extreme heat	Moderate	Moderate	**Moderate**	**High**	**Critical**	↑
Extreme cold	Moderate	Moderate	**Moderate**	**Moderate**	**Low**	↓
Storms	Moderate	Moderate	**Moderate**	**High**	**High**	↑
Droughts	Low	Low	**Low**	**Moderate**	**High**	↑
River floods	Moderate	Moderate	**Moderate**	**High**	**Moderate**	→
Urban floods	Moderate	Moderate	**Moderate**	**Moderate**	**Moderate**	→
Mass movements	Moderate	Moderate	**Moderate**	**Moderate**	**Low**	↓
Coastal gales	Moderate	Moderate	**Moderate**	**High**	**Critical**	↑
Coastal erosion	Moderate	Low	**Low**	**Moderate**	**Critical**	↑

Legend:

↑ Increasing risk

→ Maintaning risk

↓ Reducing risk

1. Extreme heat

Projections indicate that it is expected that the city will deal with a real increase in temperature of over 1°C in the medium term, and an increase in the number of days with high or very high

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temperatures, which means more frequent and longer-lasting heatwaves. The rise in temperature during an extreme heat event is not uniform throughout the territory and we can easily see that the city centre will be more impacted by the rise in temperature in summer, being an area with a higher thermal load, the result of greater artificialisation of the territory, as opposed to the western and eastern ends of the city, which have more green and naturalised areas, lower thermal loads and therefore less critical areas.

Figure 16 Critical areas according to bioclimatic discomfort (extreme heat) in summer (not critical at all [lighter colours] to extremely critical [darker colours]) (Monteiro et al., 2022).

2. Extreme cold

Although climate projections point to a generalised increase in temperature and a reduction in the number of days with frost, compared to the historical record for Porto, the projected changes will have an impact on the way the climate system interacts and regulates the different components, boosting changes in atmospheric pressure and wind currents, which will contribute to increasing extreme phenomena and worsening temperature anomalies, particularly extreme cold phenomena. Figure 15 highlights the areas with the greatest discomfort from extreme cold, corresponding, as expected, to the areas with the lowest thermal load and high ventilation potential. As a result, and as a result of a number of factors coming together, the eastern part of the city, corresponding to the parish of Campanhã, has the greatest exposure to extreme cold, and is the parish in the municipality of Porto with the most socially vulnerable population. This particular socio-economic situation in this area of the city amplifies the risk of extreme cold for the resident population, creating a particularly vulnerable and sensitive area of the city.

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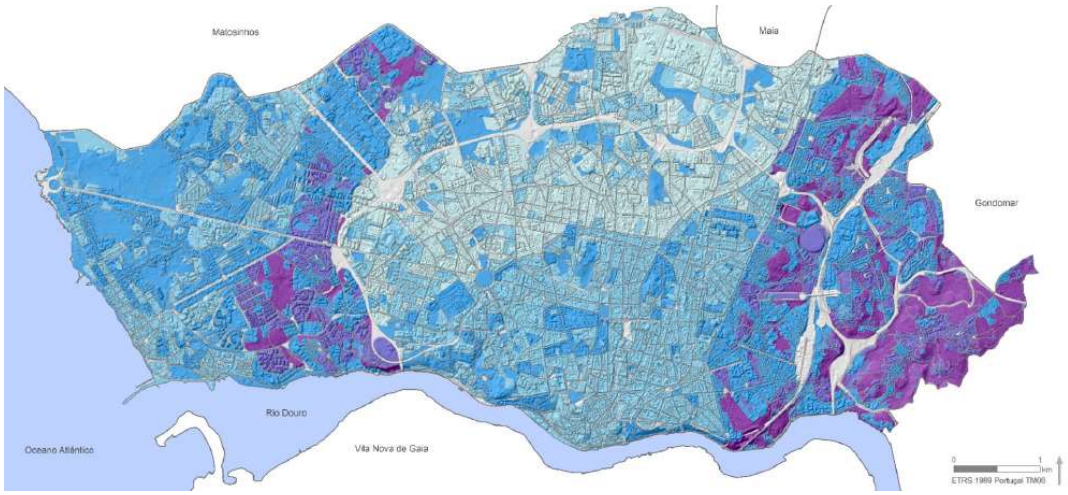

Figure 17 Critical areas according to bioclimatic discomfort (extreme cold) in winter (not critical at all [lighter colours] to extremely critical [darker colours]) (Monteiro et al., 2022).

3. Storms

It is expected that episodes of extreme wind and heavy rainfall will worsen, resulting in an increase in the frequency of storms and other associated climatic events (river flooding, urban flooding, mass movements and coastal gales). The impacts associated with storms are strongly linked to other adverse climatic events, which creates a greater dispersion throughout the city of the most vulnerable areas. Specifically for storm phenomena, the most vulnerable areas of the territory are considered to be located in Porto's Historic Centre, due to the characteristics of its buildings and high soil sealing, in the vicinity of riverside areas and steep slopes, which leads to the possibility of urban and river flooding and mass movements, and on the seafront due to the strong sea waves associated with storms.

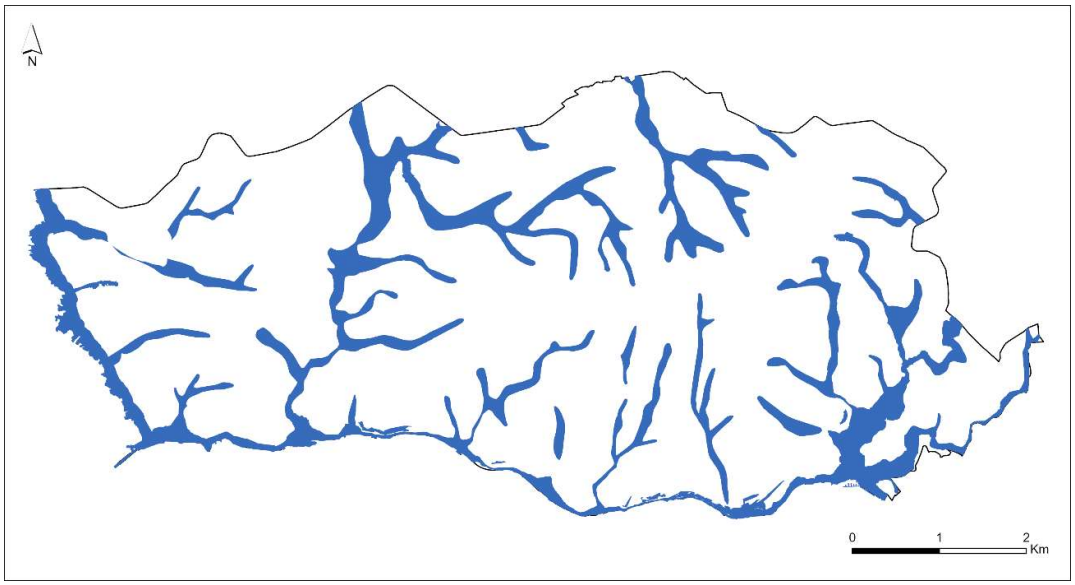

Figure 18 Critical areas according to exposure to the impacts of storms or other associated phenomena, adapted from the Porto Municipal Development Plan.

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4. Droughts

The drought phenomenon is strongly linked to the rise in temperature and the reduction in accumulated annual rainfall, which will cause an increase in evapotranspiration and a reduction in the replenishment of water levels, resulting in a net loss of available water in the soil, aquifers and water lines. The areas of the city most vulnerable to drought correspond to publicly accessible municipal green spaces, with a greater lack of water for irrigation and maintenance of vegetation and tree cover, as well as water lines in their contribution to the maintenance and upkeep of blue and green infrastructure.

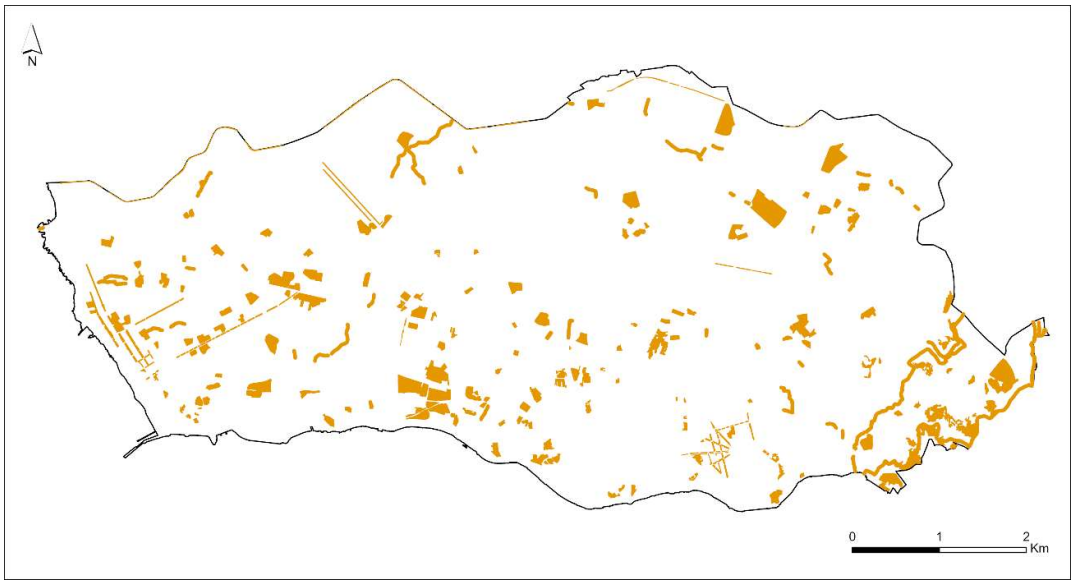

Figure 19 Critical areas according to the impacts associated with drought phenomena, adapted from the Porto MMP.

5. River floods

In the future, cities like Porto will see a gradual increase in the number of days with intense and persistent rainfall, with a clear impact on water lines, and it is expected that rivers and streams will quickly reach their maximum limits, alternating between periods of low or very low flow with periods of high flood flows. This wide range of flows implies greater pressure on drainage systems, from rainwater networks to water lines and retention structures.

Heavy rainfall and rising water levels could be fuelled by the discharge of dams with a major impact on the Douro River, due to the number and capacity of dams upstream of the city of Porto, increasing the risk of flooding in the city's riverside area. In addition to Porto's riverfront, the areas adjacent to the Tinto and Torto rivers, in the eastern part of the city, also present a greater risk of river flooding.

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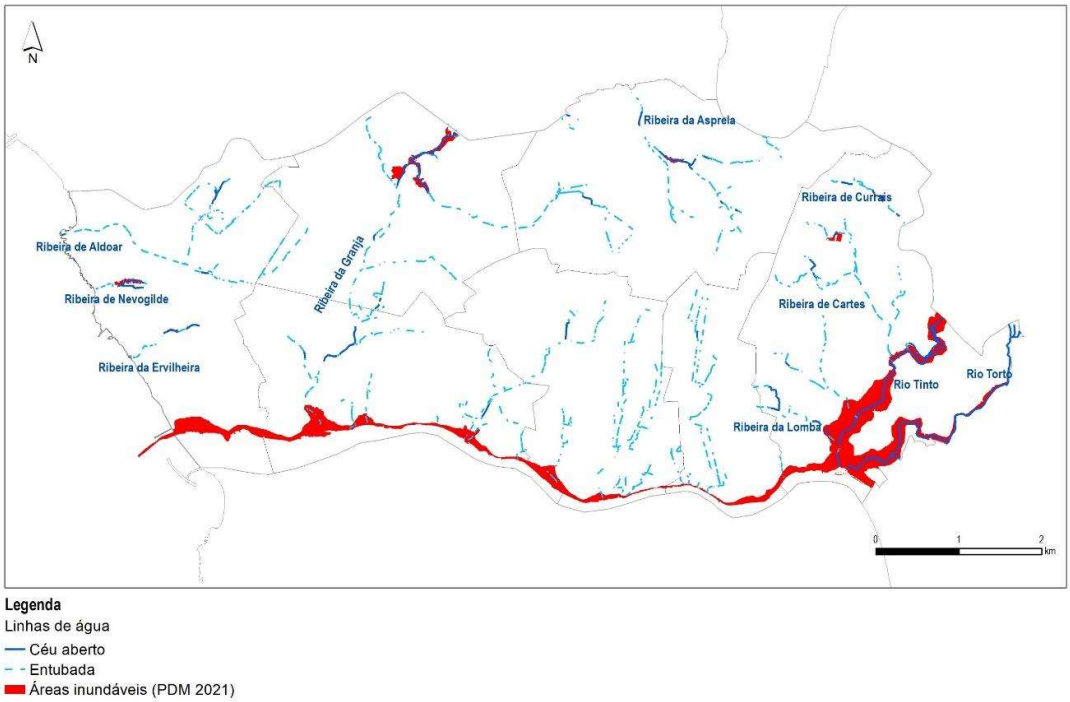

Figure 20 Critical areas according to the impacts of river flooding phenomena, adapted from the Porto MMP.

6. Urban flooding

Despite the reduction in accumulated annual rainfall and rainy days resulting from climate projections, an increase in heavy and intense rainfall is expected, causing peaks in precipitation. These abnormal volumes of rainfall over short periods of time will require greater drainage and surface run-off efforts, given the heavy waterproofing of urban soil. Data from the Regiment of Firefighters points to a record of 580 incidents related to urban flooding between 2018 and 2023, which indicates the need to improve the drainage network. While not all of the incidents can be linked to episodes of heavy rainfall, they show a dominance in the city centre, bringing together two relevant factors: the strong artificialisation and occupation of the land and the prevalence of canalised water lines in this area.

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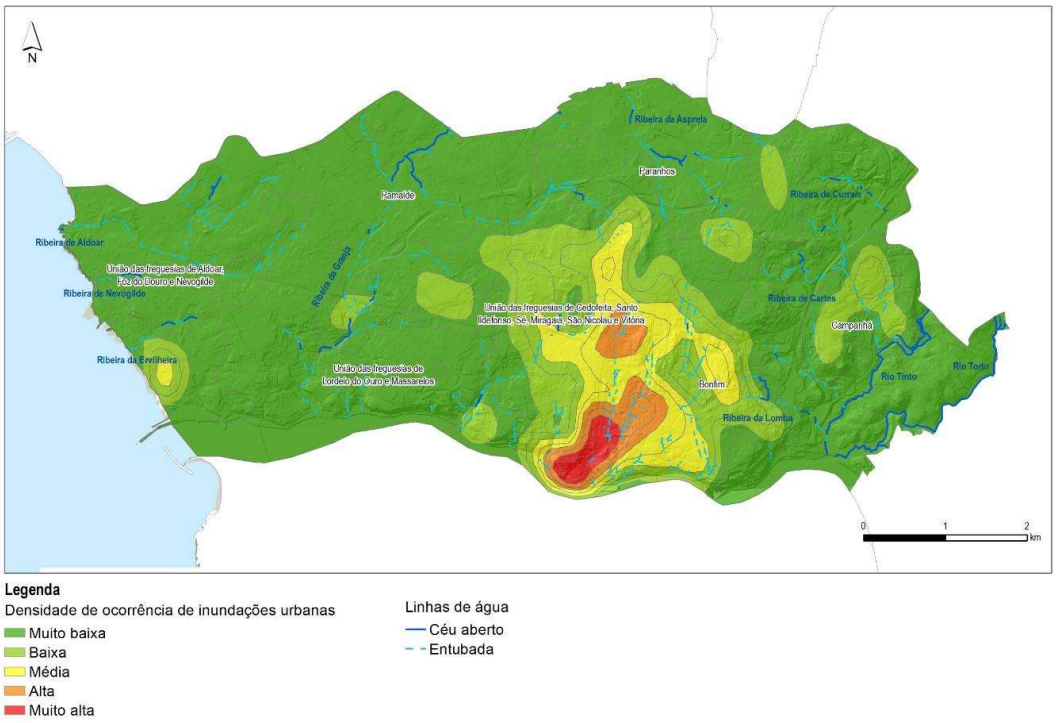

Legenda

Densidade de ocorrência de inundações urbanas

- Muito baixa
- Baixa
- Média
- Alta
- Muito alta

Linhas de água

- Céu aberto
- Entubada

Figure 21 Density of occurrences of urban flooding (data for 2018 and 2023), according to data from the Fire Brigade Regiment.

7. Mass movements

Mass movements can result from a number of factors which, together or individually, can cause soil or rock masses to detach and thus cause landslides, blocks of rock or structures. The city has some fronts with very steep slopes, mostly located to the south where they meet the River Douro, and whose slope characteristics and soil composition encourage mass movements. Hence, the city's vulnerability to this type of event is confined to the south-facing slope that faces the River Douro, as shown in figure 21.

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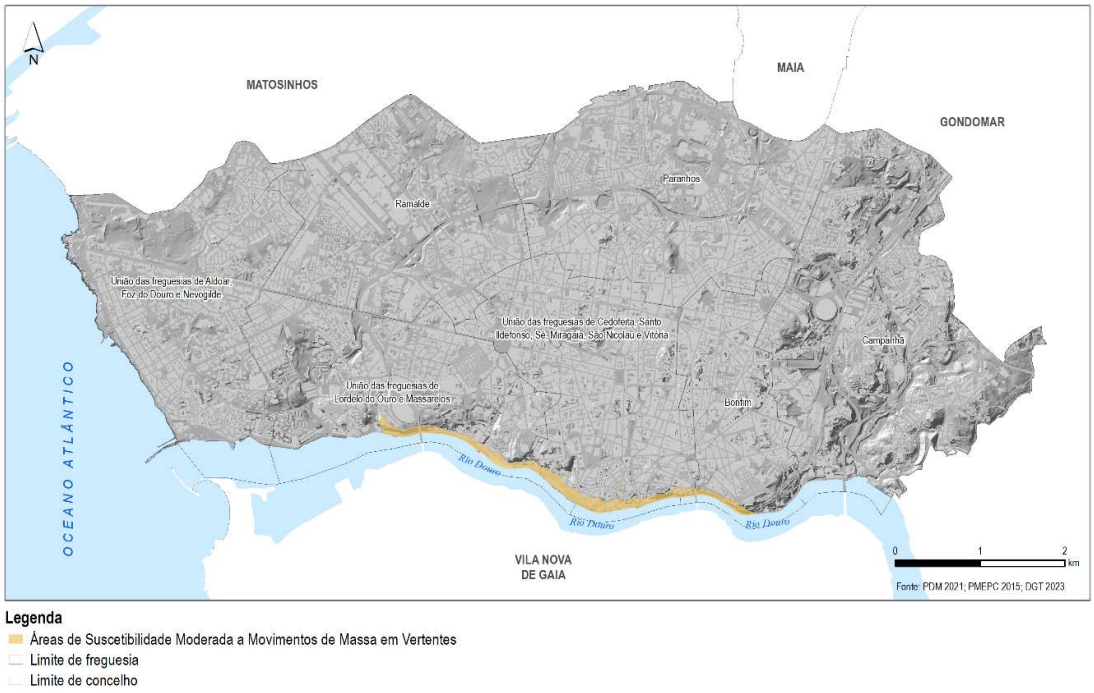

Figure 22 Critical areas according to the impacts of phenomena related to mass movements, adapted from Porto's MMP.Coastal gales

The geomorphological characteristics of Porto give it some protection from coastal erosion, since the coastline has a significant geological composition. However, the recent past has shown some occurrences related to coastal overtopping, limited to the extreme south-west of the municipality. Climate projections for the Mean Sea Level (MSL) point to an upward trend, with the model for Porto proposing a rise of between 0.53 and 0.73 metres in 2100 for the two scenarios tested. However, the area around Foz do Douro in Porto can be influenced by the height of the tide and the height of the Douro River, whose contributions to overtopping events could be unpredictable, since coastal overtopping could be aggravated by the combination of factors such as strong winds, heavy and persistent rainfall, high tide and discharges from the Douro River dams, maritime agitation and the rise in the NMM, conditions that could easily become more frequent and serious in the future. Currently, the area vulnerable to coastal overtopping is limited to the coastline and Avenida Dom Carlos I. In a 2100 scenario, it is expected that the rise in the NMM could cover a larger area encompassing heavily consolidated and urbanised areas.

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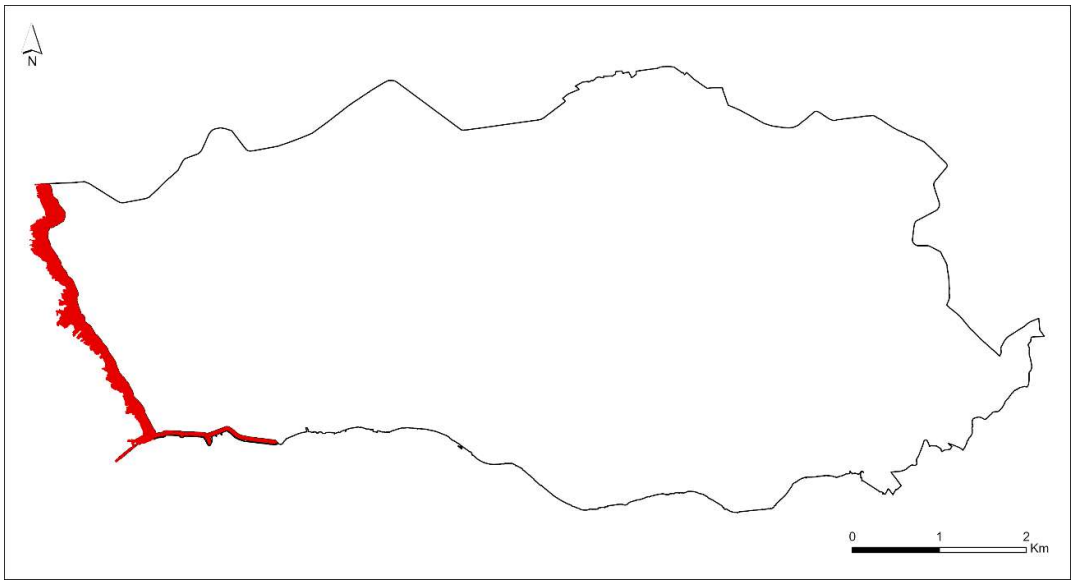

Figure 23 Critical areas according to the occurrence of phenomena related to coastal gales, adapted from the Porto MMP.

8. Coastal erosion

The construction of the Leixões harbour breakwater to the north of the city, and in particular its recent extension, will lengthen the inversion effect of the sedimentary current to the south of the São Francisco Xavier Fort, and it is expected that sediment will be deposited in a south-north direction on the beaches of Porto up to the Touro pier. Notwithstanding the sedimentary drift, the rise in the NMM and the construction of maritime infrastructures or infrastructures on the coastline will have an impact on coastal erosion in the long term, putting the fort's seafront, which is heavily urbanised and consolidated, at risk, both from the point of view of private housing and the range of commercial and tourism infrastructures available.

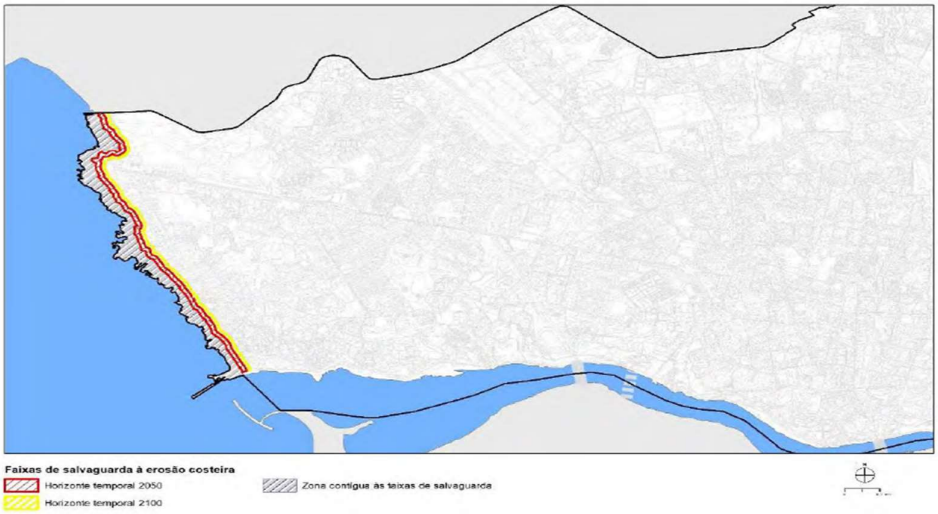

Figure 24 Coastal erosion safeguard zones, adapted from the Natural Risks Chart, Porto Municipal Development Plan.

6 Key Community Systems

Main impacts associated with climate change events for Porto municipality (PMAC, 2024):

Excessive precipitation, floods and landslides

- Buildings and infrastructure damage
- Traffic restrictions and road closures
- Problems with electrical cables and power failures
- Drainage and retention system degradation
- Injured and homeless people

High temperatures and heat waves

- Health problems - illness, injury and death

Sea level rise and strong swell

- Coastal erosion
- Coastal flooding
- Damage to buildings and infrastructure
- Changes in the use of equipment, services and transport

Storms and tornadoes

- Vegetation damage - falling branches and trees
- Buildings and infrastructure damage

6.1 Health system

6.1.1 Health care system in Portugal and Porto

Porto has an extensive health system that is universal and centralised and exists out of primary care, specialized care and hospital facilities. At local level, the hospitals and primary care centres are managed by the regional health administration. In 2024, a significant change took place, with all primary care units to be integrated in the local health units in order to ease access to health care. Municipalities have responsibility to manage and invest in primary care infrastructure and overseeing programmes to promote healthy life styles

People in Porto can easily access the health care system. A part of them are public health care facilities (known as **Serviço Nacional de Saúde** (SNS)). Public health care system is subsidised and accessible for all residents. While another part is private health care, covered by private insurance. Porto has in total 10 public and private hospitals. These hospitals also provide emergency care. There are also a number of urgent care centres and walk-in clinics for less severe medical needs. Over the past years, Porto also experience health care tourism, mainly for dental services. Pharmacists are widely accessible and operate 24/7. Healthcare, including medicines are subsidies, making the health care systems rather accessible for the population. However, waiting times may increase. Mental health care is also provided though hospitals and

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clinics and people can also rely on services from psychologists and psychiatrists. Portugal has strong primary care services, leading to low avoidable hospital admissions. The system is performing quite well. Portugal has lower rates of preventable and treatable mortality than the EU average, particularly for conditions like lung cancer and ischaemic heart disease. However, unmet medical needs are higher than in other EU countries, particularly among low-income groups, with dental care being a significant gap.

6.1.2 Health

Life expectancy of Portuguese people[3] has increased faster than the EU average over the past two decades, reaching 81.7 years in 2022. Circulatory diseases, such as stroke and ischemic heart disease, remain the leading cause of death, followed by cancer, particularly colorectal cancers. However, Portugal also faces rising health challenges. Excess deaths are prevalent in Portugal, with summer heatwaves as one of the possible explanations of the amounts of excess deaths (Silva et al., 2023).

While life expectancy is increasing, it can be observed that people aged 65 years and older are mostly not disabilities free. 61% of this group of elderly people is experiencing activity limitations.[4] Diabetes is prevalent, making Portugal one of the European countries with the highest diabetes rates (13% of adults[5]). This is largely attributed to poor diet and lack of physical activity. Obesity is on the rise, with over 17% of adults classified as obese. Additionally, around 20% of Portuguese teenagers are either overweight or obese, a concerning trend that may worsen due to low levels of physical activity. Overall, Portugal fares better than most EU countries on behavioral health risk factors, except physical activity and obesity.

Mental health is a significant issue in Portugal, with around 22% of the population experiencing a mental health disorder, well above the EU average. High rates of anxiety and depression, particularly among women and low-income groups, are prevalent. While suicide rates are lower than the EU average and have declined over the past decade, certain regions, especially in the south, continue to face higher rates.

The recent economic crises have exacerbated stress and mental health problems, further affecting the welfare of citizens and the national economy. It is estimated that, in 2019, mental health disorders will have resulted in the loss of nearly 310,000 years of productive life (IHME, 2022). Although access to mental health services is available, regional disparities and socioeconomic barriers hinder timely care, especially in rural areas and among low-income populations. Additionally, access to dental care is particularly limited for these groups.

Health disparities are particularly evident in Porto, where lower-income and less educated communities experience higher rates of chronic diseases and poorer health outcomes. In these neighborhoods, conditions such as diabetes, obesity, and mental health issues are more pronounced, reflecting broader national trends but with a sharper impact on vulnerable groups.

[3] tate of Health in the EU Portugal Country Health Profile 2023
[4] State of Health in the EU Portugal Country Health Profile 2023
[5] Diabetes in Europe – 2021. Factsheet. International Diabetes Federation.

6.1.3 Impacts of climate change on health

Climate change is expected to significantly impact the health of people living in Porto, leading to a range of challenges. The prevalence of respiratory and cardiac pathologies is likely to rise, putting greater pressure on health and emergency assistance systems. Living conditions may deteriorate due to issues such as increased humidity, water infiltration, and inadequate heating in buildings, which could also heighten the risk of carbon monoxide poisoning as people rely more on fireplaces for warmth.

Furthermore, social housing may face a growing likelihood of infestations, while the frequency of injuries caused by floods, falling trees, and landslides could also increase. The proliferation of allergens, pollutants, and disease-transmitting insects is expected to rise, exacerbating health problems. Ultimately, these factors could contribute to an increase in the overall mortality rate in the region.

6.2 Food system

The Porto case is mainly an Urban Demonstrator. The current agricultural and food system has limited presence in the Porto Municipality. The Demonstrator will explore urban agriculture as a Nature Based Solution, to store the water in cases of heavy rainfall and flooding. These climate change risks may affect the agricultural land-use negatively, while it can lead to soil erosion and damage to agricultural land and vegetable gardens of small producers with crop losses. Heat may cause risks of rural and forest fires.

6.3 Water management

Porto's water management system is challenged by the impacts of climate change, particularly in the context of rising temperatures, changing rainfall patterns, and the risk of sea level rise. The city is experiencing more frequent and intense rainfall, which overwhelms its drainage and sewage systems, leading to urban flooding and the overflow of untreated sewage into rivers and coastal waters. This not only affects water quality but also causes risks to public health and the local ecosystem. Heavy rains also contribute to increased surface runoff, which carries pollutants from urban areas, roads, and industrial zones into the Douro River and other water bodies, further compromising water resources.

Rising sea levels add another layer of complexity to water management in Porto, increasing the risk of coastal flooding and saltwater intrusion into freshwater systems. This can degrade the quality of drinking water and can impact agricultural activities that rely on freshwater.

Beyond climate-related challenges, urban population growth in Porto places additional pressure on the city's water resources. There is a growing demand for water and water related infrastructure. Additionally, more urban paved places are resulting in more water runoff and pollution.

- Degradation of the environmental quality of aquifers – infiltration of contaminated rainwater or pollutants into groundwater
- Degradation of the environmental quality of watercourses
- Degradation of water quality

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- Damage to drinking water supply infrastructure
- Damage to rainwater and sanitation infrastructure
- Destruction or damage to retention basins – overflow of retention basins due to intense precipitation, clogging of drainage channels due to waste entrainment
- Greater pressure on supply systems – greater demand and consumption of water, bursting of supply pipes
- Greater pressure on wastewater treatment systems

6.4 Critical infrastructure

The infrastructure is an important urban category and community system in logistics of all kind of basic products for the Porto inhabitants as well as important for reaching hospitals and groceries. Climate changes may affect the infrastructure. Within Porto the elevation levels will lead to vulnerable parts in the lower lying areas, in case of heavy rainfall and floodings. The following risks and potential negative effects on key infrastructure are relevant:

- Damage to public and private building assets
- Increased costs associated with adapting buildings – installation of thermal insulation and energy efficiency solutions, increased maximum temperatures, greater frequency of heat waves, greater frequency of dry periods, increased thermal anomalies, extreme cold and strong winds
- Infrastructure and communication network damage
- Hospital assistance and school activities restrictions due to storms, intense precipitation and strong winds, landslides, flooding, interruption in water supply
- Closing roads due to traffic interruption. Damage to vehicles and transport infrastructure (road and railway networks).
- Interruption and restriction of public transport lines
- Metro tunnels and stations flooding
- Failures in electricity supply due to infrastructure damage, landslides, floods and burst pipelines

6.5 Local/Regional Economy

Porto is a dynamic economic hub, contributing approximately 16.2% of Portugal's national GDP[6]. The city boasts a well-balanced economy, combining a strong industrial base with flourishing services, particularly in technology and innovation. Most of the economic activities are concentrated in the largest urban centers, such as business services, commerce, hotel industry, education, health and social support. Around 42% of Portugal's workforce lives and works in the Porto metropolitan area, which plays a crucial role in the country's economic development. Porto has experienced significant growth in exports, representing 45% of Portugal's goods exports. Additionally, foreign direct investment (FDI) has been a major driver of job creation, with over 22,000 jobs generated in the last five years, including 6,000 jobs in 2023

[6] Wealth generated in the Porto region already accounts for 16.2% of the national GDP (News Porto, 2024) https://www.porto.pt/en/news/wealth-generated-in-the-porto-region-already-accounts-for-162-of-the-national-gdp

alone. The city's[7] ability to attract global companies like Natixis, BNP Paribas, and BMW has been boosted by its highly skilled workforce, cost competitiveness, and modern infrastructure.

Key Sectors

- **Business services sector**: Business services sector is dominant, with business services alone generating 43% of the jobs in Porto. Most of which are concentrated in administrative and support service activities, consulting, scientific research and development and information and communication activities.
- **Technology and innovation**: A thriving sector that includes information technology, software development, digital media, and startups.
- **Education and research**: Universities, research institutes, and innovation centres play an integral role in the city's knowledge economy.
- **Creative industries**: Porto's vibrant culture is reflected in industries such as design, architecture, music, and the performing arts.
- **Construction and Real Estate**: Ongoing urbanization and infrastructure projects are reshaping the city's landscape and economic prospects.

Tourism also significantly contributes to Porto's economy, attracting 2.8 million visitors annually and generating approximately 434.7 million euros in revenue from tourist accommodation.

Emerging and Future-Oriented Sectors:

Porto's economy is adapting to new trends, with specific areas of potential growth identified:

- **Traditional Sectors**: Commerce, services, real estate, and tourism.
- **Emerging Sectors**: Creative industries, health, and innovation-driven activities.
- **Wild-Card Sectors**: The Blue Economy and energy/environment-related industries offer future growth opportunities.

Impacts of climate change on the local economy

Climate change is expected to have significant repercussions on Porto's economy, impacting various sectors and infrastructure systems. One of the primary adjustments will involve changing working hours to prevent outdoor labour during periods of extreme heat, which could otherwise endanger worker health and safety. As temperatures rise, employment and productivity are anticipated to decline, with worsening chronic illnesses and increased absenteeism leading to higher unemployment rates. This combination of health and climate-related issues will also affect overall economic output.

The city's commerce and service facilities face direct economic constraints due to potential damage from extreme weather events, which could lead to operational disruptions. Additionally, climate change will exert pressure on Porto's real estate market. As natural risks increase, the amount of land available for development will shrink, intensifying demand for properties near parks and green spaces. This trend may further drive-up property prices. For the insurance sectors, it is expected that changes in weather patterns will lead to increased

[7] https://www.cm-porto.pt/estudos-estrategicos/boletim-economico-porto_1

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compensation costs due to heightened insurance claims resulting from natural disasters such as storms, floods, and landslides. Lastly, Porto's municipal budget will likely experience rising costs, as the city will need to invest in repairing damaged infrastructure, restoring public spaces, and addressing ecological harm caused by extreme weather events. Although Porto has a resilient economic structure with a focus on innovation and sustainability, addressing these challenges will require long-term planning and strategic investments to mitigate the risks posed by climate change.

6.6 Ecosystem

Rising sea levels, intensified storms, temperature fluctuations, and changing precipitation patterns are impacting Porto's ecosystems, by affecting habitats and putting pressure on ecological balances.

In Porto's coastal and riverine areas, the rising sea levels and intensified storms contribute to the erosion of wetlands and estuaries, which are crucial habitats for many species. Saltwater intrusion into freshwater ecosystems alters the salinity levels, making these environments less hospitable for freshwater species and leading to significant changes in species composition. Additionally, the increased frequency of heavy rainfall and storms exacerbates pollution from urban runoff, further degrading water quality and harming aquatic life.

The city's numerous green parks, such as Parque da Cidade, Jardins do Palácio de Cristal, and Parque de São Roque, are vital for urban biodiversity and provide essential ecological services. However, higher temperatures and altered rainfall can stress plant species, particularly non-native and less resilient ones, potentially leading to changes in the composition of vegetation and reduced park biodiversity.

To address these challenges, it is essential to enhance the resilience of Porto's green spaces. This involves promoting the use of native and climate-resilient plant species, improving park maintenance practices, and integrating green infrastructure strategies. Additionally, increasing the connectivity between green spaces can help support biodiversity by providing continuous habitats and migration routes for various species.

6.7 Main Vulnerabilities

Category	Vulnerability
Biophysical and morphological characteristics of the territory	Geomorphology of the area with very steep slopes
	Coastline without natural dune protection
	Douro river mouth (international and with high hydroelectric potential)
	Native fauna and flora adapted to current conditions
Socioeconomic characteristics	Economically and socially vulnerable population
	Ageing and isolated population
	Ageing, dilapidated and inefficient buildings
	Commuting
Governance	Climate action subject to the intermittent dynamics of political cycles

	Lack of articulation and co-operation between regional and national entities
	Mismatch between decisions/actions and their consequences
	Legislation out of step with reality
	Lack of climate literacy
Territorial use and management	Dense land occupation (high waterproofing rates)
	Dense occupation at the mouth of the Douro River (international river) and in the coastal zone
	Water lines blocked and constrained by the urban fabric
	Rainwater drainage system not adapted to heavy rainfall phenomena
	Few neighbourhood green spaces (< 400 m)
	Lack of diagnosis and monitoring of the current state (water lines and slopes)
	Over-exploitation of the use of the subsoil with built infrastructure (tunnels of the metro and road networks, infrastructure for services, among others)
	High tourist pressure concentrated in the Historic Centre
External influence	High incidence of forest fires in the Porto Metropolitan Area
	High external dependence on food products and goods

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7 Connecting Natural and Social System: Nature-based Solutions

7.1 Readiness for NbS initiatives

The role of landscape in people's lives in Porto is multifaceted and significant, shaping various aspects of daily life, culture and well-being in the city. Residents often take pride in their local parks, gardens and public spaces, participating in volunteering activities, community clean-ups, and neighbourhood events. Initiatives such as community gardens, allotments and urban agriculture initiatives promote social cohesion, food security, and environmental stewardship, fostering a sense of belonging and collective responsibility for urban landscape. Altogether, this reflects a growing awareness of environmental issues and the importance of nature conservation in Porto municipality. Nevertheless, if the land is abandoned as scrubland, people don't see it as an integral part of nature, but rather as worthless scrubland, often dumping garbage on it. Additionally, also gardens and parks, if left with weeds and brambles, are considered dirty, inappropriate, or unsightly. This shows that the understanding of nature and its services is limited (Monteiro, 2018). Regarding climate change, in general, it is seen as a serious problem both by the general population and by heads of institutions and municipal councillors. However, when analysed to the scale on which they perceive climate change, it is possible to see that they attribute it to a more global scale, and therefore they assign the responsibility of resolution to a broader level, such as the European Union and the Government. Hence, overall, they do not feel as an integrated part in the cause and resolution of climate change (Monteiro, 2018).

Regarding climatic risks, people are mainly worried with impacts in air and water quality, with high temperature and excessive precipitation also reported. Institutional leaders and municipal councillors identify forest fires, extreme heat, heavy rainfall, floods and energy costs increases as the priority climate risks. People are open to learn and understand the importance of actions to minimize climate risks, giving more relevance to those related to renewable energy use and urban green spaces improvement. They also manifest interest in participating in actions of environmental education. Institutional leaders and municipal councillors are making efforts to integrate planning and management actions for climate change adaptation. Their awareness for climate change consequences is increasing and different types of strategies, plans and projects are being considered, especially to reduce economic and social losses (Monteiro, 2018).

In general, there is an awareness of climate change and its potential risks. Nevertheless, people are not yet fully integrated into nature-based solutions and what that means. It's a new concept closely linked to ecosystem services and its effects are often not economically measurable. People tend to value services that increase their quality of life or that represent economic incomes. So, there is a greater focus on more tangible actions, such as the transportation transition from fossil fuels to electric, domestic renewable energy production, waste separation and valorisation among others (Monteiro, 2018).

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7.2 NBRACER demonstrator

The proposed study area has approximately 6 hectares and is located on the grounds of an old estate – Quinta de Salgueiros. It's located in the Campanhã Parish (east area of the city), one of the most deprived parishes of the city which is now being a focus for the city's development. Porto's municipality has made public its interest and priority to invest in Campanhã in order to promote its social, environmental and economic improvement and inclusion.

Like in many other parts of Porto, elevation is one of the key features that characterizes. The former estate itself is already a green pocket within urbanized area, together with the green areas under and along the highway it is a green connection. Currently the former estate itself is not only enclosed but also closed to public.

Figure 25. Campanhã parish and Quinta de Salgueiros limits (background imagery: DGT, 2018)

Porto's purpose with the Quinta de Salgueiros project (focus area of NBRACER project in Porto) is to:

- Test scalable nature-based solutions in the urban context.
- To regain for the city and for the population an area that is currently socially and environmentally degraded (formerly an historical estate).
- To restore ecosystems (streams, woodlands, meadows) and increase climate resilience, biodiversity, ecosystem services, creating a demonstration area on NBS.
- To establish a BioLab in the area, a space where universities, citizens and policy makers can conduct experiments and test new nature-based solutions.
- To consolidate an ecological corridor as planned in the municipality's ecological structure, functioning as an important corridor in the city's Eastern Park - Alameda de Cartes – Antas continuum.

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8 Key insights and conclusion

Main conclusion from the baseline is that Porto has good conditions to start the NBRACER demonstration. The policies and frameworks are available. There is a program office with clear outreach to various departments and policy fields. There is a good connection and interplay with the knowledge domain. The information about the natural aspects is available, and also the climate change risk assessment has been carried out. Porto has selected an interesting Demonstration project on a site – a Bio lab environment - where different NBS will be tested and demonstrated. This demonstration is taking place in an environment with elevation, which is typical for the Porto situation. Further an interesting and challenging aspect will be the involvement of the citizens and the exploration of the social aspects and benefits of NBS.

The former estate still forms a green pocket within urbanised area. Still developments are going on around the area, including urban renewal projects. The place and potential role in the system is linked to the elevation levels. Challenges will further connect this enclosed and currently closed for public area to its wider system to unlock further potentials. Nature based solutions could focus on the improvement of green pockets to reduce heat stress, additional urban food provision (nutritional value, high value/fresh), including a social component and buffering water (although for some areas it is low in the system). Due to its position nature based approach can also be challenging; for instance how to deal with urban runoff and water quality. It could hamper ecological quality, but on the other side it could capture and clean water.

The demonstrations and experiences on NBS and the applied approach of the Bio-Lab, the collaborations and the involvement, within the urban context of Porto, will lead to new insights of applying the approaches and solutions within other parts of the Metropolitan Region of Porto, and for similar environments and contexts.

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Annex 7: Baseline presentation Friesland

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Regional Baseline

Fryslân

NBRACER Regional Workshop
February 26, 2025

Compiled by

Deltares

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Why the Region?

Regional Approach
Role of a Regional Baseline

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The Mission on Adaptation to Climate Change

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for Atlantic Regional Climate Resilience

Focuses on:

- **Supporting EU regions**, cities and local authorities
- Their efforts to **build climate change resilience**

The Mission's objective:

- **Accompany at least 150 European regions and communities** towards climate resilience by 2030.

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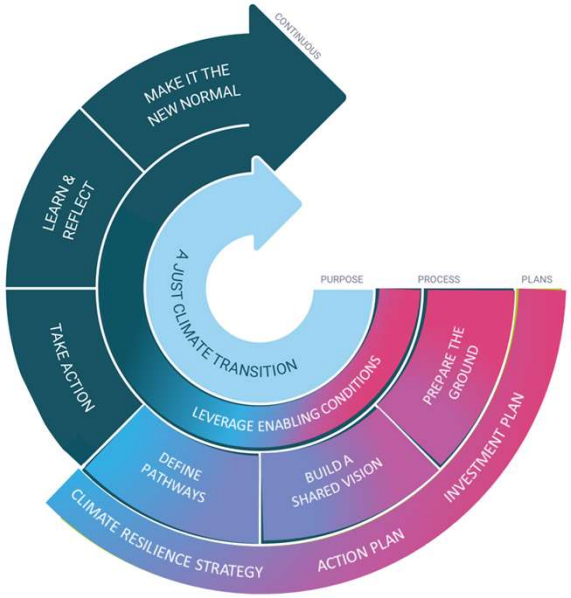
…via a Transformative Adaptation Journey



Regional approach

Regions are made and remade. They bring, and hold, together processes of economy, politics and cultural development.

Focuses on **integration of local places, social conditions and the regional geography**

Climate, society and the environment

Changing how we **live with nature**, **organize** this interaction and keep an eye on **the future**

Demonstration and implementation

Focus on regions that **demonstrate** the use of **Nature-based Solutions**, to then **implement** them in affiliate regions

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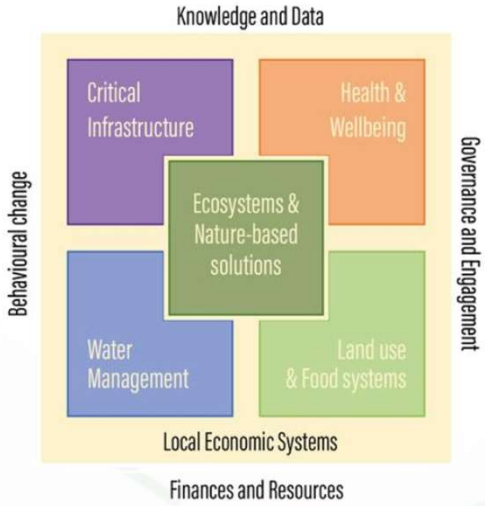
…systemic and transformative

towards a safe, prosperous and healthy environment

mainstreaming

Key Community Systems



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Regional Baseline

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Region: **Province of Fryslân**
Pilot Case:
Municipalities:

Aim

- **Collect** regional information
- **Create collective starting point; common understanding**
- **Provide insights** into physical and socio-economic context
- **Start** of the Transformative Adaptation Journey (prepare the ground)

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Connecting the dots

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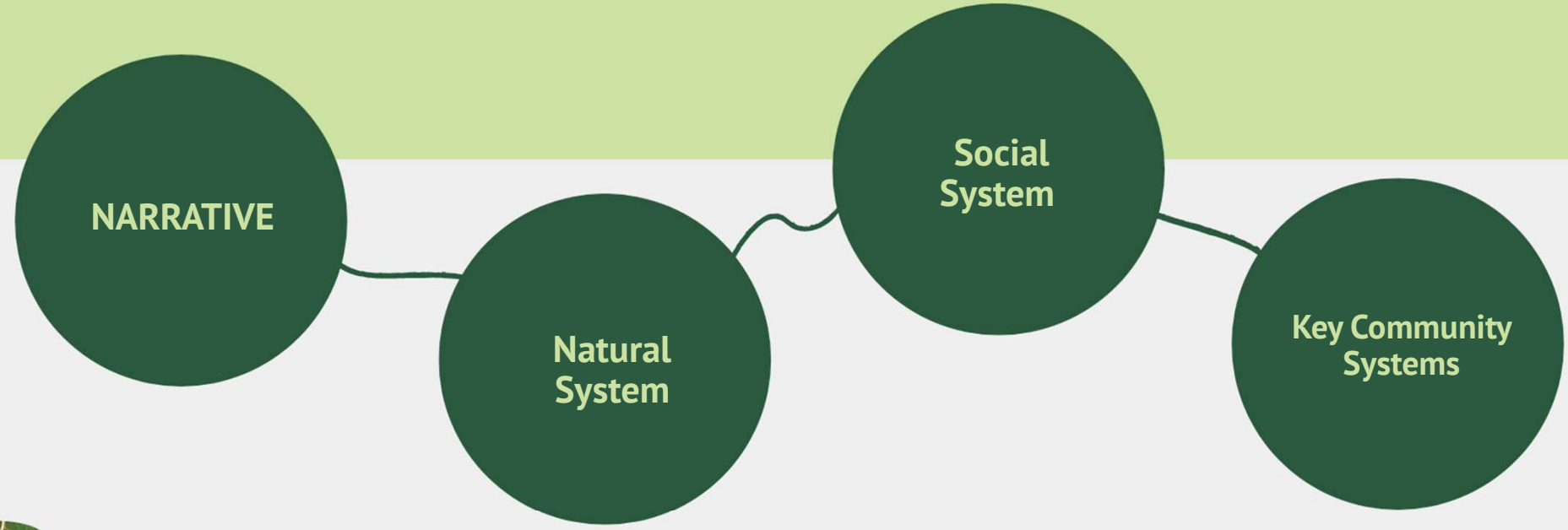

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Natural System

(Sub)soil system

Hydrological system

Nature and biodiversity

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Soil system

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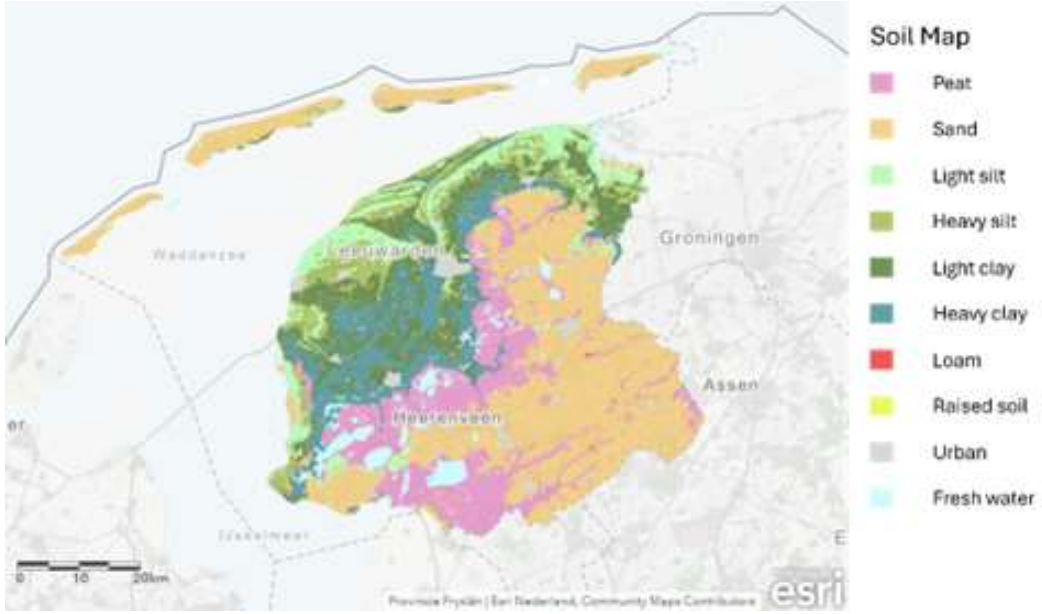
Fryslân is characterised by high sandy soils, low-lying peat areas in the middle and clay areas along the coastal area. Fryslân has a series of areas that are distinctive from the perspective of the water system. Within these different areas the water system works differently due to the soil composition, altitude and land use. These areas also behave differently in terms of climate effects.



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Water issues (current)

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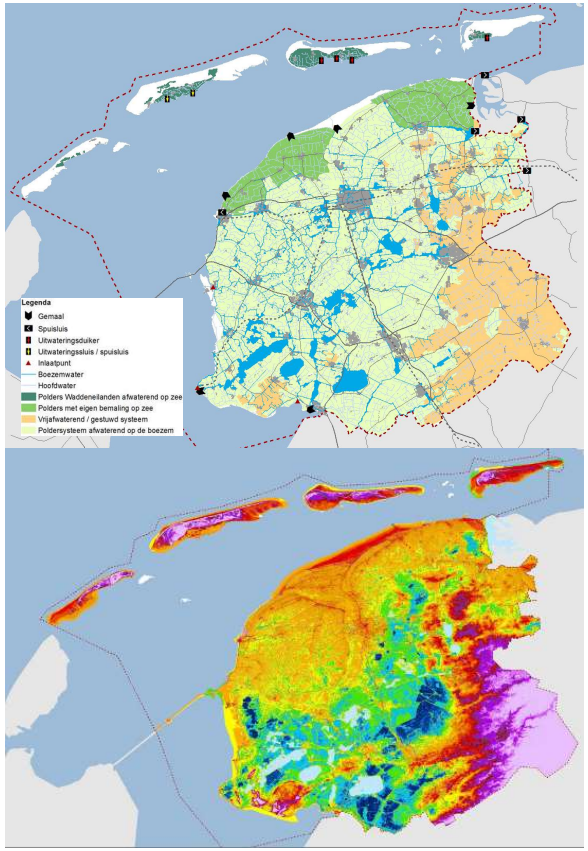
The Frisian water system is a so-called 'boezem-polder' system combined with free-flowing areas, protected by primary flood defenses along the IJsselmeer and Wadden Sea. The Frisian storage basin is a continuous system of lakes and canals and has a fixed year-round level of -0.52 m NAP.

It is an artificial system with as many as 8.000 level sections where the level is regulated by almost 1.000 polder pumping stations and about 5.800 weirs.



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Future water issues

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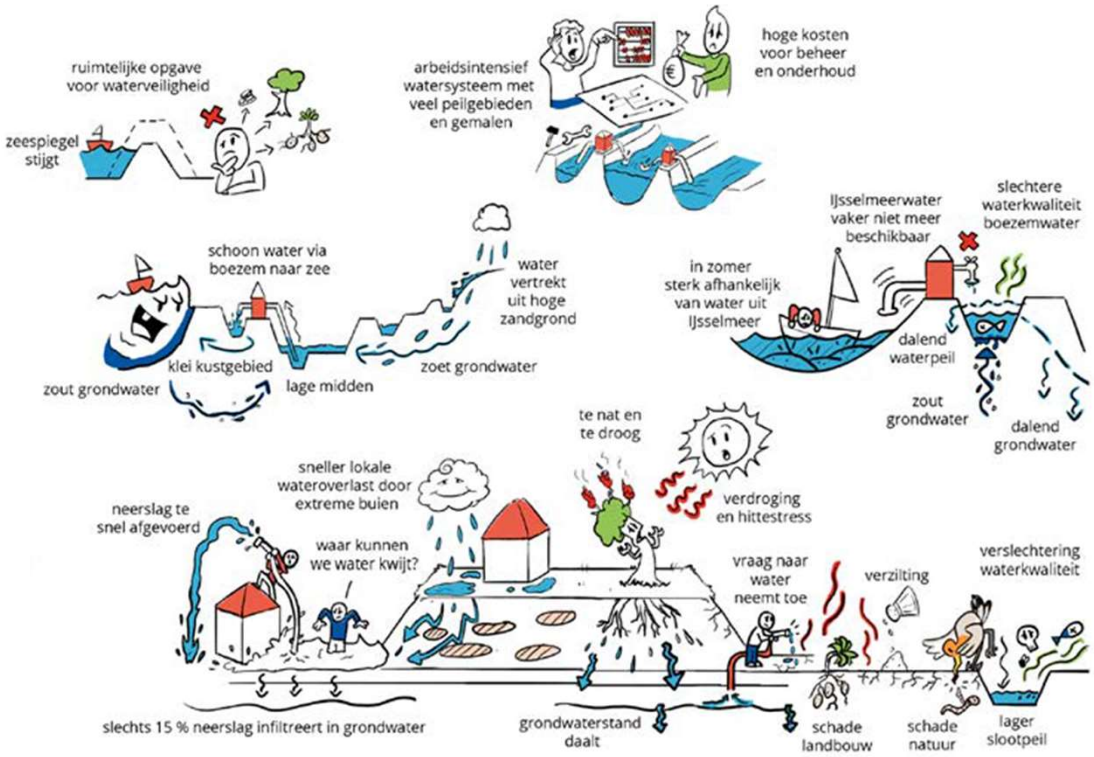
- Flooding (sea level rise, fluvial, heavy rainfall, seasonal changes)
- Heat
- Drought
- Salinization
- Wildfires



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Nature & biodiversity

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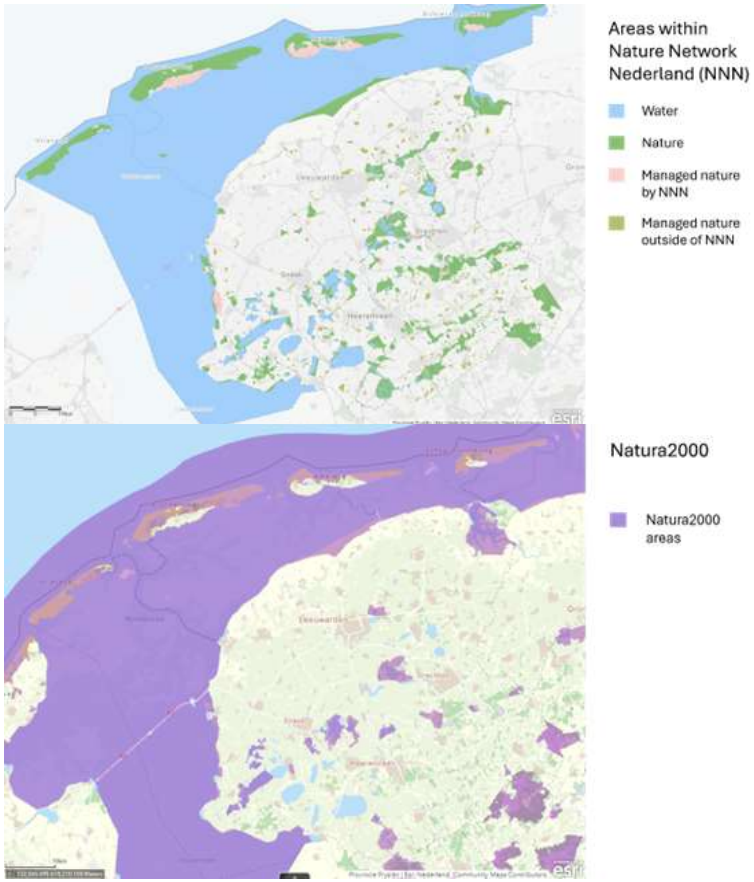
Biodiversity in Fryslân

Green-blue ecological networks

Natura2000 areas relatively bundled

Questions remain:

- Interactions between water issues, soil issues and biodiversity decline
- Nature on agricultural land



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Social System

Policy Environment

Governance & Quadruple Helix

Economic Structure

Social Structure

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Policy environment

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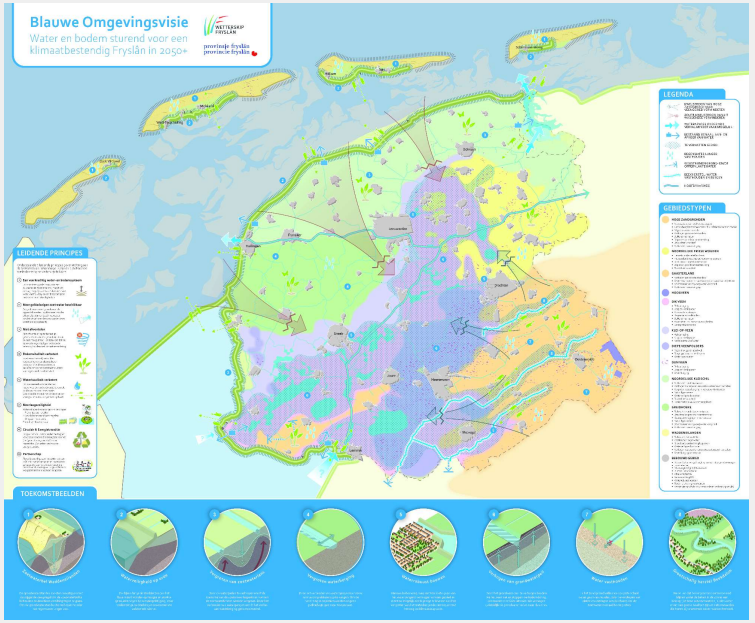
- Water and soil as a basis for spatial planning (WaBoS)
- Fryslân Climate Resilient 2050+ (NOVEX and former NPLG / Omgevingsvisie and FPLG)
- Municipal omgevingsvisies and Blue omgevingsvisie
- Water Framework Directive
- National Delta Program: climate-proof and water-robust by 2050
- Regionaal waterprogramma
- Circular bioeconomy
- Agricultural transition (?)



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Quadruple Helix

Involves representatives from all members of society

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Public Partners

Province of Fryslân, Wetterskip Fryslân, Frisian municipalities

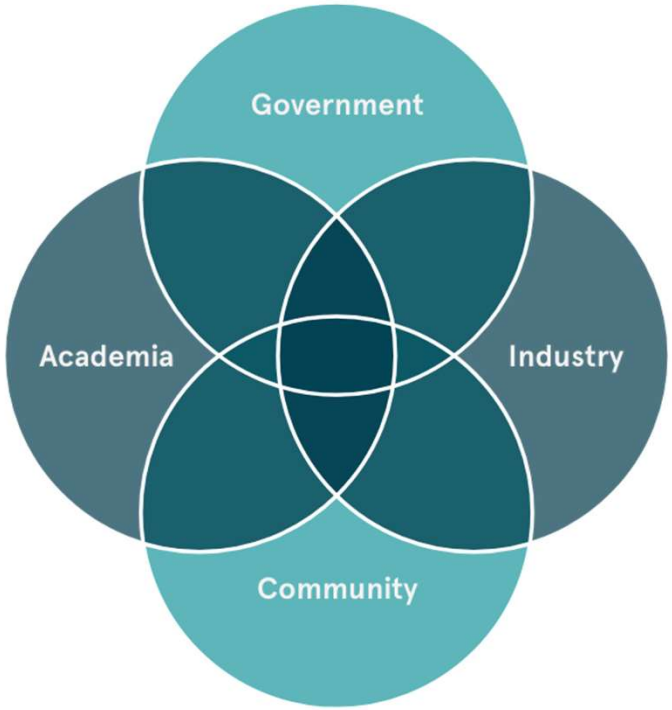
Private Partners

Knowledge & Academic Partners

EU Horizon / LIFE / INTERREG projects such as NBRACER, Soilcrates, All4Biodiversity, Water4All, etc.
CEW, Wetsus, VHL
LN2050 and NL2020 (Deltares, WUR, Sweco, etc.)

Civil Society

Fryske Gea, Staatsbosbeheer, Natuurmonumenten



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Key economic activities

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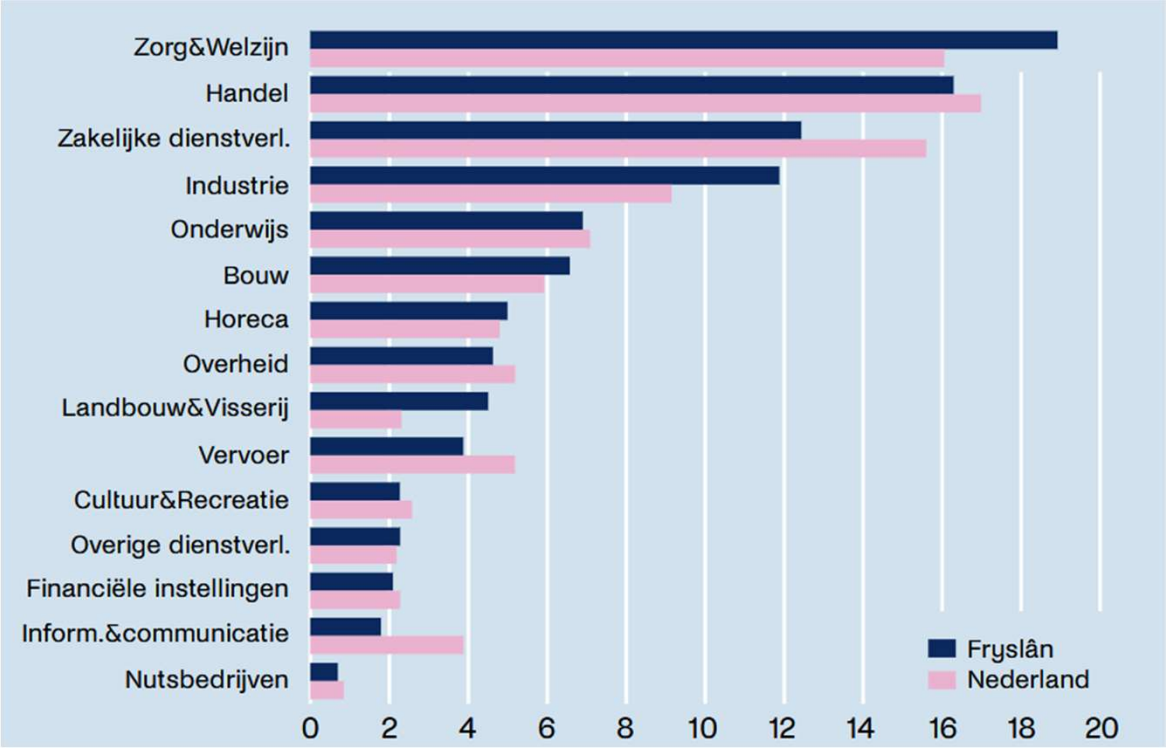
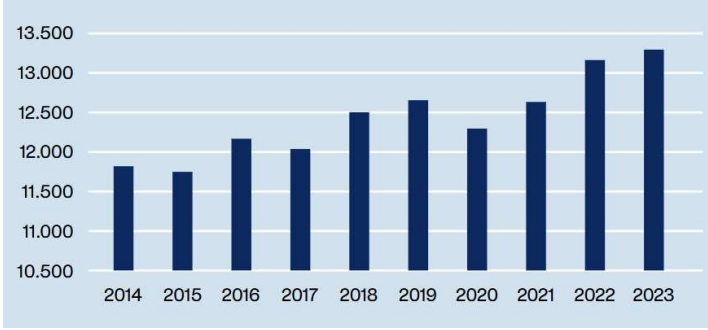
Employment per sector (LISA, 2023)



Employment circular economy (LISA, 2023)



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Smart Specialisation (RIS3 2021-2027)

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- 'Brede welvaart' (broad prosperity)
  - Despite having lower economic indicators such as GDP per capita and average income compared to other Dutch regions, the Frisian population consistently reports higher levels of subjective well-being and life satisfaction.
- Spatial quality, attractive living environment and high level of well-being
- Short connections ('korte lijnen'), SME economy
- Agriculture, biobased/circulair economy, water technology
- Four transitions:
  - From a linear to a circular economy
  - From fossil to sustainable energy
  - From care to (positive) health
  - From analogue to digital

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Land use & food systems

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- Most land is gras land for livestock (dairy farming and industry)
- Tourism (lakes and islands)
- Arable farming on clay soils in the north
- Agricultural collectives and mienskip
- Dispersed urban pattern. No metropolis, but various middle-sized cities

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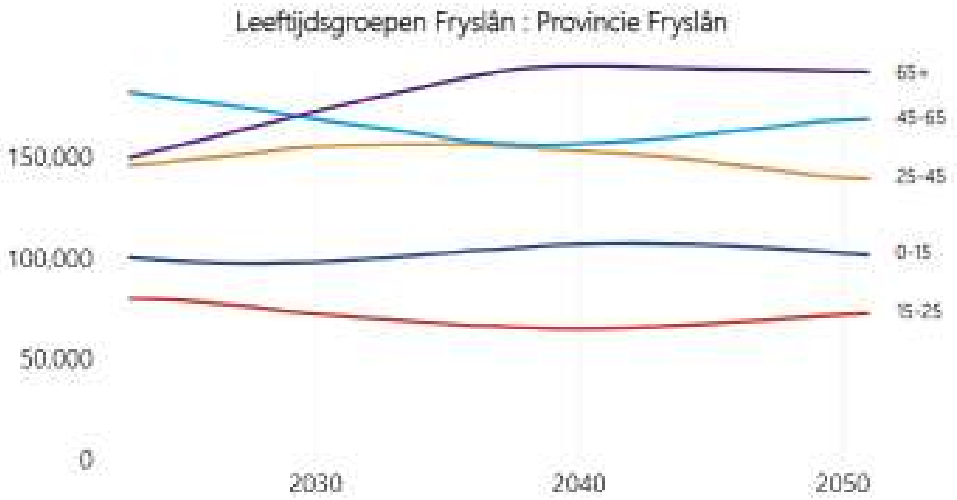
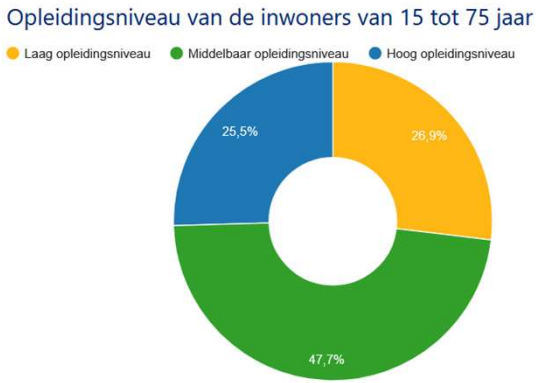
Social Structure

- Strong social cohesion and community bonds
- Cultural identity and traditions (language)
- Vulnerable groups to climate change (elderly, low-income households, farmers, disabilities, children)





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Key Findings Social System

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Indicatief:

- From water and soil policy to a regional approach
- Exploring novel (regenerative, water tolerant) agricultural practices water technology and housing innovations
- Building on Broad welfare approach
- Engaging with the Mienskip (society)

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Key Community Systems

Critical Infrastructures

Water Management

Health and Wellbeing

Land Use & Food Systems

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Key Community System: Area of transformation, part of a larger interdependent system.

Critical Infrastructure

Climate-proof infrastructure

From connections to key places

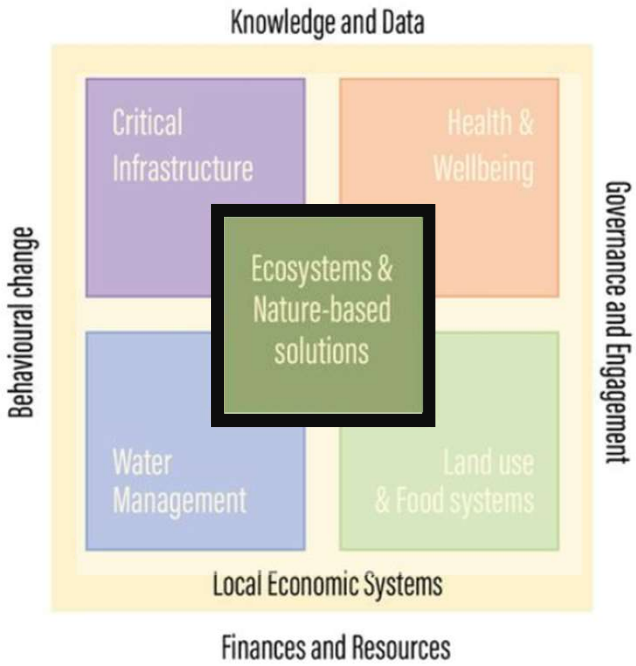
How?
- Nature-based solutions
- Development of common standards

Water Management

Freshwater availability

Reduce water-related risks

How?
- Innovation in water practices
- Innovative coastal protection
- Smart water allocation



Health & Wellbeing

Health in a changing climate

Early-warning and surveillance systems

How?
Protection of people at higher risks
Urban and rural health strategies

Land Use & Food Systems

Revive landscapes with climate resilient practices

Secure and sustainable food systems

How?
- Understanding and predicting risks and vulnerabilities
- New business models
- Promoting new technologies
- Upskilling actors

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Next Steps from the EU Mission on Climate Adaptation

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Interlinkages by nature

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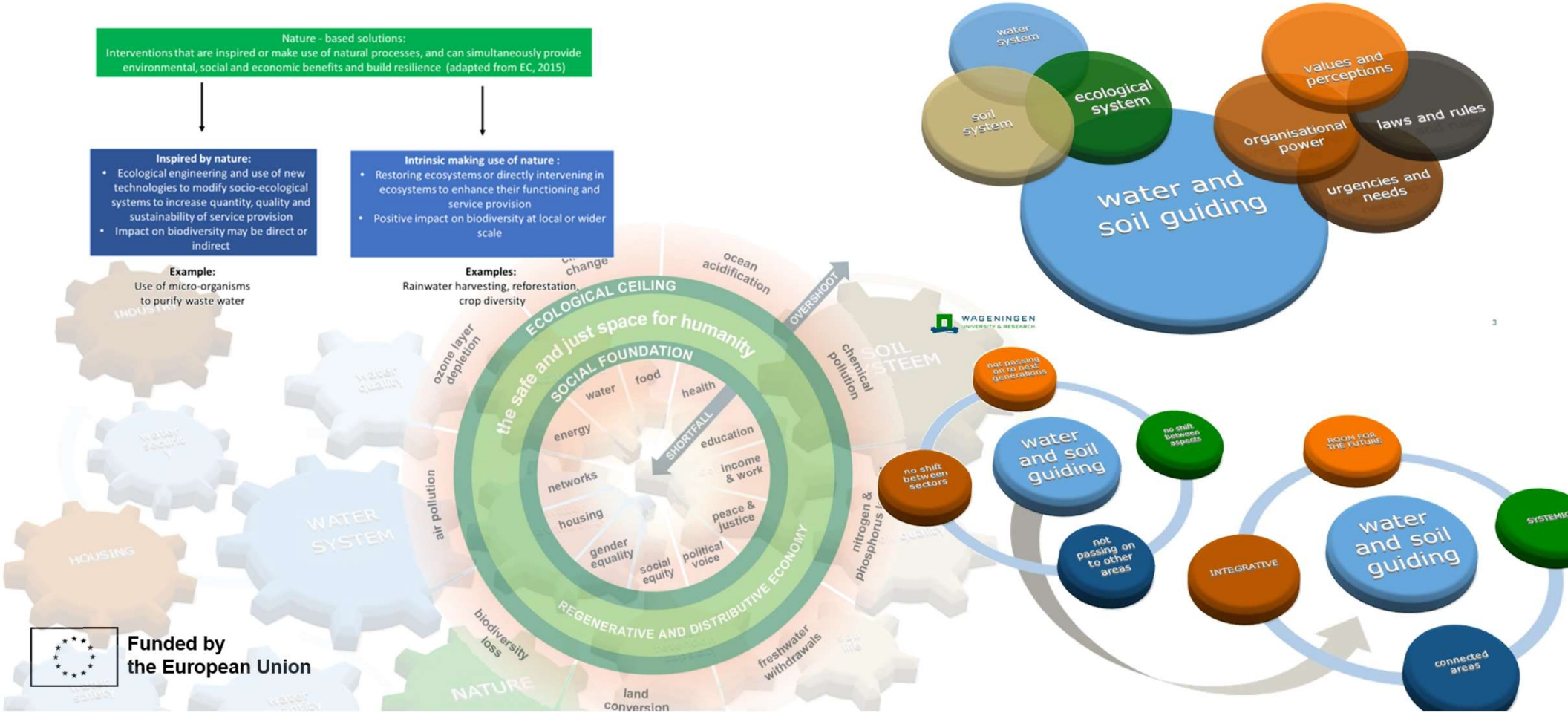

Governance Next Steps

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for Atlantic Regional Climate Resilience

Governance **interplay**:	The functioning of decision-making, responsibilities, relations between actors, top-down, formal-informal, interactive. Interviews, workshops, mapping etc.
Governance **needs**:	Desired steps to realize a just, co-created and resilient approach to climate adaptation. To identify issues that need support. Observation, regional input, established documents.

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Transformative Adaptation Journey

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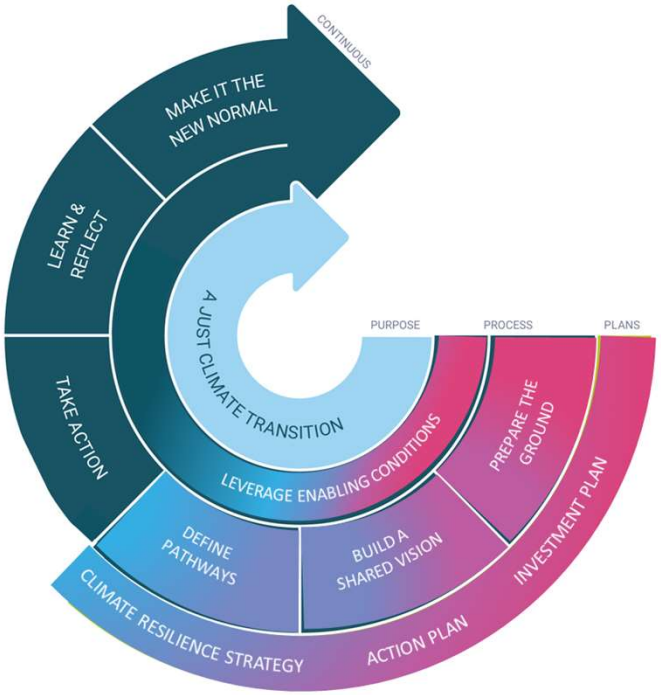

From preparing the ground

to

Shared vision

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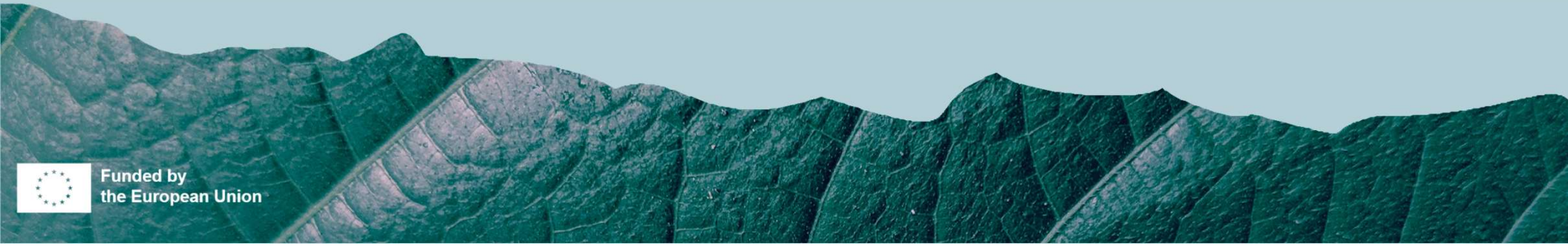
Thank you!



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Annex 8: Baseline presentation East Flanders

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Regional Baseline

East-Flanders

Pilot case: Flemish Ardennes

NBRACER Regional Workshop
February 24, 2025

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Mission

Integrated approach
Regional Approach
Transformative change

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The Mission on Adaptation to Climate Change

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Nature Based Solutions
for Atlantic Regional Climate Resilience

Focuses on:

- **Supporting EU regions**, cities and local authorities
- Their efforts to **build climate change resilience**

The Mission's objective:

- **Accompany at least 150 European regions and communities** towards climate resilience by 2030.

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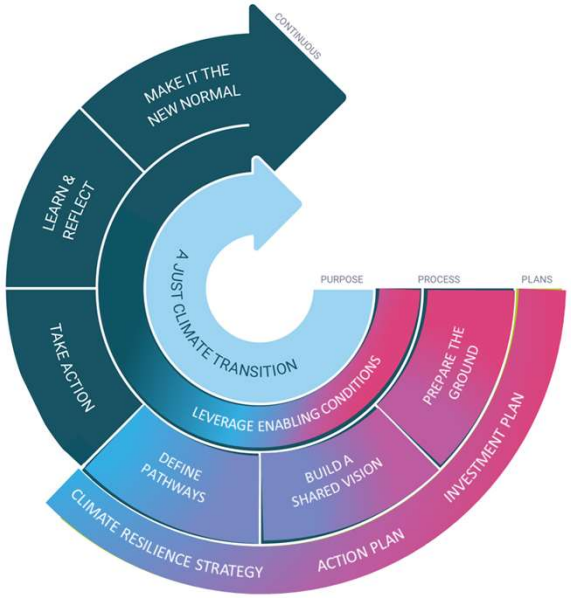
…via a Transformative Adaptation Journey



Regional approach

Regions are made and remade. They bring, and hold, together processes of economy, politics and cultural development --> regional development

Focuses on **characteristics and qualities of the regional geography and social conditions --> regional profiling**

Climate, society and the environment

Relation of society and **nature**, **organize** this interaction and keep an eye on **the balance - planetary boundaries**

Demonstration and implementation

Focus on regions that test and **demonstrate Nature-based Solutions**, to make it happen - upscaling towards regional resilience

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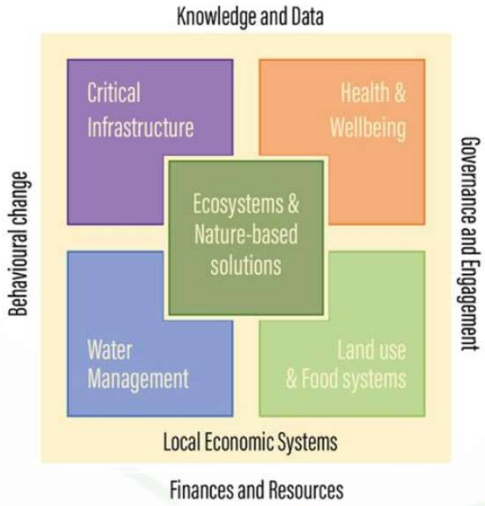
…systemic and transformative

towards a safe, prosperous and healthy environment

mainstreaming

Key Community Systems



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Regional Baseline

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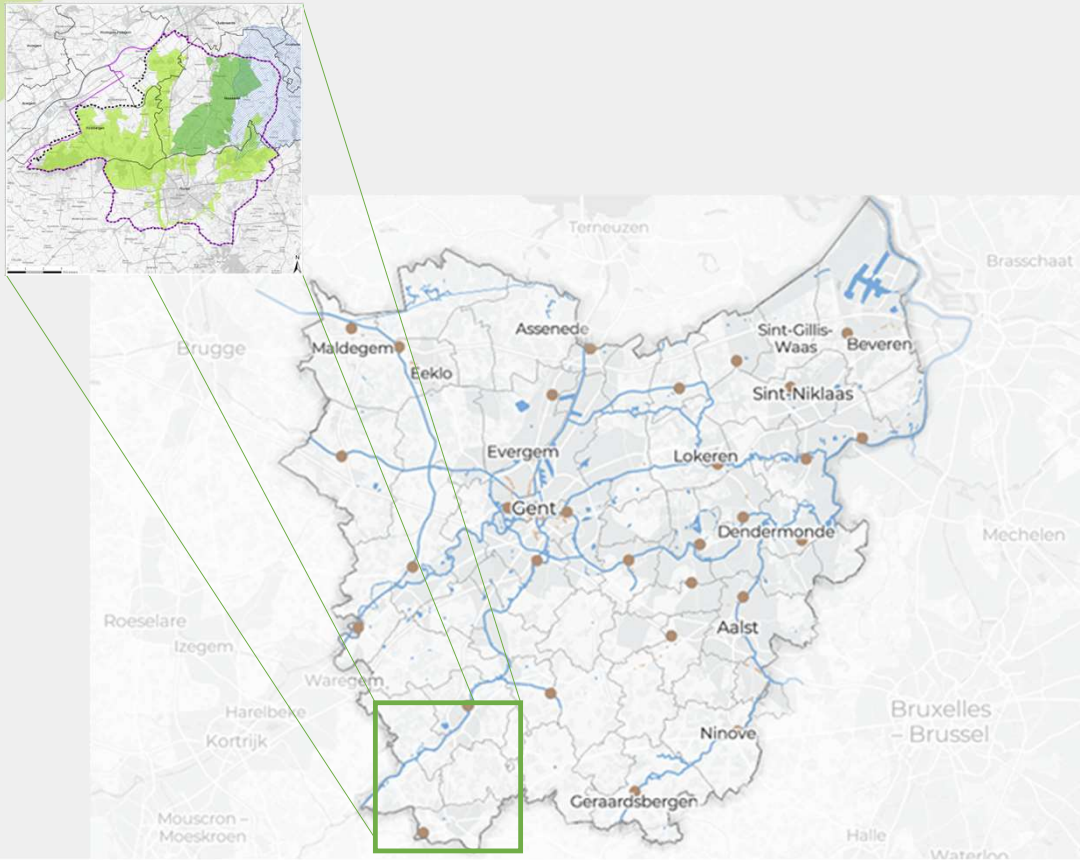
Region: East-Flanders
Pilot Case: Flemish Ardennes
Municipalities: Ronse, Maarkedal and Kluisbergen

Aim

- **Collect** regional information
- **Create collective starting point; common understanding**
- **Provide insights** into physical and socio-economic context
- **Start** of the Transformative Adaptation Journey (prepare the ground)



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Connecting the dots

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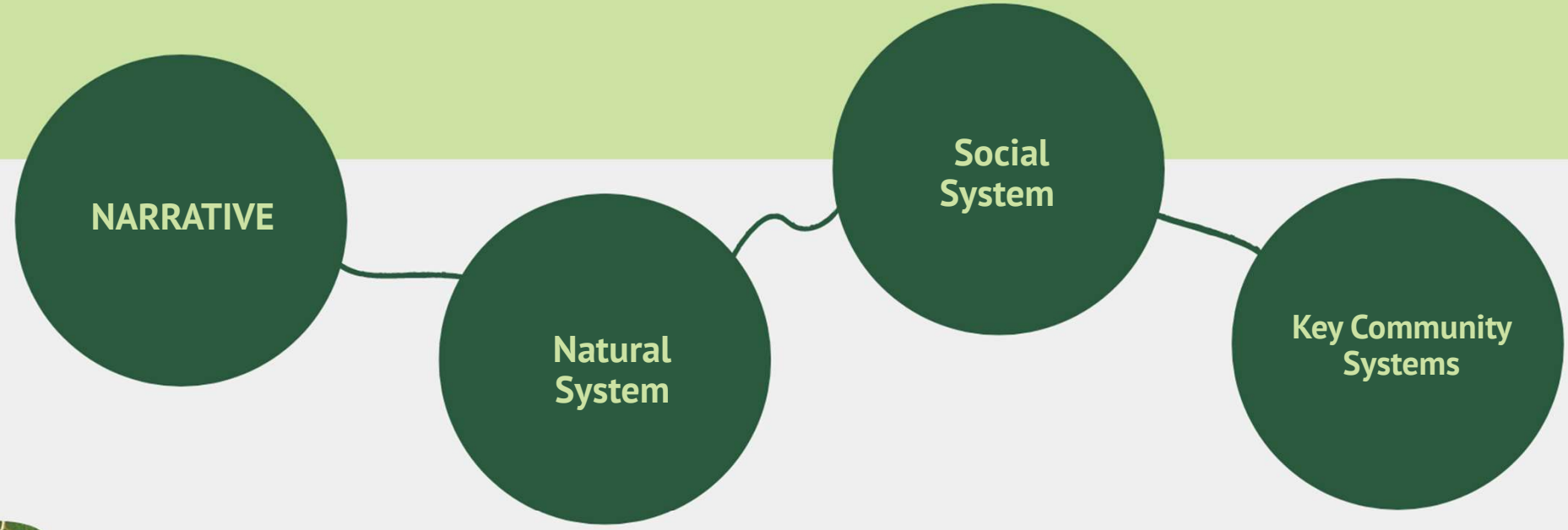

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Natural System

(Sub)soil system

Hydrological system

Nature and biodiversity

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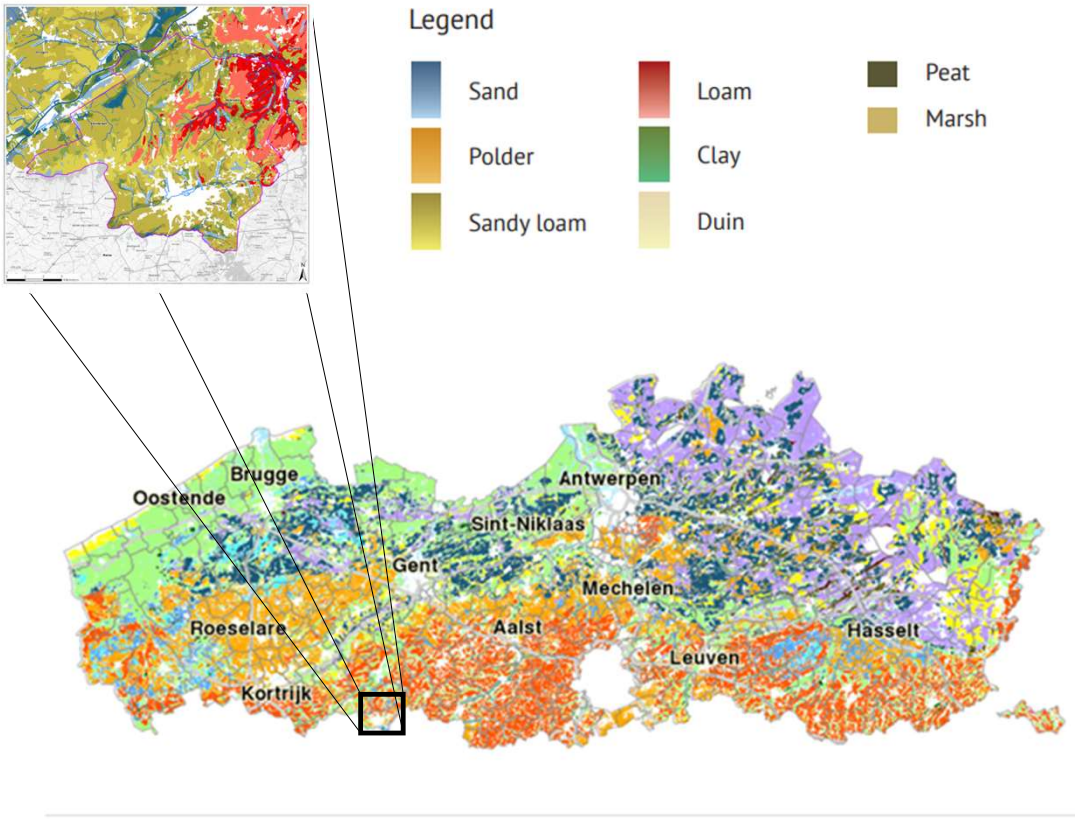
Soil system

Soil texture ranges from sandy to (very loamy), includes sandy soils and polder landscapes. Challenges are multifaceted

i.e. Challenges Vlaams programmma Grond+Zaken

- Healthy, living soils as necessary condition
- Soil quality is declining
- Soil processes occur slowly
- Need to scale initiative power
- From sectoral -> integral



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Flood Risk (current & future climate)

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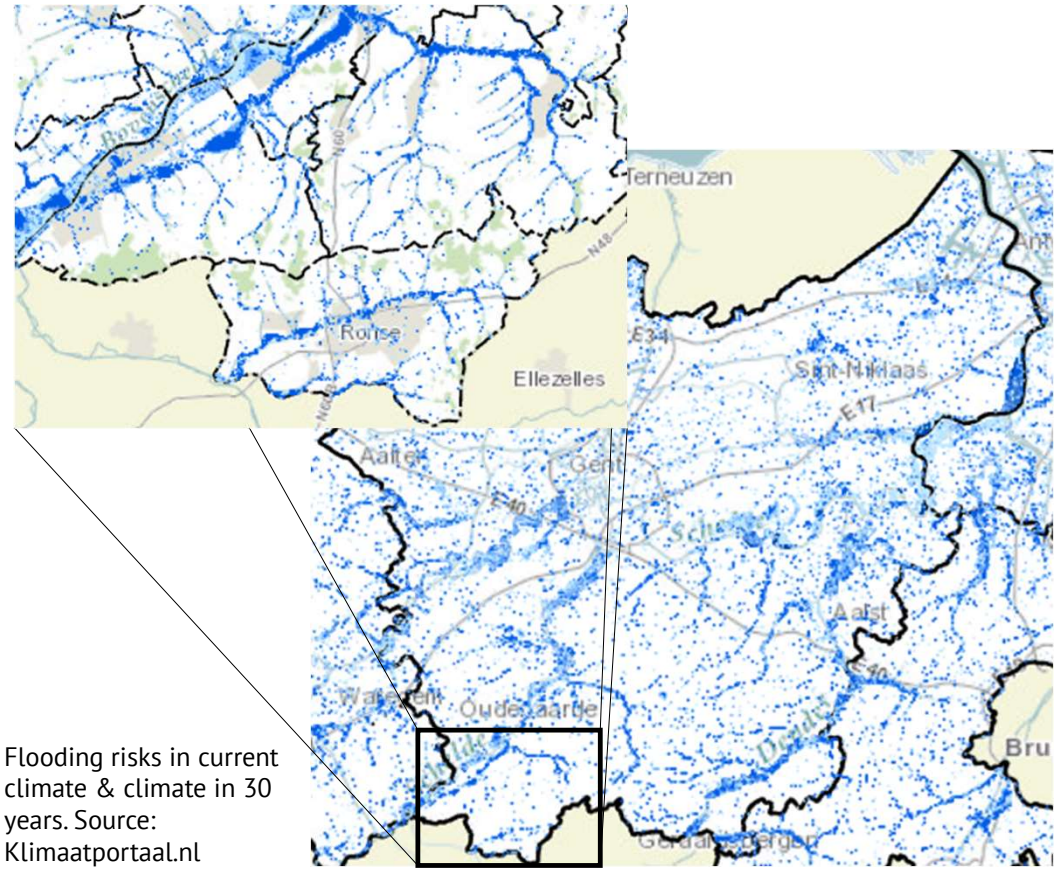
The water system in the Flemish Ardennes

- **Mix** of pluvial and fluvial risks
- **Big rivers *and* smaller waterways** provide challenges
- Current flooding risk (pluvial and fluvial) already severely present in current climate -> **getting worse in future climates**
- Future flooding risk **exacerbating** current risk areas and **creating new risk areas**

Compounding Risks:

- **Salinization**
- **Drought** (in the long-term)
- **Flooding**



Flooding risks in current climate & climate in 30 years. Source: Klimaatportaal.nl

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...and nature & biodiversity

Biodiversity (natuurwaarde) in the Flemish Ardennes..

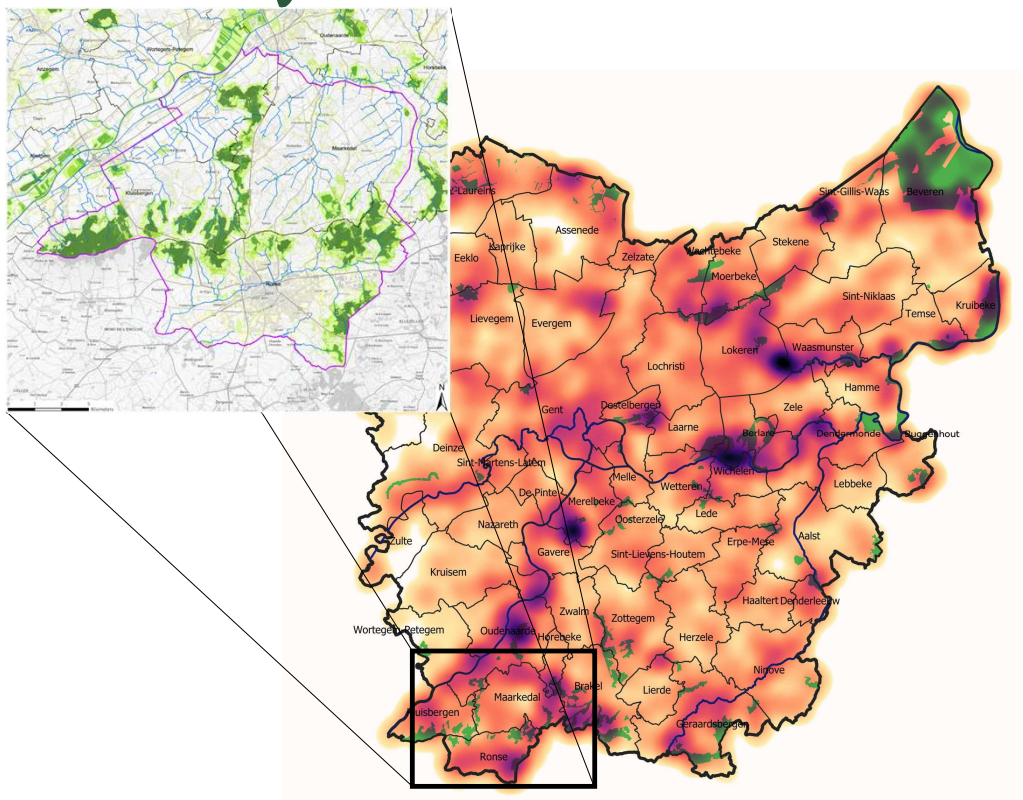
Some hotspots, but poor throughout

Green-blue ecological networks

Natura2000 areas relatively bundled

Questions remain:

- Rural-urban interface and nature
- Natural and health benefits
- Interactions between water issues, soil issues and biodiversity decline



Heat map of provincial priority habitat-typical species, Natura2000 areas are in green.
Natuurwaarde in groen 1-4

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Social System

Policy Environment

Governance & Quadruple Helix

Economic Structure

Social Structure

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Policy Environment

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Federale overheid	Vlaams Gewest	Vlaamse Gemeenschap
economie	ruimtelijke ordening	cultuur
mobiliteit	wonen	onderwijs
financiën	milieu	gezondheidszorg
sociale zaken en volksgezondheid	natuur	welzijn
overheidsbedrijven	water	justitie
justitie	landbouw en visserij	
pensioenen	wetenschappelijk onderzoek	
defensie	economie	
klimaat en milieu	toerisme	
binnenlandse zaken	dierenwelzijn	
energie	energie	
buitenlandse zaken	stedenbeleid	
ontwikkelingssamenwerking	werk	
	openbare werken en mobiliteit	

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Policy Environment province of East-Flanders

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- Reponsable for tasks which are municipalities can not fulfil of their own, interest of multiple municipalities
- Supporting other public governments, as well Federal, Flanders or municipalities
- Are base collaboration between various partners, mission driven approach to solve societal problems

Oost-Vlaanderen

- **bovenlokale taakstelling** voor aangelegenheden die het lokale, gemeentelijke belang overstijgen en die gemeenten moeilijk zelf kunnen behartigen
- **ondersteunende taken voor andere overheden**: de provincie voert sommige taken uit op verzoek van de federale of Vlaamse overheid of de gemeenten en OCMW's
- **gebiedsgerichte samenwerking tussen besturen in een regio**: de provincie organiseert samenwerking tussen de verschillende partners (lokale besturen, privé-organisaties, Vlaamse overheid,...) in een bepaald gebied en zoekt samen met die partners naar oplossingen voor maatschappelijke problemen

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Quadruple Helix

Involves representatives from all domains of society

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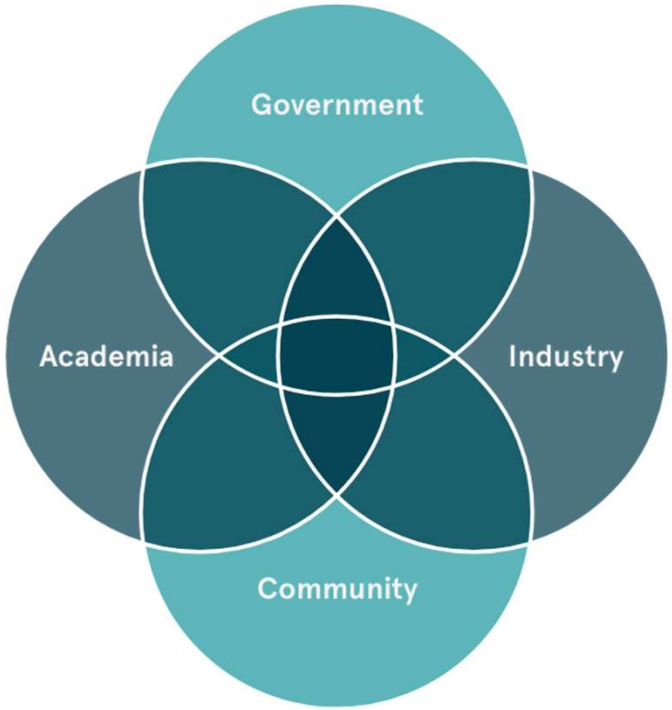
Public Sector
Provincie Oost Vlaanderen, provincie West Vlaanderen
Gemeenten Ronse, Hoorebeke, Maarkedal
VLM

Private Sector

Knowledge & Academic Partners
Universiteit Gent
Vito

Civil Society
ANB
NLVA



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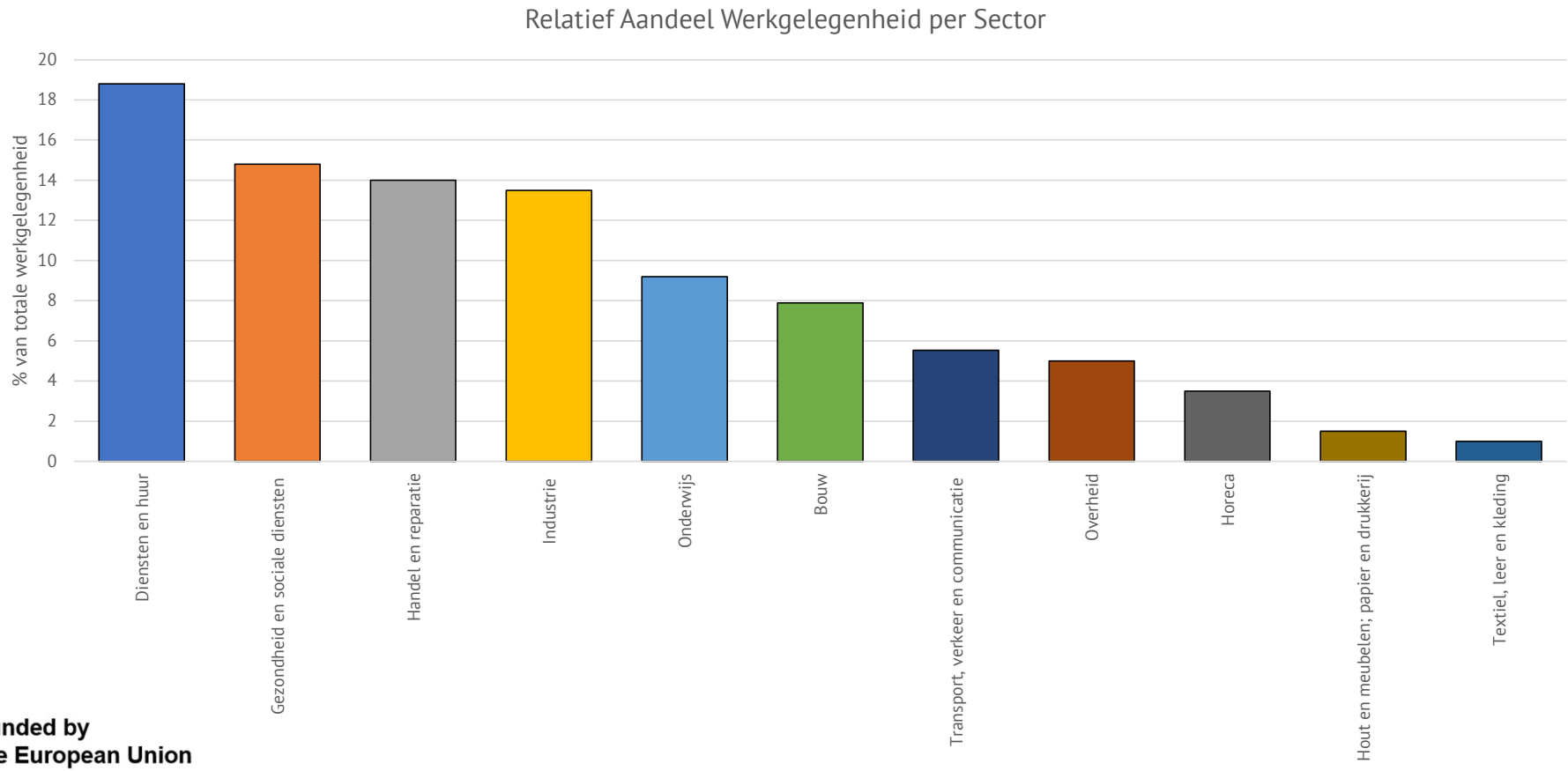
Key economic activities



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Smart Specialisation

Situatieschets Oost-Vlaanderen 2023 – Status en vooruitzicht economie

Smart specialization: pillar of socio-economic policy

Circular economy: 1 of the 7 transitions in the Vlaamse Visie 2050

- Circular building
- Chemicals/plastics
- Water cycles
- Bioeconomy
- Food chain
- Manufacturing industry

Wine growing

- Promotion
- Professionalization

Use the strategies, qualities and capabilities of the regional development in Flanders for solutions, innovations and specializations in NBS development

Economic valorization of territorial assets and resources

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Land use & food systems

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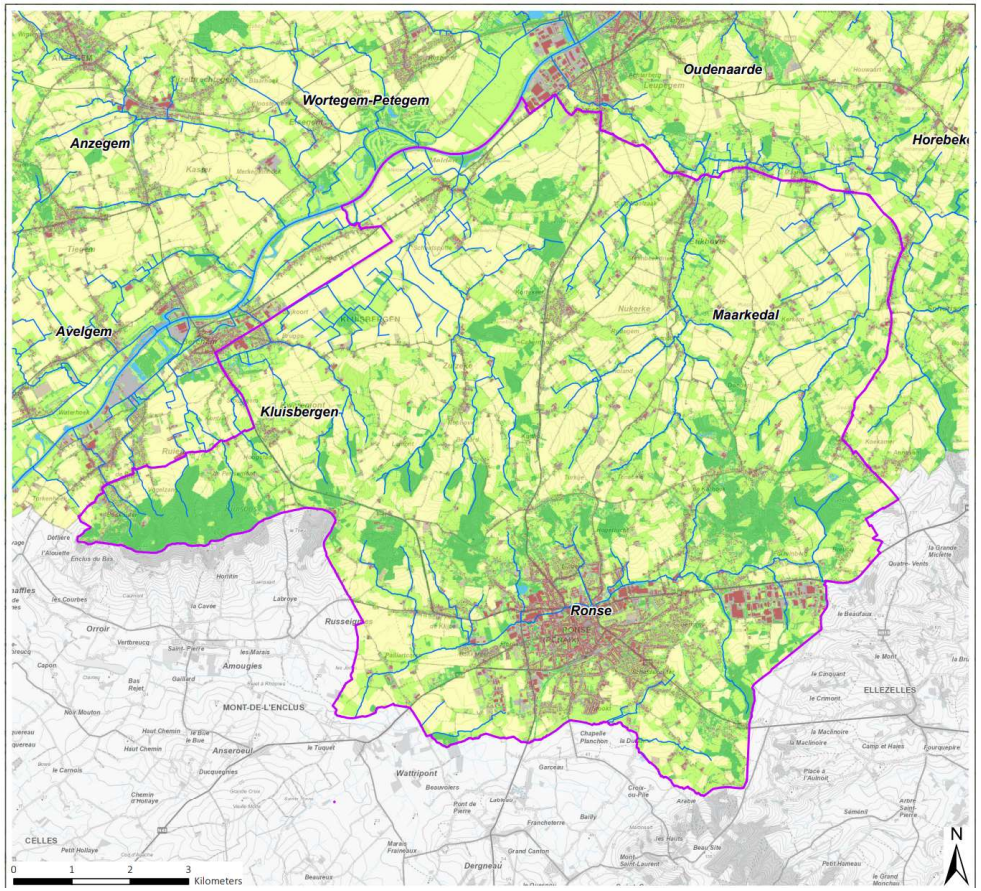
Farming area
Industry: Ronse

Tabel 2: Overzicht van de bedrijfstypes van de gebruikers, de totale en gemiddelde oppervlakte in het projectgebied volgens de vestigingsplaats van de gebruikers

Bedrijfstype van de gebruikers	Aantal	Oppervlakte (ha) in projectgebied
bedrijf met combinaties van gewassen	2	42
bedrijf met combinaties van gewassen en veeteelt	46	1.105
bedrijf met combinaties van veeteelt	5	74
gespecialiseerd akkerbouwbedrijf	134	1.255
gespecialiseerd bedrijf blijvende (vrucht-) teelten	3	20
gespecialiseerd graasdierbedrijf	153	3.027
gespecialiseerd hokdierbedrijf	18	384
gespecialiseerd tuinbouwbedrijf	3	6
niet-geclassificeerde bedrijf	19	57
Eindtotaal	**383**	5.971



LANDINRICHTING
Zuidwestelijke Vlaamse Ardennen - fase 1

Onderzoek naar opportuniteit en haalbaarheid

Kaart 4: landgebruik

Legende
- Perimeter LIR Zuidwestelijke Vlaamse Ardennen
- Waterlopen
- Gebouwen
- Akker
- Gras, struiken
- Bomen, bos
- Water
- Wegen
- Spoorwegen
- Overig afgedekt
- Overig onafgedekt

bron:
- Waterlopen en waterwegen in Vlaanderen, toestand 03/01/2022
- Rastertoestand van de bodembedekkingskaart: 1m resolutie, toestand 2018 (Digitaal Vlaanderen, 2021)
- Het voorlopig referentiebestand gemeentegrenzen, Digitaal Vlaanderen, toestand 04/01/2019 (Digitaal Vlaanderen, 2019)
- Cartoweb, kleur, NGI (2021)

aangemaakt op: 18/04/2023

NGI IGN

Vlaamse overheid

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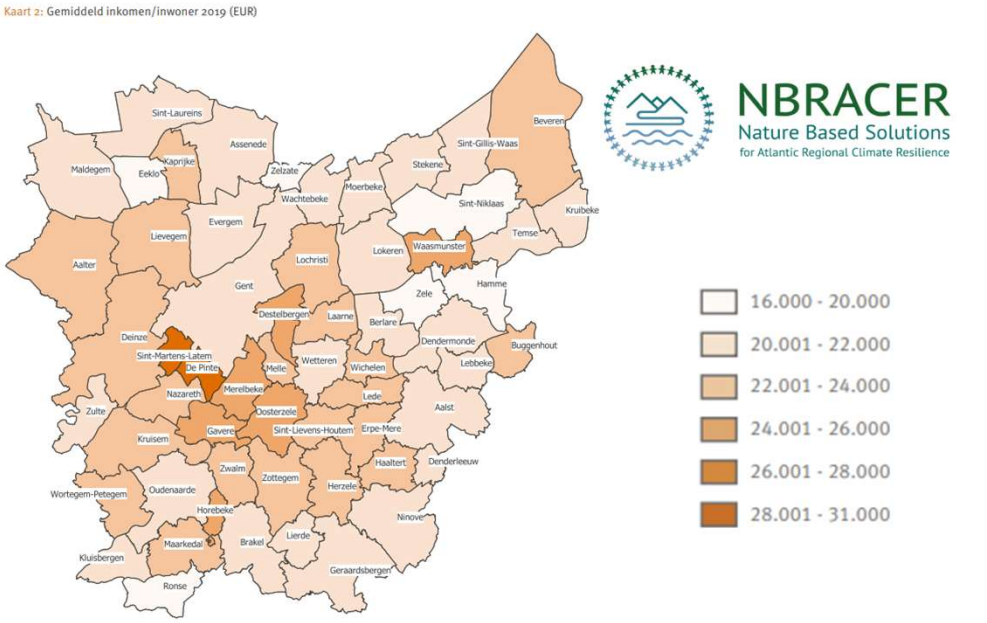
Social Structure

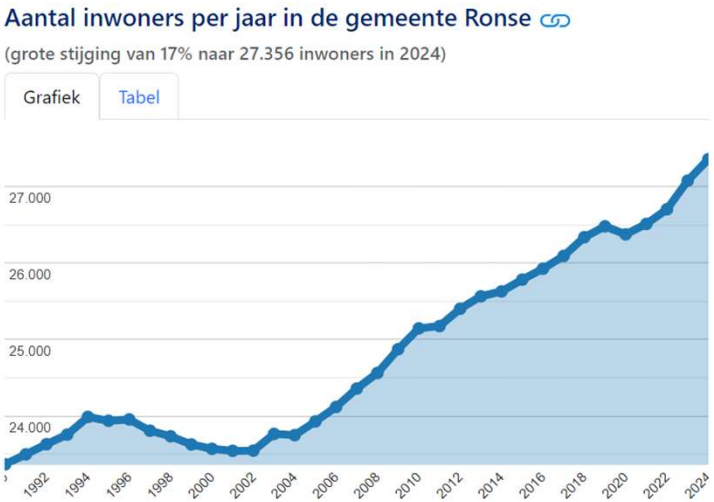
Income inequality across space

Inhabitants: 35000
Migratiesaldo 338
Natural saldo -79

Income relatively low

Vulnerable groups:
Farmers, poor society members, elder generation





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Key Community Systems

Critical Infrastructures

Water Management

Health and Wellbeing

Land Use & Food Systems

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Key Community System: Area of transformation, part of a larger interdependent system.

Critical Infrastructure

Climate-proof infrastructure

From connections to key places

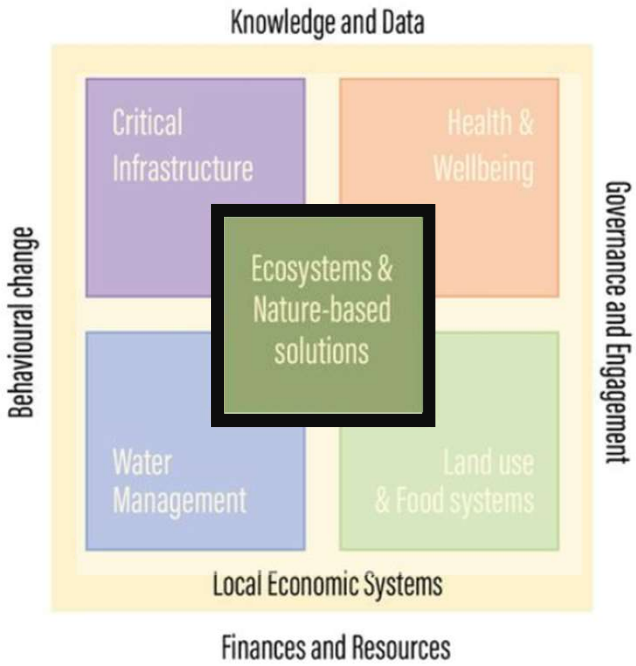
How?
- Nature-based solutions
- Development of common standards

Water Management

Freshwater availability

Reduce water-related risks

How?
- Innovation in water practices
- Innovative coastal protection
- Smart water allocation



Health & Wellbeing

Health in a changing climate

Early-warning and surveillance systems

How?
Protection of people at higher risks
Urban and rural health strategies

Land Use & Food Systems

Revive landscapes with climate resilient practices

Secure and sustainable food systems

How?
- Understanding and predicting risks and vulnerabilities
- New business models
- Promoting new technologies
- Upskilling actors

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Next Steps from the EU Mission on Climate Adaptation

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Interlinkages by nature

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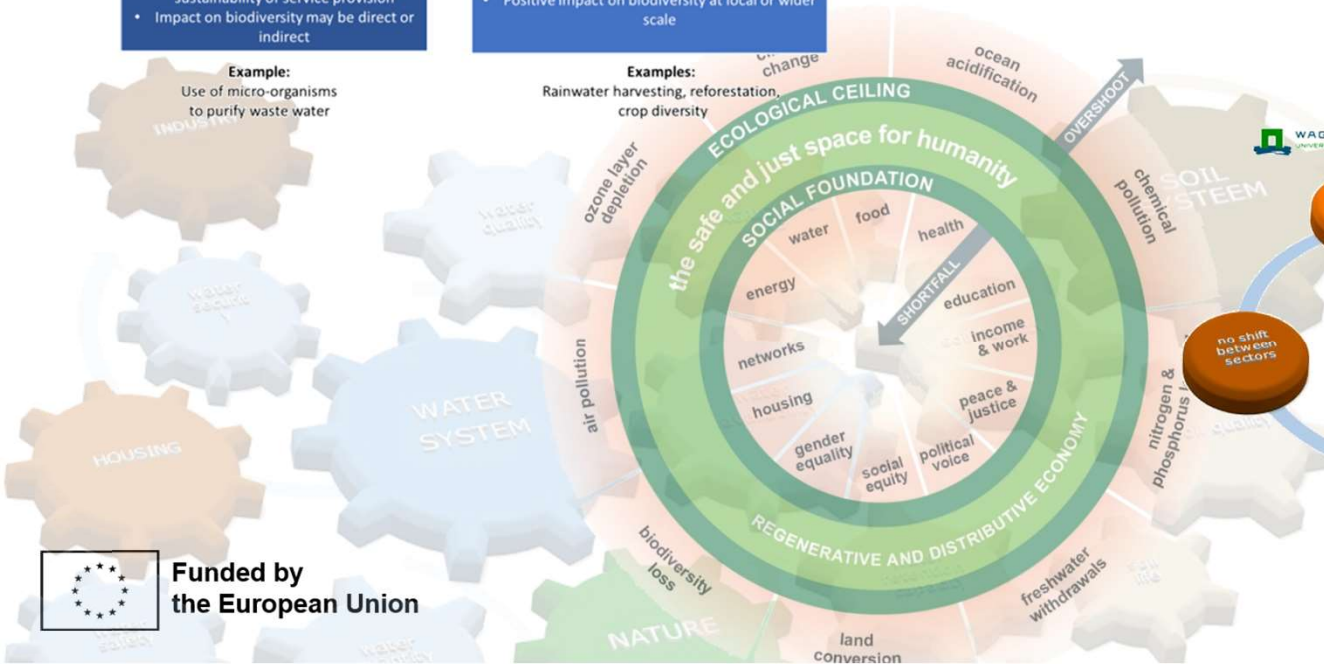
Nature - based solutions:
Interventions that are inspired or make use of natural processes, and can simultaneously provide environmental, social and economic benefits and build resilience (adapted from EC, 2015)

Inspired by nature:
- Ecological engineering and use of new technologies to modify socio-ecological systems to increase quantity, quality and sustainability of service provision
- Impact on biodiversity may be direct or indirect

Example:
Use of micro-organisms to purify waste water

Intrinsic making use of nature :
- Restoring ecosystems or directly intervening in ecosystems to enhance their functioning and service provision
- Positive impact on biodiversity at local or wider scale

Examples:
Rainwater harvesting, reforestation, crop diversity



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Governance Next Steps

Governance **interplay**:	coordination, collaboration, visioning and implementation among regional partners; top-down bottom-up, formal-informal, interactive.
NBRACER support	Interviews, workshops, mapping etc.

Governance **needs**:	Desired steps to realize a transformative, just, co-created and resilient approach to climate adaptation. To identify governance issues that can be improved and need support.
NBRACER support	Observation, regional input, established documents.

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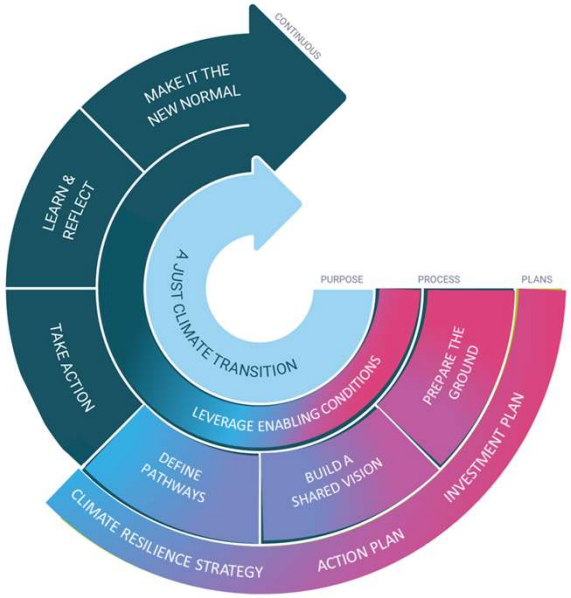
Transformative Adaptation Journey



From preparing the ground

To

Shared vision

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Workshop

Exercise

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Workshop

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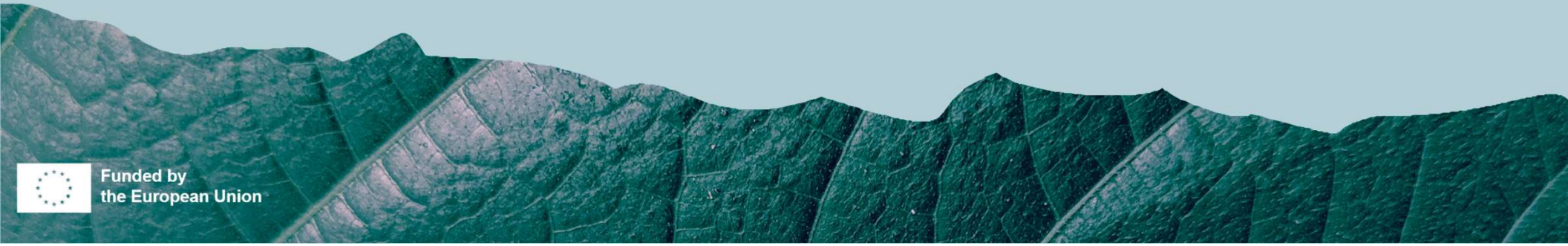
Thank you!



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Annex 9: Baseline presentation Cavado

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Regional Baseline

RR Cavado

NBRACER Regional Workshop
February 12, 2025

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Mission

Integrated approach
Regional Approach
Transformative change
Role of a Regional Baseline

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The Mission on Adaptation to Climate Change

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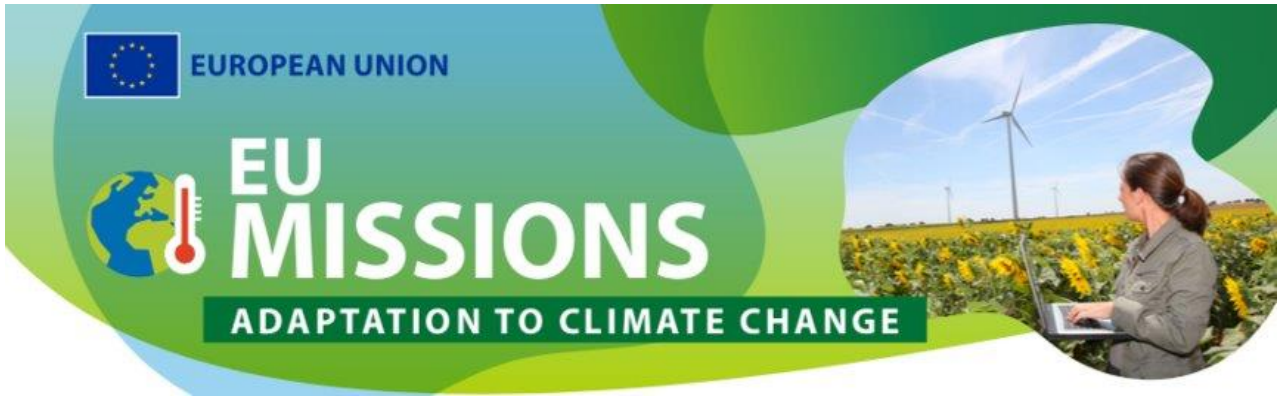
Focuses on:

- **Supporting EU regions**, cities and local authorities
- Their efforts to **build climate change resilience**

The Mission's objective:

- **Accompany at least 150 European regions and communities** towards climate resilience by 2030.



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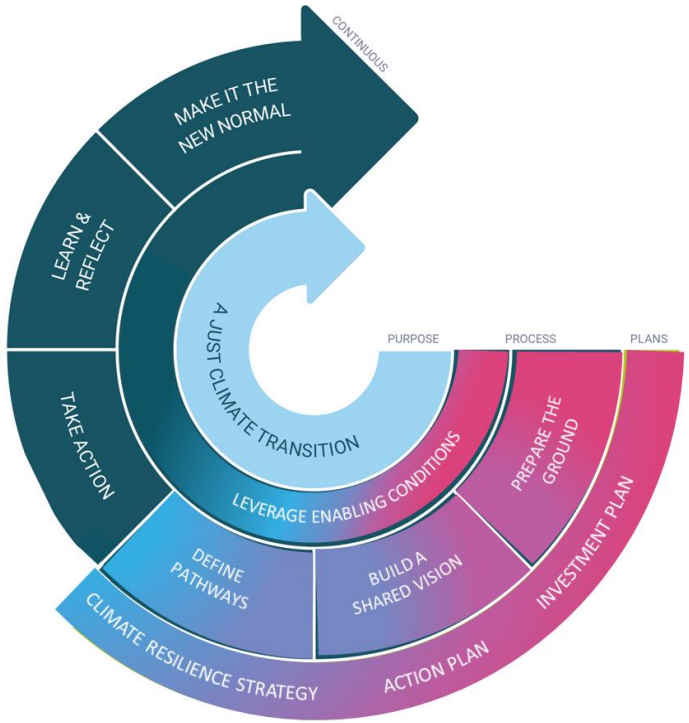
…via a Transformative Adaptation Journey



Regional approach

Regions are made and remade. They bring, and hold, together processes of economy, politics and cultural development --> regional development

Focuses on **characteristics and qualities of the regional geography and social conditions --> regional profiling**

Climate, society and the environment

Changing how we **live with nature**, **organize** this interaction and keep an eye on **the future**

Demonstration and implementation

Focus on regions that test and **demonstrate Nature-based Solutions**, to upscaling and regional resilience

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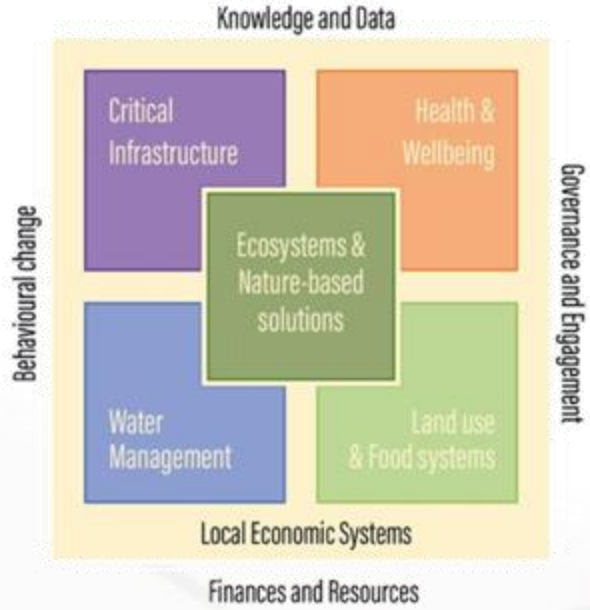
…systemic and transformative

towards a safe, prosperous and healthy environment

mainstreaming

Key Community Systems



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Regional Baseline

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Region: Cavado
Pilot Case: Urban: the renaturalisation of river Este in Braga
Urban/rural/coast: Interceptor channel of Esposende
Municipalities: Amares, Barcelos, Braga, Esposende, Vila Verde, Terras de Bouro

Aim

- **Collect** regional information
- **Create collective starting point; common understanding**
- **Provide insights** into physical and socio-economic context
- **Start** of the Transformative Adaptation Journey (prepare the ground)

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Connecting the dots

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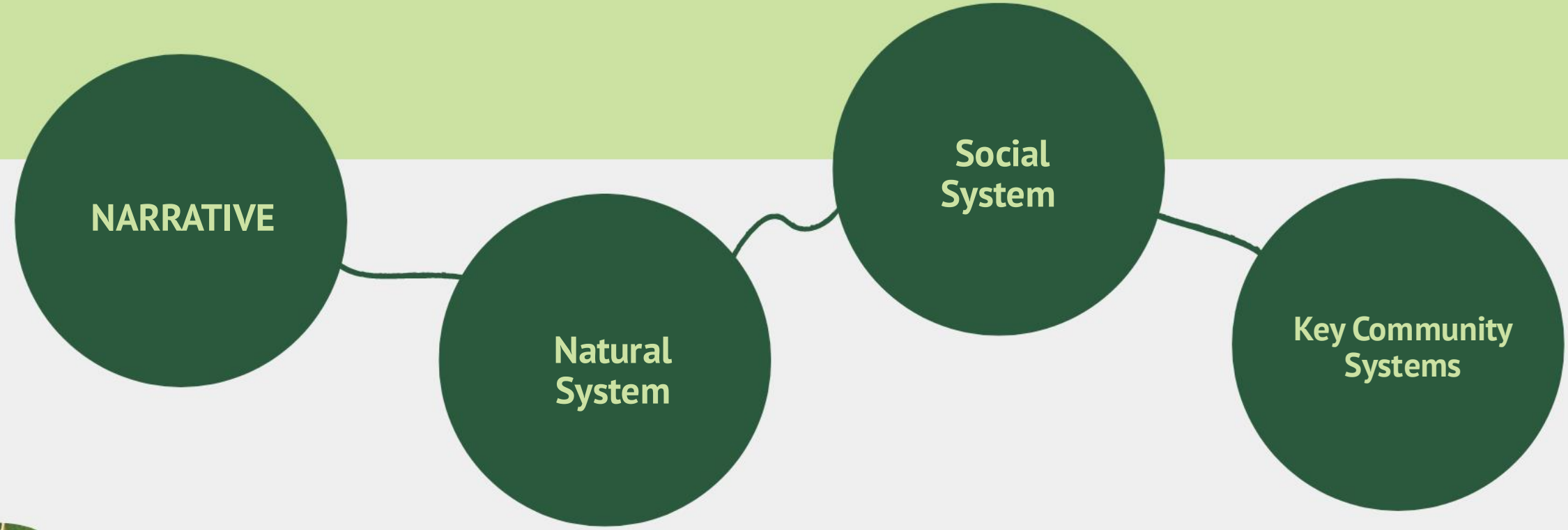

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Natural System

Soil system

Hydrological system

Landscapes

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Landscapes of Cávado

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water treatment plant (ETA)
Cávado river - public supply

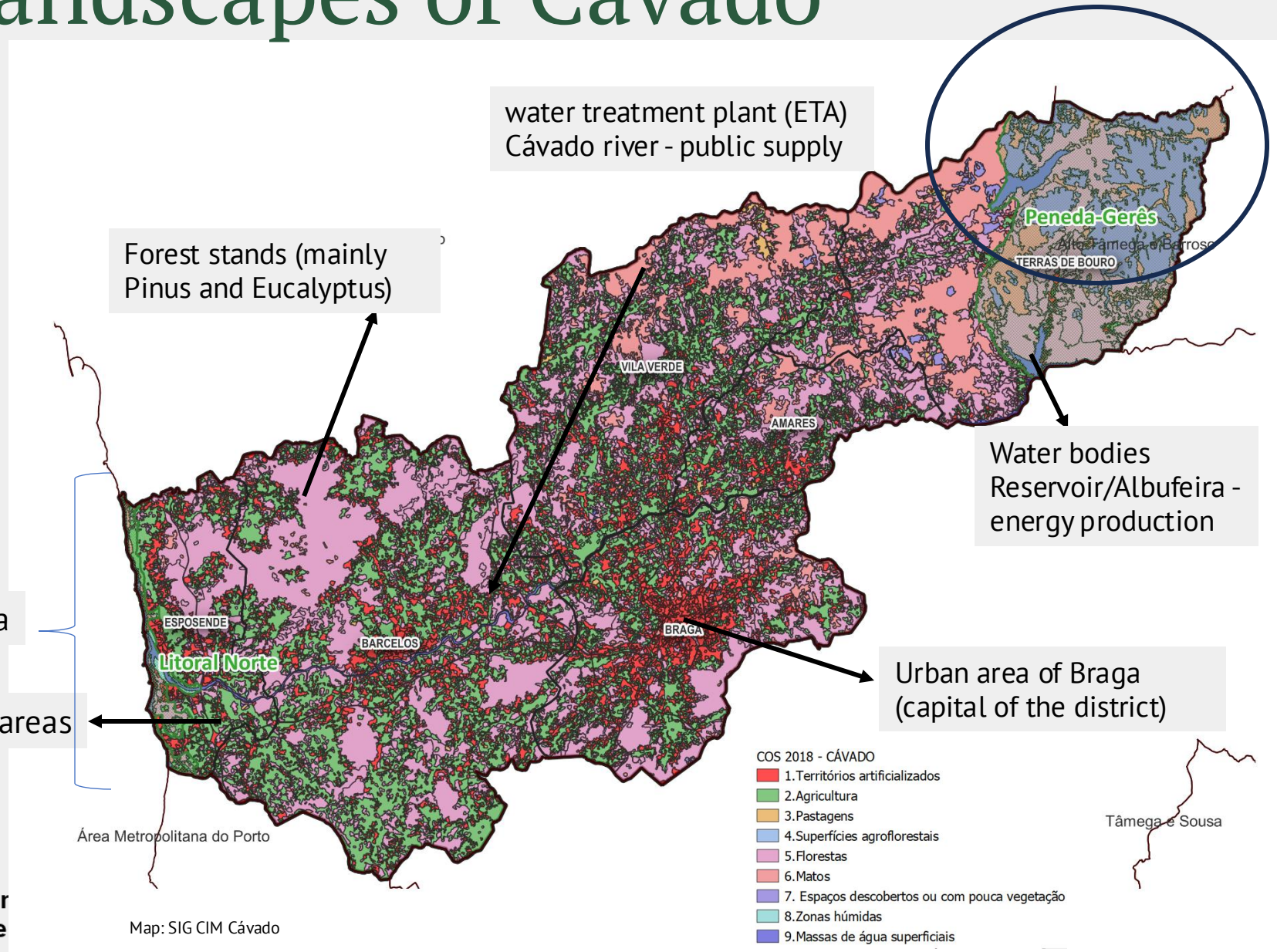
Forest stands (mainly Pinus and Eucalyptus)

Water bodies
Reservoir/Albufeira - energy production

coastal area

Agriculture areas

Urban area of Braga (capital of the district)



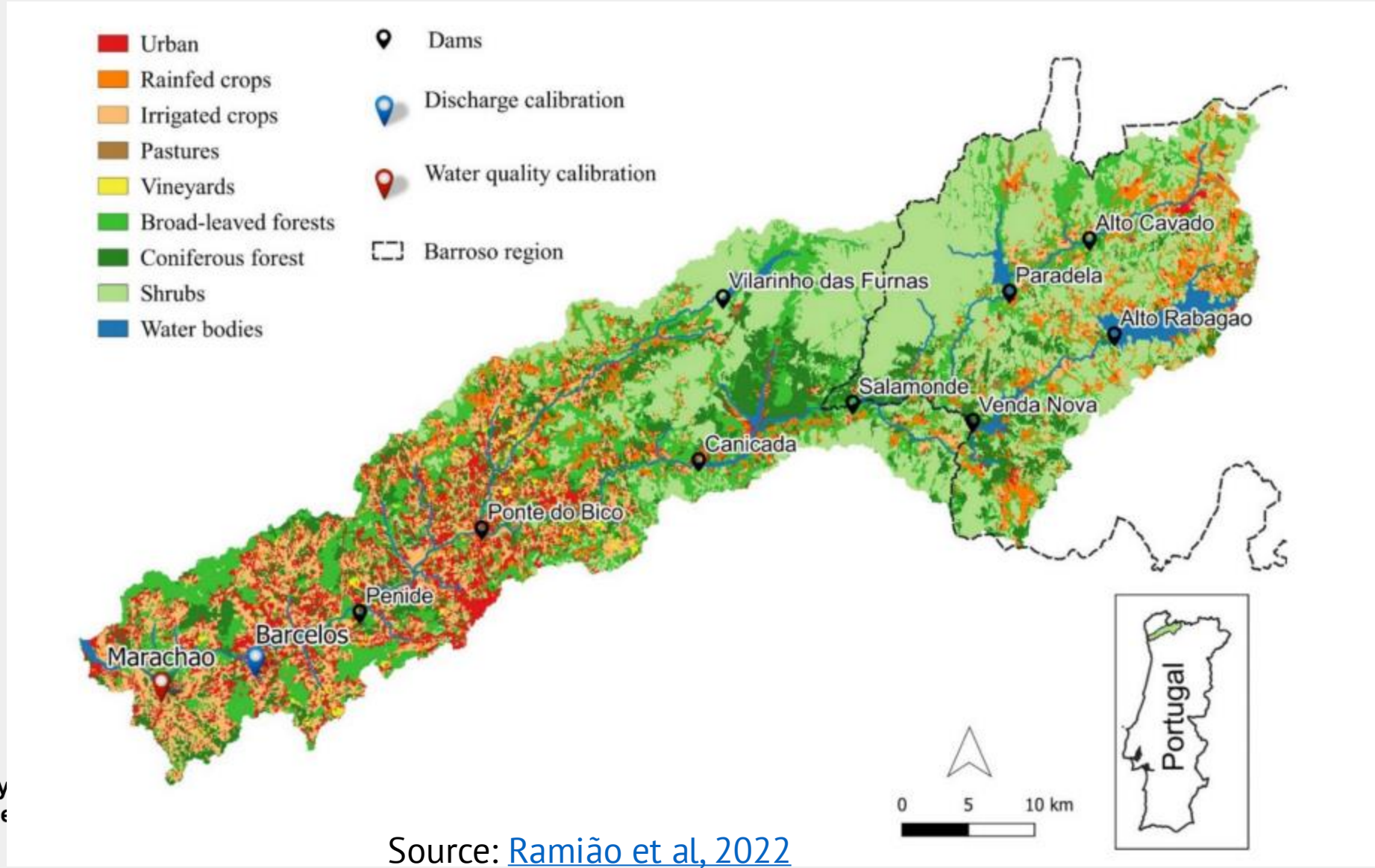
Map: SIG CIM Cávado

National Park of Peneda-Gerês (mainly endemic forest stands – oak, chestnut, yew)

Source: https://www.arcostour.net/post/parque-nacional-peneda-geres
Parque Nacional da Peneda-Gerês - Peneda-Gerês (walkingpenedageres.pt)

Fur
the

Landscape use and Dams



Source: Ramião et al, 2022

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Landscapes of Cávado

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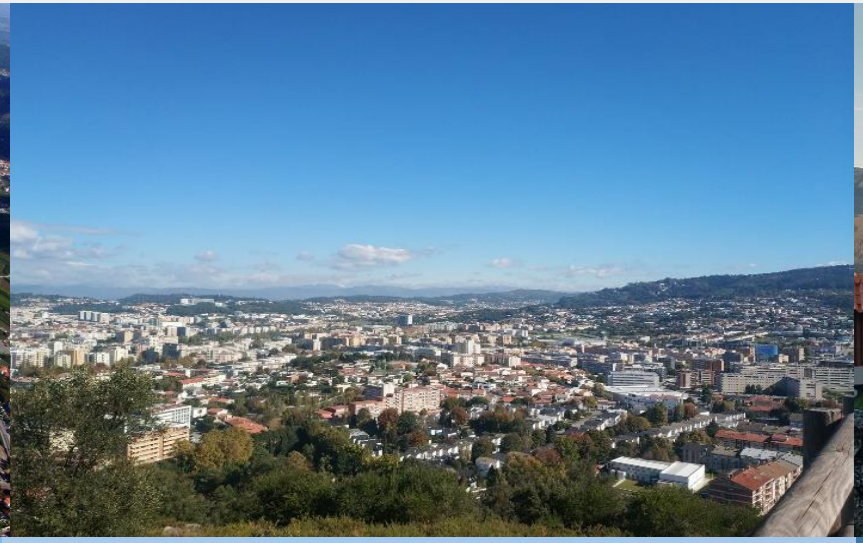

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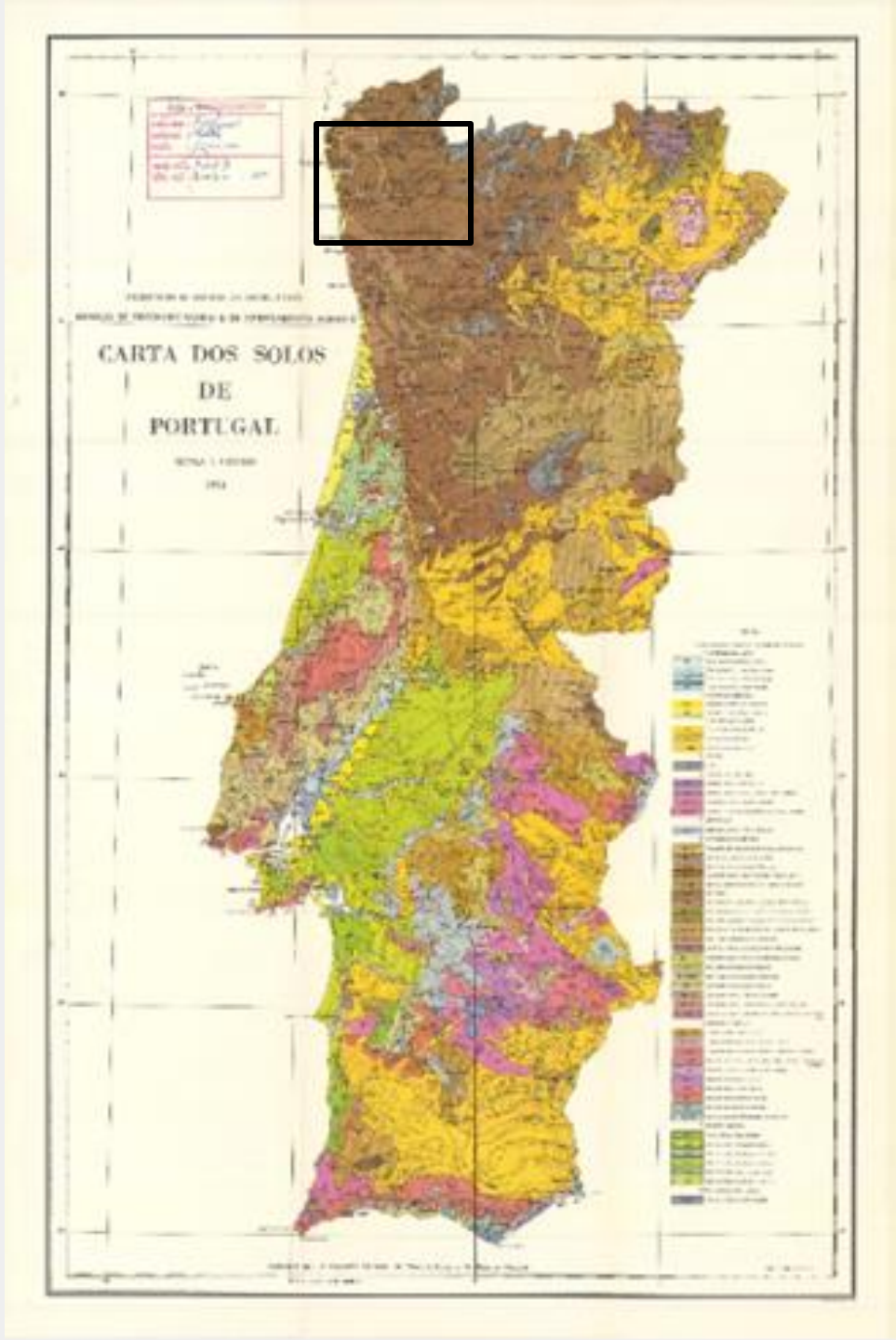
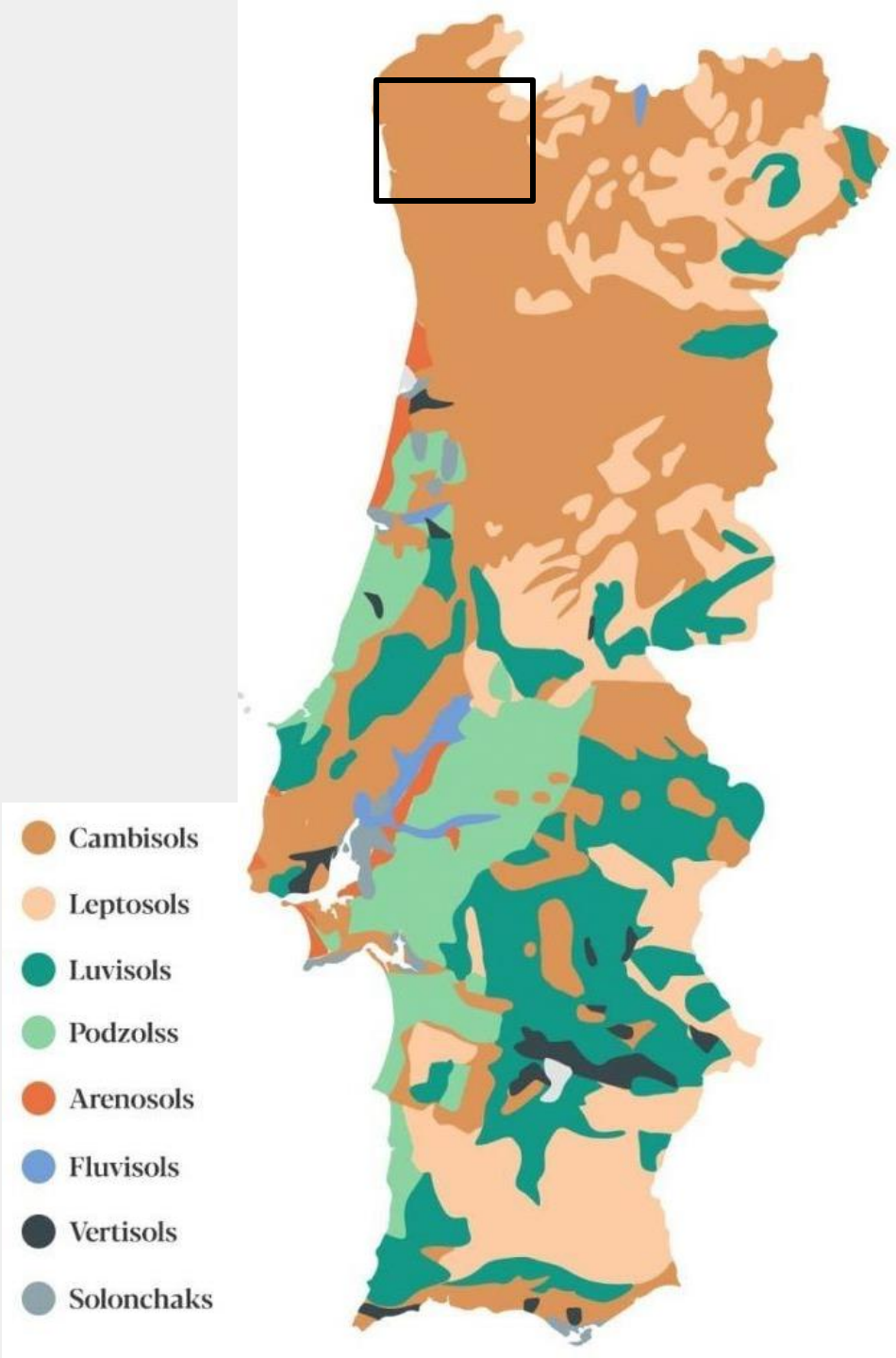
Soil system

- Cambisols are prevalent
- Some Leptosols near the coast
- Irregular fertility rates: from highly productive to poorer soils (higher altitudes)





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Hydrology

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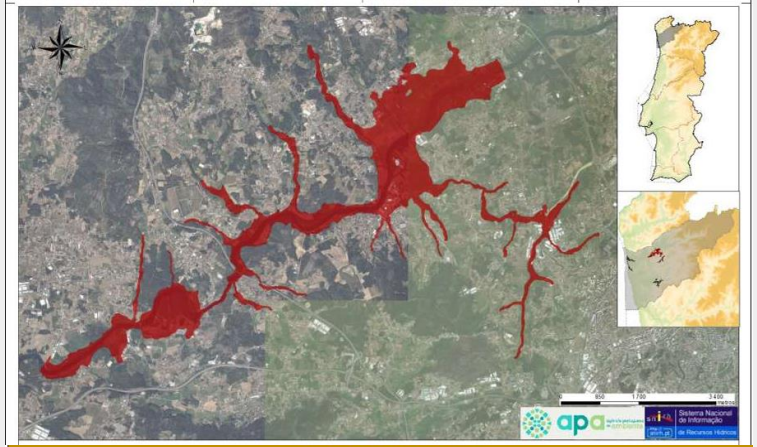
Areas of Significant Potential Flood Risk (ARPSI) - Cávado Hydrographic Basin

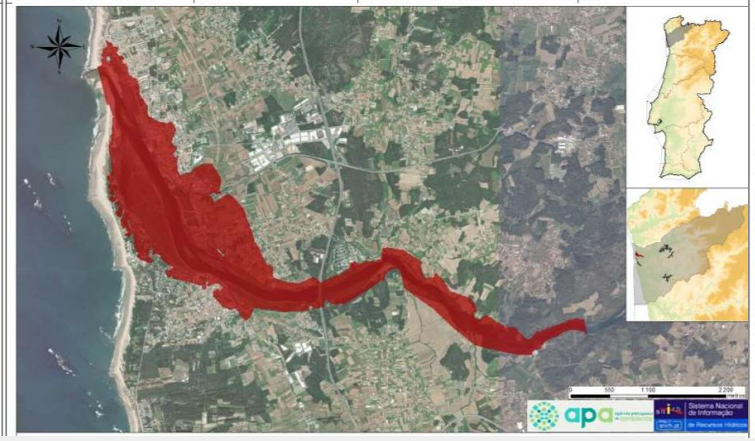
Hazards
Impacts
Challenges

FICHA DA ARPSI BRAGA–PADIM DA GRAÇA			
Nome ARPSI	**Braga-Padim da Graça**	**Código ARPSI**	PTRH2Cavado02
Bacia Hidrográfica	Cávado	**Curso de Água**	Rio Cávado
Tipo de Inundação	Fluvial	**ARPSI Transfronteiriça**	N.A.
Nova ARPSI (Sim/Não)	Sim	**Alteração em Relação ao 1º Ciclo**	N.A.

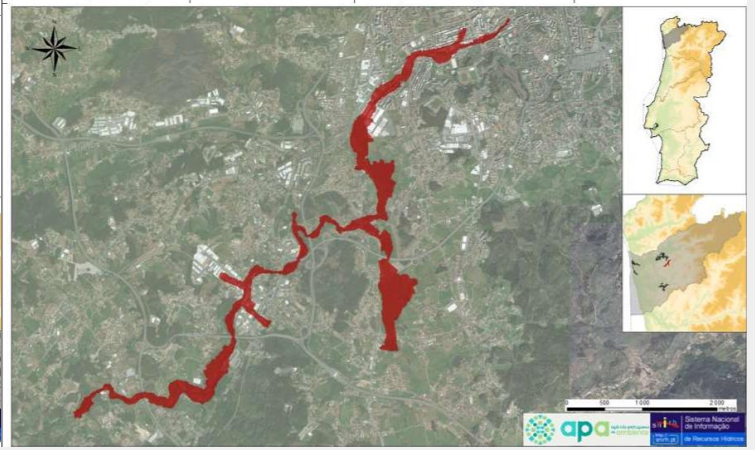


FICHA DA ARPSI OFIR-APÚLIA			
Nome ARPSI	**Ofir-Apúlia**	**Código ARPSI**	PTRH2Costeira01
Bacia Hidrográfica	Costeiras entre o Cavado e o Ave		
Tipo de Inundação	Costeira	**ARPSI Transfronteiriças**	N.A.
Nova ARPSI (Sim/Não)	Sim	**Alteração em Relação ao 1º Ciclo**	N.A.

FICHA DA ARPSI ESPOSENDE			
Nome ARPSI	**Esposende**	**Código ARPSI**	PTRH2Cavado01
Bacia Hidrográfica	Cávado	**Curso de Água**	Rio Cávado
Tipo de Inundação	Fluvial	**ARPSI Transfronteiriça**	N.A.
Nova ARPSI (Sim/Não)	Não	**Alteração em Relação ao 1º Ciclo**	Não



FICHA DA ARPSI BRAGA-ESTE			
Nome ARPSI	**Braga-Este**	**Código ARPSI**	PTRH2Este01
Bacia Hidrográfica	Ave	**Curso de Água**	Rio Este
Tipo de Inundação	Fluvial	**ARPSI Transfronteiriça**	N.A.
Nova ARPSI (Sim/Não)	Sim	**Alteração em Relação ao 1º Ciclo**	N.A.



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Fonte: Fichas_ARPSI_RH2.pdf (apambiente.pt) Flood risk management plan for RH2 - Cávado, Ave e Leça - APA

Land use

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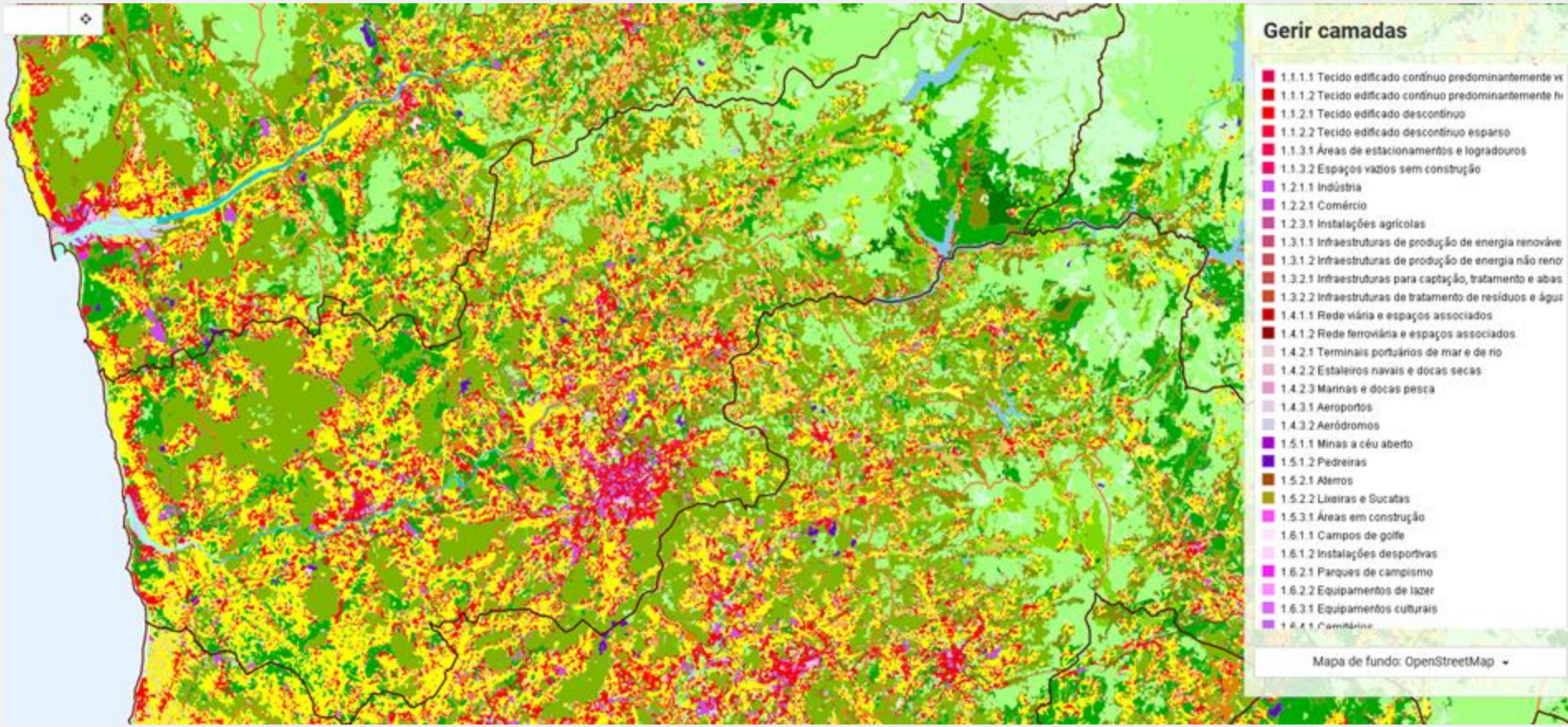
- Large part of Cávado basin characterized by agricultural areas
- Forest areas
- Mountainous territory upstream, incl. agricultural land use
- Peneda Gerês National Park (703km²)



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Climate change hazards and impacts on Cávado

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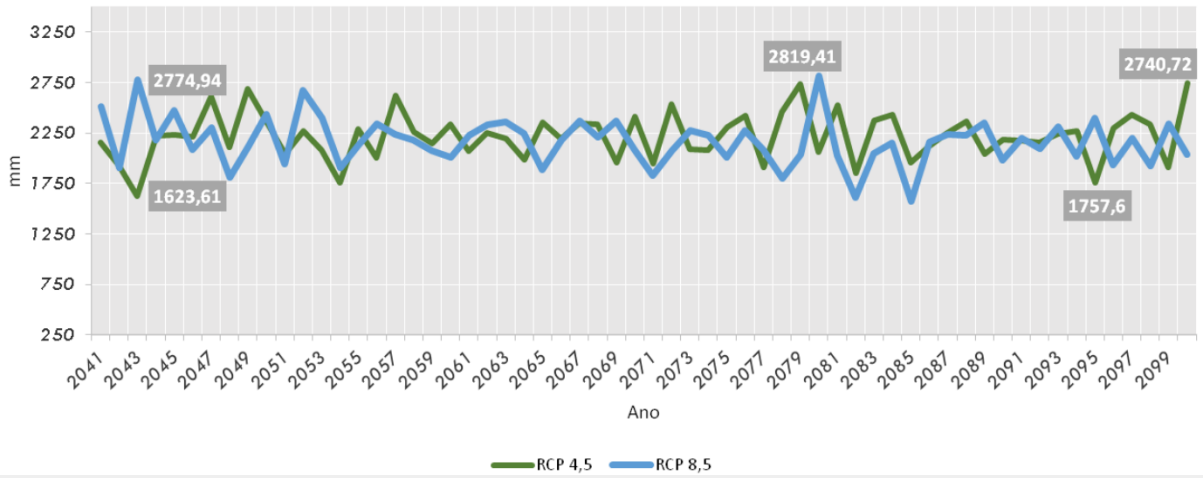
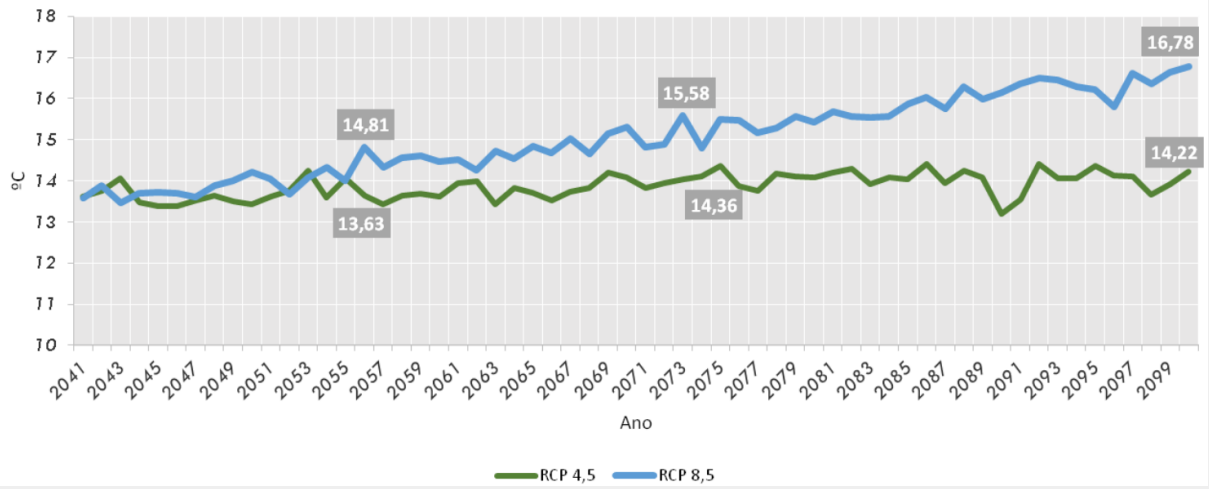
Annual average accumulated precipitation (mm) for 2041-2100



Annual average temperature (ºC) for 2041-2100



Observed and future Climate hazards on Cávado

- Heatwaves
- Wildfire

- Drought
- Heavy precipitation
- Flood (costal, fluvial, pluvial, groundwater)
- Landslide

- Strong wind

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Interactive public portal of Portuguese climate (historical and RCP series):
http://portaldoclima.pt/en/#

Intermunicipal Climate Change Adaptation Strategy of Cávado:
https://www.cimcavado.pt/estrategia-intermunicipal-de-adaptacao-as-alteracoes-climaticas-da-nut-iii-cavado/

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Social System

Policy

Governance & Quadruple Helix

Economic Structure

Social Structure

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Policy

Characteristics:

Top down policy structure, strategic planning, management and implementation

Multi level: national, regional, local

Multi sector: climate, agriculture, nature, water, soil, rural development, circular bio economy, regional development

Most important regional documents:

1. Intermunicipal Climate Change Adaptation Strategy of Cávado region
2. 2022-2027 Management Plan of Hydrographic Region of Cávado, Ave and Leça
3. 2022-2027 Flood Risk Management Plan of Hydrographic region of Cávado, Ave and Leç
4. Regional Spatial Planning Plan of North

... and many more (regional action programmes for rural fires, conservation, circular economy etc.)

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Quadruple Helix

Involves representatives from all members of society

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Public sector

- Cávado, with its 6 municipalities, is a sub-region (NUTS III) of the North region (NUTS II) of Portugal. Intermunicipal Community (CIM) of Cávado is the regional public administration entity.

Private sector

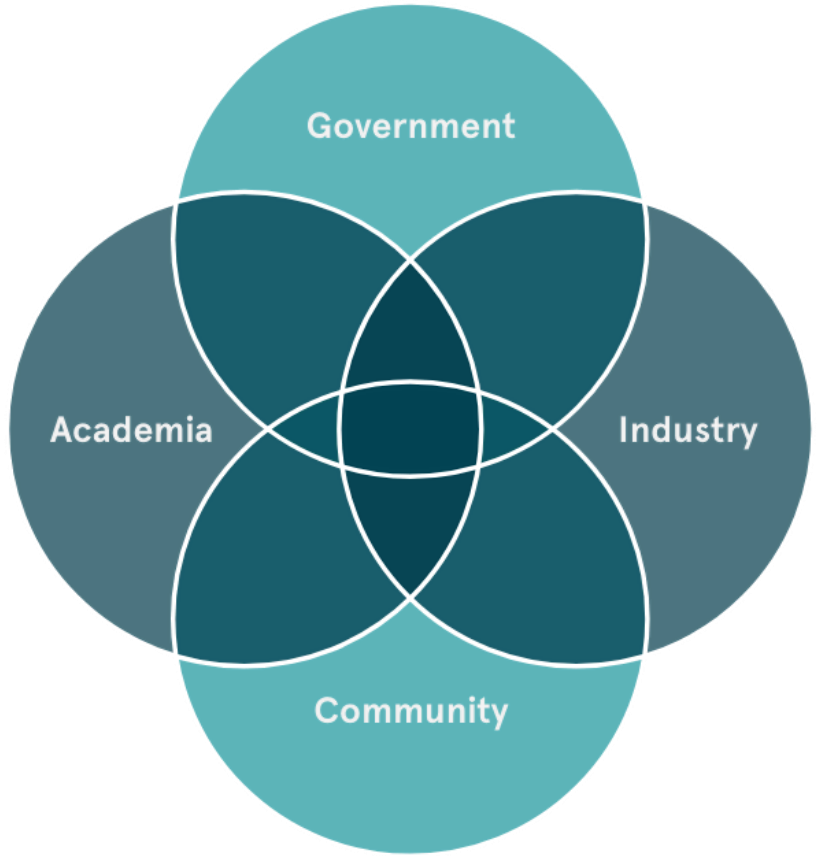
- Some big companies, agricultural and forestry companies are involved in cooperation with the public sector (inter-municipal)

Knowledge partners

- University of Minho
- Schools (occasionally participated in projects of environmental education)

Civil Society

- Several NGO's operate in the field
- Fire brigades and civil protection units



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Economic structure

- Norte: region with the lowest GDP per inhabitant in Portugal (66% in PPP of the EU27 average): low productivity sectors, capital deficit and low wages.
- Industrial region
- Tourism is a very important activity in the region; its attractiveness is strongly dependent on weather conditions, which have a major influence on tourists' decision-making, and their satisfaction is often related to weather conditions and their safety.
- Industrial sector, there are vulnerabilities in terms of the supply of raw materials and the geographical location of industrial units/complexes
- The commerce and services sectors are also susceptible to the effects of climate change, particularly insofar as they can be located in sensitive areas
- Agriculture and forestry activities in rural areas will be affected by droughts and extreme temperatures/heat waves.

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Regional development and Smart Specialisation

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Smart specialization: Region de Norte

- Tourism Services and Teretorial Assets
- Food and environmental systems
- Advanced Manufacturing Systems
- Sea Resources and Economies
- Human Capital, specialized services
- Culture, creativity, fashion

Larger region – use the qualities and capabilities of de Norte Region

Specialization on NBS, innovative solutions, new services and "technologies"
Economic valorization of territorial intensive assets and resources

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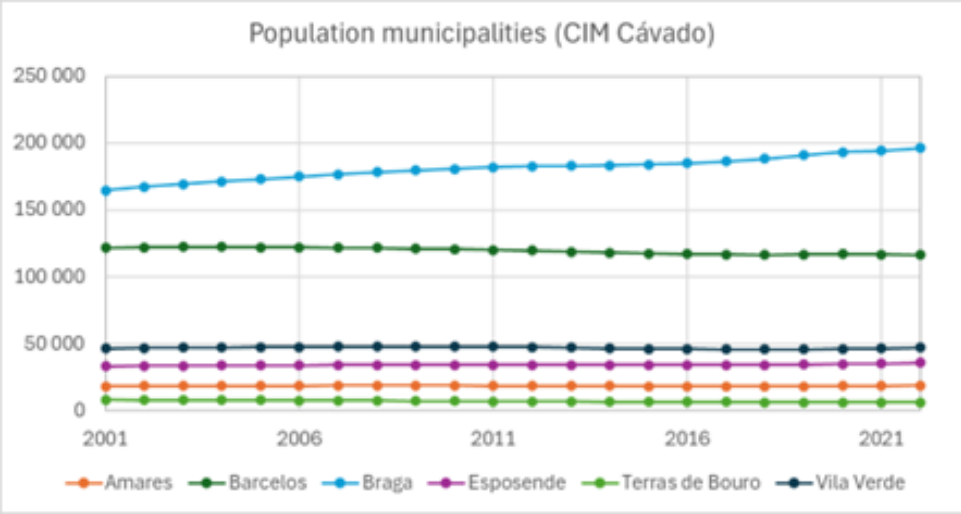
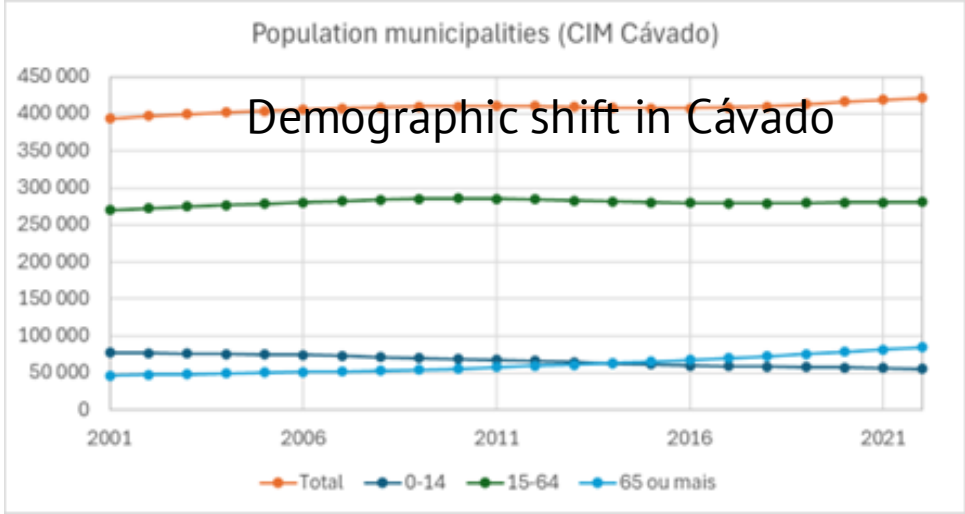
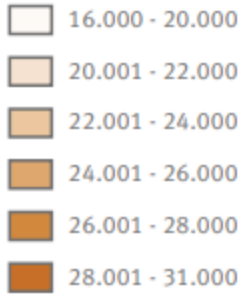
Social Structure





Demographic shift in Cávado

Small increase of population, mainly in Braga, mainly 65+ age
Elderly people exposed and vulnerable to climate change.
Difficult to reach and involve.
(Intermunicipal Climate Change Adaptation Strategy of Cávado region)



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Key Community Systems

Critical Infrastructures

Water Management

Health and Wellbeing

Land Use & Food Systems

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Key Community System: Area of transformation, part of a larger interdependent system.

Critical Infrastructure

Climate-proof infrastructure

From connections to key places

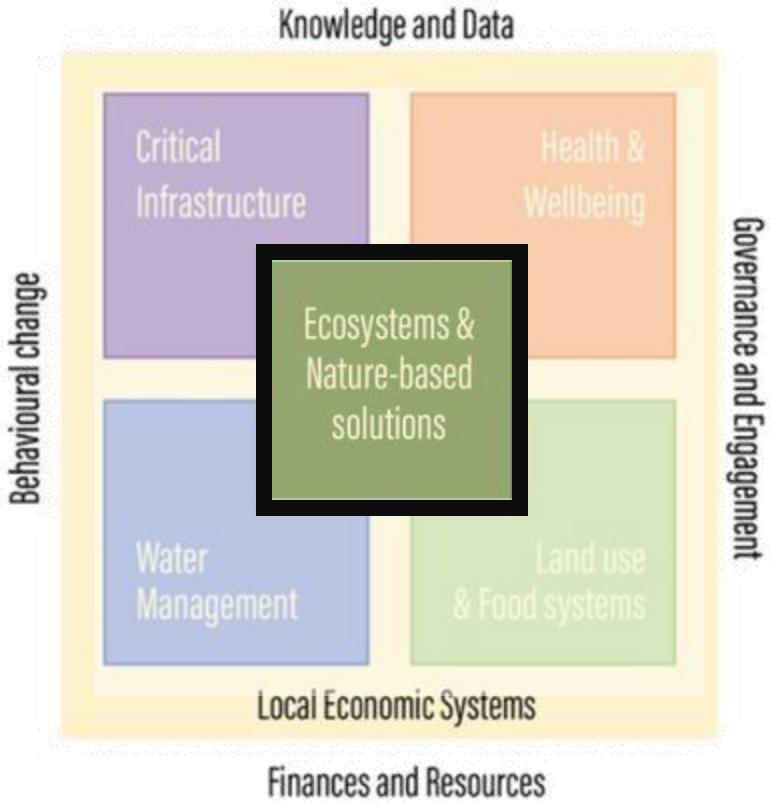
How?
- Nature-based solutions
- Development of common standards

Water Management

Freshwater availability

Reduce water-related risks

How?
- Innovation in water practices
- Innovative coastal protection
- Smart water allocation



Health & Wellbeing

Health in a changing climate

Early-warning and surveillance systems

How?
Protection of people at higher risks
Urban and rural health strategies

Land Use & Food Systems

Revive landscapes with climate resilient practices

Secure and sustainable food systems

How?
- Understanding and predicting risks and vulnerabilities
- New business models
- Promoting new technologies
- Upskilling actors

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Next Steps from the EU Mission on Climate Adaptation

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Regional challenges

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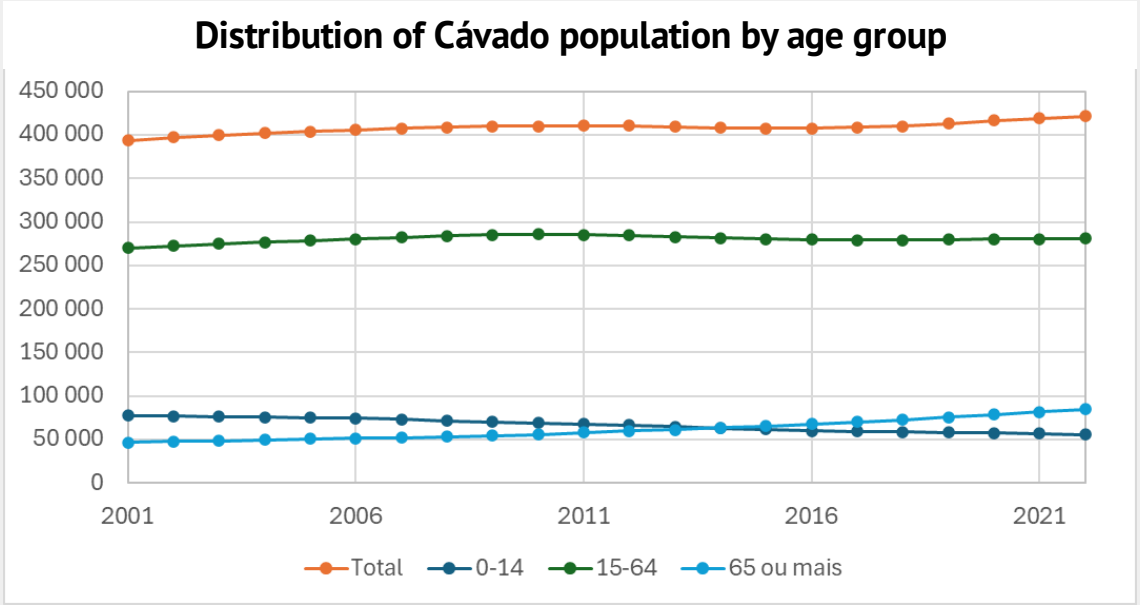
- Protect the most vulnerable social groups against climate change impacts in the future.
- Protect the Biosphere Reserve and Natura 2000 Network of the National Park of Peneda-Gerês.
- Protect urban areas against heatwaves and floods.
- Protect the Atlantic coast and urban area of Esposende against erosion, floods and heavy rainfall.
- Protect the forest, agriculture and agroforest areas against wildfires and soil erosion.



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Project NBS of Cávado

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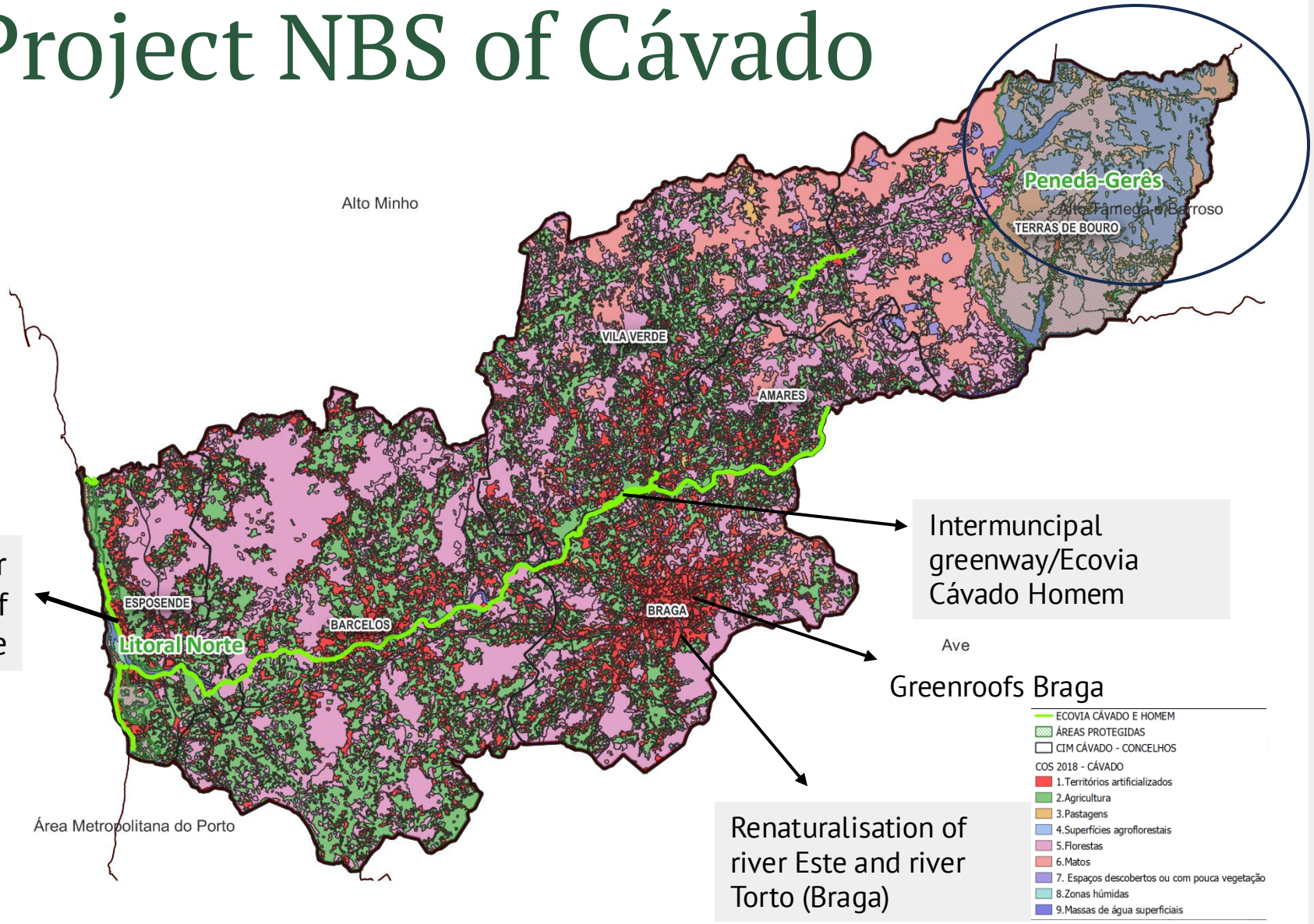

Interceptor Channel of Esposende

Intermuncipal greenway/Ecovia Cávado Homem

Greenroofs Braga

Renaturalisation of river Este and river Torto (Braga)

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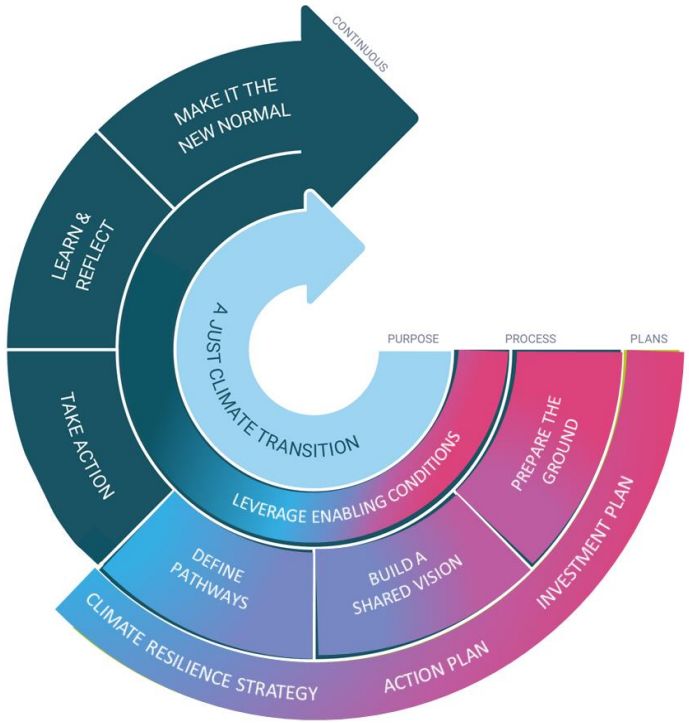
Map: SIG CIM Cávado

Transformative Adaptation Journey



From preparing the ground

To

Shared vision

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Governance Next Steps

Governance **interplay**:	coordination, collaboration, visioning and implementation among regional partners; top-down bottom-up, formal-informal, interactive.
NBRACER support	Interviews, workshops, mapping etc.

Governance **needs**:	Desired steps to realize a transformative, just, co-created and resilient approach to climate adaptation. To identify governance issues that can be improved and need support.
NBRACER support	Observation, regional input, established documents.

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Workshop

Exercise

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Workshop

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Thank you!

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