RESIST

Needs Assessment for Leading and Twinning Regions updated and finalised

Deliverable 1.11

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[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **OTHER**=other

[2] **PU**=Public, **CO**=Confidential, only for members of the consortium (including the Commission Services), **CI**=Classified

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Abbreviations

AENEA	Unified Stakeholders Needs Co-creation Process
AIGP	Integrated Areas of Landscape Management
AR	Augmented reality
AR5	5th Assessment Report
AR6	6th Assessment Report
C2C CC	Coast to Coast Climate Challenge
CAB	County Administrative Board
CAP	Climate Adaptation Planning
CBA	Cost-benefit analysis
CCA	Climate change adaptation
CDR	Central Denmark Region
CEREMA	French Centre for Studies and Expertise on Risks
CIM	Commission for Coordination, Regional Development and Inter-Municipal Councils
CIMBAL	Inter-municipal community of Baixo Alentejo
COPs	Conferences of the Parties
CRA	Climate Risk Assessment
EEA	European Environment Agency
EMT	Eastern Macedonia and Thrace
ENAAC	National Strategy for Adaptation to Climate Change
ENEA	National Agency for New Technologies, Energy and Sustainable Economic Development
EO	Earth Observation
ERDF	European Regional Development Fund
ESF	European Social Fund
ESCACC30	Strategic Reference Framework for Adaptation to Climate Change for the Horizon 2030
ESPON	European Observation Network for Territorial Development and Cohesion
EWS	Early Warning System
FCCP	Finnish Climate Change Panel
FSL	Fire Smart Landscape
GDT	Graphical Digital Twin
GHG	Greenhouse gas
GIEC Normand	Norman Intergovernmental Panel on Climate Change
GVA	Gross Value Added
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
LEGMC	Latvian Environment, Geology and Meteorology Centre
LSD	Large-scale Demonstrator
LSDT	Large-scale Demonstrator-Twinning Region
MCCE	Map of Climate Change in Extremadura
MH-EWA	Multi-hazard Early Warning Application
ML	Machine Learning
MSB	Swedish Civil Contingencies Agency
NAP	National Adaptation Plan

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NAS	National Adaptation Strategy to Climate Change
NbS	Nature-based Solutions
NC	National Communication
NCCAS	National Climate Change Adaptation Strategy
NGO	Non-governmental Organisation
OFB	French Biodiversity Agency
PCAET	Territorial climate-air-energy plans
PEIEC	Extremadura's Integrated Energy and Climate Plan
PIAAC BA	Intermunicipal Plan for Adaptation to Climate Change in Baixo Alentejo
PIAAC RC	Intermunicipal Plan for Adaptation to Climate Change in the Coimbra Region
PIAAC MT	Intermunicipal Plan for Adaptation to Climate Change in Médio Tejo
PLU(i)	Local (Inter-municipal) Urban Development Plan
PNACC	National Climate Change Adaptation Plan
PROCICAT	Catalan Territorial Civil Protection Plan
RAAP	Regional Adaptation Action Plan
RBMP	River Basin Management Plan
RCCAS	Regional Climate Change Adaptation Strategy
RCP	Representative Concentration Pathway
SDAGE	Master Plan for Water Development and Management
SECAP	Sustainable Energy and Climate Action Plans
SMHI	Swedish Meteorological and Hydrological Institute
SLR	Sea-level rise
SRADDET	Regional Scheme for Planning, Sustainable Development and Territorial Equality
SSW	Site-specific Warning
SW Finland	Southwest Finland
UNFCCC	United Nations Framework Convention on Climate Change
VR	Virtual reality
WP	Work Package
ZPR	Zemgale Planning Region
XR	Extended Reality

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1 Introduction

This deliverable builds on the needs assessment for the large-scale demonstrator (LSD) regions (D1.1) and for the twinning regions (D1.10). On the basis of these analyses, adelphi performed an update and review of the needs assessment for all twelve regions that form part of the RESIST project. Any questions that remained open during this first analysis were looked at in more detail. In cases where new information had become available, this was integrated in the update process. The update forms the basis for identifying possible avenues of support and relevant transfer opportunities between the regions, so that they can explore the full potential of innovative solutions and digital technologies developed within RESIST.

To navigate the following analysis, it can be helpful to have the composition of the LSD and twinning region clusters (summarised as LSDT) in mind:

Table 1: Overview of clusters of large-scale demonstrator and corresponding twinning regions (LSDTs).

	LSDT1	LSDT2	LSDT3	LSDT4
Large-scale demonstrator	Southwest Finland (SW Finland)	Central Denmark (CDR)	Catalonia	Centro Portugal
Twinning regions	Normandy Eastern Macedonia and Thrace (EMT)	Zemgale Blekinge	Puglia Baixo Alentejo	Extramadura Vesterålen

1.1 Purpose of the needs assessment

Task 1.1, which this needs assessment is part of, aims at supporting the regions in the RESIST project in their climate adaptation actions. In order to develop a plan of action for this support as well as a basis for designing innovative adaptation solutions, it is first necessary to understand the status quo in each of these regions. This includes an analysis of the challenges they are facing and the needs they have, regarding both the immediate project activities that will be implemented as part of WP 3, as well as in the wider regional adaptation context. Examining the baseline from which the regions are starting into the project is therefore a core component of this analysis.

The needs assessments form the first step in the climate change adaptation (CCA) framework of Task 1.1. As described in the proposal, this framework follows several overarching principles, which are integrated into the analytical approach of this needs assessment:

1. Following a flexible and context-specific approach in which the developed solutions are tailored to the needs and vulnerabilities of each individual region. To implement this

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approach, it is essential to have detailed insights into the context in which climate adaptation takes place in each region. This is a prerequisite for solutions being designed to fit the needs of the region.

2. The design of adaptation solutions and decision-making process is based on a participatory approach, considering the most vulnerable population groups[3] in the context of climate change and accounting for the gender-specific impact of climate change. Contributing to just resilience is therefore a central principle of this framework. Examining in how far these considerations are already integrated into adaptation activities is a core component of the needs assessment.
3. The facilitation of Nature-based Solutions (NbS), in line with the new EU Adaptation Strategy. Understanding whether NbS already play a role in regional adaptation measures or if they could be integrated into future adaptation activities.
4. Employing and realising the full potential of digital tools and technologies is a core element of the framework. Within the project, a large array of digital solutions is developed by horizontal partners and the regions. Successful utilisation incorporates these tools at all stages of the adaptation process, from planning to implementation of adaptation activities.
5. Following, where possible, a transformative adaptation approach (see section 2.1.2) which enables large-scale and long-lasting impacts. The results of the needs assessment can in the subsequent steps point towards possible paths of upscaling solutions, using currently planned activities as a basis for designing more transformative options.

Identifying starting points for possible support to regional partners allows adelphi and other partners to tailor their next steps to the most important needs and challenges. It also gives an indication of ways in which the effectiveness or scale of adaptation activities could be increased in order to achieve large-scale impacts.

It is crucial to understand that the purpose of these assessments is not to evaluate the regions' work on climate change adaptation. On the contrary, it is to find ways in which to most effectively support their work and understand the context in which regional partners operate. Another goal of the needs assessment is to identify questions that remain open at this point in time but will be answered as soon as the necessary information is available in order to support regional climate change adaptation in the most effective way.

[3] The term "vulnerable groups" refers to people who are socially, economically, culturally, politically, institutionally, or otherwise marginalized and thus especially vulnerable to climate change (IPCC 2014). These include, for example, poor and remote groups and communities that have limited adaptive capacity due to their economic status. Besides socio-economic status, geography, gender, age, indigenous or minority status, national or social origin, birth or other status and disability can lead to increased exposure and vulnerability to climate change risks.

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1.2 Overview of this document

This deliverable contains the individual needs assessment for each of the four large scale demonstrator regions and the eight twinning regions that are part of RESIST. Chapter 2 details the methodological approach to these assessments and outlines the individual steps in the analysis (2.1). It also describes the information sources that were included in the analysis and how they were utilized (2.2). Limitations in some of the data used, specifically the European Observation Network for Territorial Development and Cohesion (ESPON) dataset, are pointed out. Chapter 3 contains the twelve needs assessments of the large-scale demonstrator and twinning regions. Each of these assessments follows the same structure:

- Brief introduction to regional characteristics
- Analysis of current and future climate risks and already existing climate risk assessments (CRAs) (either at local, regional or national level)
- Evaluation of existing and planned adaptation measures, potential improvement opportunities and implementation support by horizontal partners
- Analysis of stakeholder and community engagement aspects
- Evaluation of regional capacities and constraints
- Discussion of potential for transfer of existing knowledge and expertise as well as synergies through collaboration
- Summary of the results and overview of the identified regional needs and challenges as well as potentials for transfer between regions.

Finally, Chapter 4 provides an overview of the most important results of the assessment, identifies common themes in the twelve regions and discusses some of the experiences made during the needs assessment process. Conclusively, this chapter looks ahead at the next steps and outlines the subsequent support scheme.

Annex A and Annex B contain documents that formed part of the needs assessment process. Annex C and Annex D describe details about a dataset (ESPON) that was used as part of this assessment.

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2 Methodological approach

2.1 Analytical concept for the needs assessments

The needs assessment collects information on currently existing climate risk assessments (adaptation policies and measures as well as information about stakeholder involvement and different capacities to identify any gaps, challenges or needs for support in each region (see Figure 1). For the first two components (CRA and adaptation measures), which constitute the main focus of this analysis, a list of “best practice”-criteria was applied. These criteria are framed as guiding questions for the analysis and constitute characteristics of adaptation that, when fulfilled, lead to effective, just and sustainable adaptation actions.

Following this structured approach allows to identify any areas of potential improvement or further development of adaptation measures as well as determining more general challenges the regions are facing in the context of climate adaptation. The results indicate possible angles for support from horizontal partners. For each region, the structure or focus of the assessment may be changed slightly to accommodate the individual circumstances, available information and adaptation dimensions of the respective region.

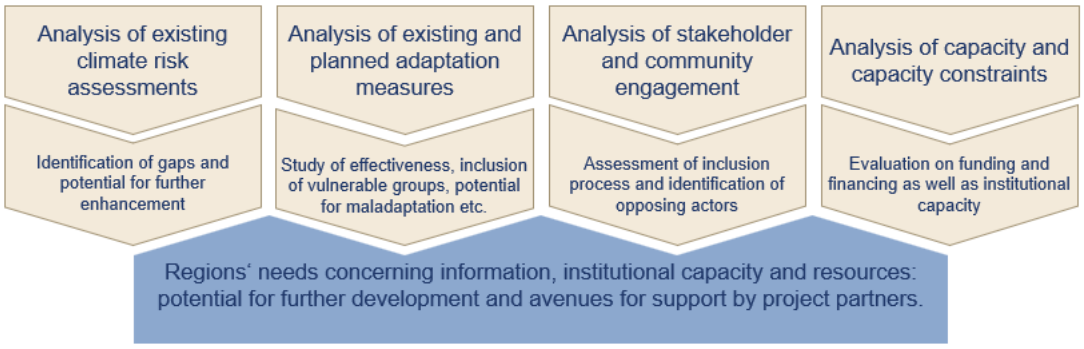

Figure 1: Schematic illustration of applied methodology for needs assessments.

Some of the questions and analytical components outlined in the following sections may not be answered at this moment since the information available regarding planned adaptation measures is not sufficiently detailed. However, this lack of detail is in no way to the detriment of this needs assessment.

Each section of the regions’ needs assessment summarises information about the status quo, existing climate risk information and adaptation measures as well as the stakeholder community and institutional and financial capacities. It then examines whether criteria of good practice are met,

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where gaps exist and how the existing information or plans can be improved. This assessment of information, institutional capacity and resource needs on the one hand points to further development potential and possible avenues for support by the horizontal partners of measures planned within RESIST. On the other hand, it indicates ways in which the overall goal of the project can be achieved, i.e. developing and upscaling innovative solutions and supporting systemic adaptation.

2.1.1 Analysis of climate risk assessments

Not all regions that are part of RESIST have their own CRA. What is referred to here as CRA are any documents that contain an analysis of or information about climate hazards, exposure or vulnerability to the impacts of climate change that cover the region or parts of the region. The information provided in these documents is analysed by adelphi to identify in how far certain good quality characteristics for CRAs are fulfilled.

Following the international standard EN ISO 14091 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment (ISO 14091:2021) and the requirements of the EU Taxonomy for CRA (see EU Delegated Act 2021/2178 (European Commission 2021) and corresponding interpretation) a number of key steps for CRAs can be identified. As part of the needs assessment, adelphi assesses in how far the past CRA in the target regions have included these steps. This is beneficial for putting the findings of past assessments into context and determining possible needs and approaches with respect to future risk assessments. The key steps or features are as follows:

1. The analysis covers at least two Representative Concentration Pathway (RCP) scenarios. Preferably, scenarios should be used that conform to current emission pathways, i.e. RCP8.5.
2. The analysis looks at medium- and long-term changes, e.g. mid-century and end of century.
3. The analysis touches on a wide range of climate-related hazards, not only changes in temperature and rainfall.
4. The analysis considers both extreme events (such as flooding or heat waves) as well as slow onset changes (such as sea-level rise (SLR)).
5. The analysis includes examination of the main risk components and is not simply looking at hazards or only operating with aggregated factors like risk or vulnerability. The main risk components are:
    - sensitivity, defined as “the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change” (IPCC 2022),
    - exposure, defined as “the presence of […] assets in places and settings that could be adversely affected” (IPCC 2022), and
    - adaptive capacity, defined as “the ability of systems […] to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (IPCC 2022).

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6. When looking at exposure, sensitivity and adaptive capacity, temporal aspects are taken into account, e.g. it is considered how these factors are likely to change over time. For example, sensitivity might change to due changes in the population structure.
7. The analysis outlines impact chains in a transparent way. Impact chains are a tool to better understand, visualize, systemize and prioritize the factors that drive climate risk (ISO 14091:2021).
8. Uncertainties and data sources used are highlighted.
9. The results of the analysis have a spatial component, e.g. indications where certain risks are most prevalent.

It is not expected that an analysis of climate risks complies with all of these features. Some regions may not have any CRA to begin with. In these cases, the analysis looks at information available from international datasets. The list provides a framework for assessing the information already covered in existing analysis to identify potential gaps. CRA containing information on all the aspects listed above provide a meaningful basis for the design and prioritization of adaptation measures. For example, pointing out particular spatial "risk hotspots" or areas with a population particularly sensitive to the impacts of heat waves allows policy makers to design adaptation measures specifically targeted to these areas and vulnerabilities.

2.1.2 Analysis of adaptation measures

A similar approach is applied to the analysis of the existing and planned adaptation measures in each region. We defined a number of characteristics that these measures should exhibit. Many of these are process-based, meaning that the process of designing and implementing adaptation measures should include certain steps and considerations and the analysis looked at whether these were integrated in steps already taken in the regions. As already mentioned, the aim of this approach is not to point out deficiencies in past or ongoing work in the regions, but to allow the horizontal partners to tailor their support services in the most effective way. Any gaps or needs pointed out in this analysis provide the horizontal partners with crucial information on how to design their activities in this project.

Are measures effective in addressing identified climate risks?

For adaptation measures that are already implemented in the regions, any information available on their effectiveness, such as evaluations of adaptation action plans, is collected and analysed.

The effectiveness of adaptation measures in reducing climate risks is a central criterion for their quality. Effectiveness of adaptation measures refers to the impact they have on one or more climate change risks in the area where they are applied. Common indicators for effectiveness are their wide-ranging impact (reducing risk not just in one specific location), their long-term impact, the extent to which they reduce one or more climate risks, or the number of people they benefit.

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Estimating the effectiveness of measures that are not yet implemented involves an ex-ante perspective on the anticipated effects these will have and whether they are deemed suitable to address relevant climate risks.

Are measures designed in a gender-sensitive way and explicitly consider the implications on different genders?

This question is also part of the gender framework being developed in Task 1.4. A person's gender is one attribute that can contribute to their vulnerability. Gender is a cross-cutting dimension in climate adaptation. Integrating a gender-sensitive perspective in adaptation means considering gender differences in access to information and training, access to resources, position in society or differences in risk perception (Lager et al. 2023).

Are measures designed in a way that considers the needs of particularly vulnerable population groups?

Vulnerability is defined as "the propensity or predisposition to be adversely affected due to the inequalities in the socio-economic system" comprising "sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC 2022). As mentioned in the previous paragraph, a person's vulnerability is determined by a number of attributes. Groups that are potentially particularly vulnerable include, amongst others, older people, people with disabilities, marginalised groups, minorities, lower-income groups and certain genders (Lager et al. 2023).

There is growing evidence on how the most vulnerable people are disproportionately at risk from the impacts of climate change (Lager et al. 2023). Vulnerable population groups have fewer capacities to adapt to these impacts and are less likely to be heard in the adaptation process. It is therefore essential to ensure adaptation actions benefit vulnerable groups. Where these aspects have not yet been specifically considered, this can be a useful indication for support to be provided by adelphi in the future in order to promote just resilience through adaptation.

Do the measures avoid the risk of maladaptation?

Maladaptation means that planned or implemented adaptation measures have negative side-effects such as increasing vulnerability, impairing wellbeing or otherwise undermining sustainable development. These negative consequences can occur in the same or in other locations, systems or population groups than those initially concerned by the adaptation action. When designing an adaptation action, possible unintended negative impacts on climate mitigation, ecosystems, resources, other geographical areas, the same or other sectors than the one addressed by the adaptation action should always be considered at an early stage.

The newly developed self-assessment tool to spot risks of maladaptation from the EU-funded REGILIENCE project provides detailed support in identifying possible risks of maladaptation. It contains a checklist of 17 questions to which the user can respond to by selecting either "yes", "no",

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or “partially”. The tool is designed for actors responsible for planning and implementing regional adaptation actions. The questions are divided into different sections. Some of these comprise questions that are already listed in earlier in this chapter. Many questions look at the information that was considered for the identification and design of adaptation options.

Within the analysis, it is first checked whether a consideration of possible negative side-effects is already integrated in the planning and design process of adaptation measures. Where this is not the case, the next step involves, wherever suitable and sufficient information is available, applying this list to the planned adaptation activities of RESIST regions.

Do the adaptation measures have social equity impacts?

This question can be seen as a sub-component of addressing the avoidance of maladaptation. One way in which maladaptation can occur is when an adaptation measure has negative social equity impacts. Thus, it should be checked whether any dimension of social equity could be impacted by the planned activities. In many cases these potential impacts can be difficult to predict, particularly at an early stage of the design and planning process. However, it is important to include this dimension of possible side-effects in the analysis before implementing climate adaptation measures.

Is a preference for or prioritisation of NbS discernible?

One of the priorities of the EU’s new adaptation strategy is the support for NbS for climate change adaptation. The term NbS refers to “solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.” NbS must therefore benefit biodiversity and support the delivery of a range of ecosystem services (European Commission 2023).

Within this analysis, the integration of NbS is therefore also considered. If NbS are not part of the planned activities within the RESIST project, further steps will include a closer look at whether or how adaptation measures that go beyond the immediate scope of RESIST can include NbS. Of course, it is taken into consideration that some adaptation activities are more suitable to including NbS than others.

Are measures designed in a transformative instead of an incremental way?

The RESIST project aims at innovative and large-scale solutions. Therefore, one of the aspects to analyse is whether adaptation measures are designed in a way that supports transformative, large-scale adaptation and goes beyond incremental adaptation. Incremental adaptation refers to adaptation that maintains the essence and integrity of a system or process (Pelling 2011). Transformative adaptation, on the other hand, refers to actions aiming at adaptation to climate change resulting in significant changes in structure or function which go beyond existing practices

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(Pelling 2011). In other words, incremental adaptation aims at maintaining the status quo in spite of changes in the climate. Transformative adaptation aims at a new way of doing things that can be adopted at a large scale, can lead to new strategies in a region, transform places or potentially shift locations.

These guiding questions do not only provide a framework for this needs assessment. They will be continuously applied throughout the project in the process of designing and implementing adaptation measures. They provide useful guidance for all involved partners regarding what steps should be taken and what aspects should be considered in order to design best possible adaptation solutions.

This approach of checking for good quality adaptation constitutes one core component of the climate adaptation framework that will be applied throughout the project and will guide the framing of adaptation activities.

2.1.3 Analysis of stakeholder involvement and capacities

The involvement of relevant stakeholders should form an integral part of planning and implementing climate adaptation. Analysing who these stakeholders are, how they are being included in the adaptation process and what interests they represent is therefore a further component of this needs assessment.

Opposing interests can be a significant barrier to the success of climate adaptation. At the same time, to avoid unintended effects that could lead to maladaptation, the involvement of and discussion with relevant stakeholders is crucial. In this way, previously neglected information can be brought to the attention of those responsible for adaptation measures.

This part of the analysis provides indications of where there might be a necessity to expand stakeholder involvement or what activities might be helpful in convincing relevant actors to participate in and support the projects' actions. The main guiding questions for this component of the assessment are:

1. Who are the main regional stakeholders involved in climate adaptation? What are the main opposing interests?
2. How are stakeholders being involved in the planning and implementation process?

Lastly, the needs assessment analyses the existing institutional and financial capacities in the eight regions and identifies the main capacity constraints. This step involves the consideration of current funding opportunities for adaptation and possible financial constraints as well as institutional or other relevant capacity constraints.

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2.2 Sources of data and information

2.2.1 Desk research

For this deliverable, an extensive desk research was conducted by adelphi. The most important sources that were consulted include:

- Country profiles on the Climate-ADAPT platform,
- The 8th National Communications under the United Nations Framework Convention on Climate Change (UNFCCC),
- Information provided as part of the reporting under EU Governance Regulation 2018/1999,
- Country fiches from the European Commission Adaptation Preparedness Scoreboard.

These documents provide information on national level adaptation policies, climate risks and institutional contexts. Further detailed information was collected from national adaptation strategies, action plans and, where possible, evaluations of adaptation policy. In some cases, these documents also look at the challenges and climate risks in specific regions, identifying hotspots for certain risks or particular regional challenges. They are therefore an important source for this analysis.

Another starting point for the desk research were documents mentioned in the RESIST proposal that provided crucial insights into the political, social and institutional context of the adaptation activities that are planned by the regional partners. Where available, regional climate plans and similar policy documents were consulted for the analysis. In addition, relevant scientific literature was included in the research wherever suitable.

2.2.2 Information provided by regional partners

Given the focus on the regional level, a crucial source of information were the regional partners themselves. To elicit the necessary information, a two-track approach was followed: First, a questionnaire was sent to the regional partners asking for important documents and information. This questionnaire was designed in close cooperation with other partners from WP 1 and included information requests necessary for other tasks in this WP. To provide regional partners with one consolidated information request, questions by WP 1 partners were collected and aligned before finalizing the questionnaire. The full questionnaire that was designed as part of the needs assessment is included in Annex A: Questionnaire. All regions filled in the questionnaire and provided adelphi with valuable information and links to relevant resources.

Second, in order to collect supplementary information from the regional partners, virtual interview sessions were conducted by adelphi and KU Leuven in cooperation with WP 1 partners. These sessions were scheduled between May and September 2023 and lasted two hours. Participants in

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the meeting were sent a pre-read document with information about the purpose and agenda of the sessions as well as guiding questions that would structure the discussion between WP 1 partners and regions. This pre-read document is included in Annex B: Information about virtual interview sessions. For each region, additional specific questions were added to this pre-read document addressing unclarities, data gaps and preliminary results.

2.2.3 ESPON Data

ESPON-CLIMATE is a project that aims to enhance the understanding of climate change impacts and vulnerability in European regions, including E27 countries (Switzerland, Iceland, Liechtenstein, Norway, and the United Kingdom) at NUTS3 level. The assessment was recently updated in 2022 based on the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (AR5 and AR6), utilizing data from diverse sources such as satellite and census data. The ESPON-CLIMATE dataset is thus a comprehensive source of aggregated data that offers information on climate risks based on impact chains. The primary purpose of the ESPON-CLIMATE dataset is to assist policymakers, researchers, and stakeholders in comprehending the challenges and opportunities posed by climate change in Europe (Navarro et al. 2022).

The following list outlines the impact chains / risk scenarios identified by the ESPON-CLIMATE Update 2022 based on the causal model of risk which links hazards and receptors:

- Heat stress on population
- Coastal flood on infrastructure, industry and service sectors
- River flood on population
- River flood on infrastructure, industry and service sectors
- Flash floods on cultural sector
- Wildfire on environment
- Droughts on primary sector

Each impact chain in the assessment consists of hazard, exposure, and vulnerability (sensitivity and adaptive capacity) indicators. These are comprised of aggregated proxy variables. The selection of these proxy variables was based on scientific frameworks, normative decision on what is to be included and assessed, and data availability. The data sources varied, depending on the type of indicators, including i.a. the Copernicus Climate Data Store, Risk Data hub, EUROSTAT Gisco, UNESCO, ESPON-TITAN and others, see Annex C: ESPON-CLIMATE: Data sources for more information (Navarro et al. 2022). Important to note is that only hazard indicators are projected for different emissions scenarios (RCP2.6, RCP4.5, and RCP8.5) for the time period of 2070-2100, not for vulnerability and exposure.

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The ESPON-CLIMATE dataset can be a valuable resource for the RESIST project regions, providing additional information on climate risks. It allows for comparisons with regional CRA and offers insights into key hazards, exposure, and vulnerability for regions without regional-specific assessments. The indicators used in the dataset, described in Annex D: ESPON-CLIMATE: Framework of Impact Chains, contribute to a better understanding of the factors which are influencing climate risks. For each region, the climate impact chains were extracted and analysed. The results are presented within the chapters describing climate risks which are prevalent in the region and can assist in determining the priority areas that require specific attention due to the identified risks (Navarro et al. 2022). Together with national and regional analysis, the results paint a comprehensive picture of climate change risks in the regions. However, the following limitations need to be considered. As mentioned above, projections based on the three RCP scenarios are only simulated for hazard indicators. Exposure, sensitivity and adaptive capacity are solely based on historical data. This can particularly lead to incorrect assumptions and interpretations when it comes to the aggregated risk indicator. Furthermore, uncertainty has to be taken into account for future scenarios regarding the hazard indicators (Navarro et al. 2022). The ESPON-dataset is thus used as a supplementary source of information about regional climate risk and vulnerability factors.

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3 Needs assessments for large-scale demonstrator and twinning regions

3.1 Needs assessment Southwest Finland

3.1.1 Introduction

Figure 2: Location of Southwest Finland.

With a population of 479,000, the region of Southwest Finland (SW Finland) is one of the most densely populated areas in Finland, in which a larger urban area is surrounded by a relatively dense but rural hinterland. The region comprises 27 municipalities, of which the largest city and administrative seat is Turku. Its landscape is characterised by a unique archipelago and fertile agricultural land. SW Finland is a high-income developed region with strong and diverse economic activities, i.a. in the field of pharmaceutical production, bioimaging and food production.

Located at the coast of the vulnerable Archipelago Sea (Figure 2), rising temperatures and changing precipitation patterns threaten marine ecosystems, urban agglomerations and rural, agricultural lands. Flooding, erosion, drought and heat stress are critical climate change related risks in SW Finland. Within RESIST, planned activities focus on Nature-based Solutions (NbS) in the context of stormwater and sustainable water management. The measures will be designed and implemented in collaboration with local stakeholders and subsequent cost-benefit analysis (CBA) will improve knowledge on the effectiveness and co-benefits of NbS.

3.1.2 Climate risks

3.1.2.1 Regional climate risk assessments and identified risks

The central documents analysing climate change related risks in SW Finland are the **Finnish Climate Change Panel Report** (“Suomen ilmastopaneeli Raportti 2/2021”; Gregow et al. 2021) for the regional level, and the **Turku Climate Plan 2029** (Turku City Council 2018) for the City of Turku.

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The **report of the Finnish Climate Change Panel** (hereafter abbreviated as FCCP) collected information on the temporal and local impacts of climate change and compiled tables on changes in weather, climate and marine factors for each of Finland's regions (Table 2). These include meteorological parameters of temperature and precipitation as well as marine factors such as sea surface temperature, salinity and medium water level. Special focus is laid on flood risks, comprising inland watercourse floods, flash floods and seawater floods. The impacts of the latter are assessed for all five Finnish sea and coastal areas, including the Archipelago Sea. The aim of the report is to illustrate what is already known about climate change impacts and adaptation, what calls for particular attention and where knowledge gaps exist.

Table 2: Changing climate variables in SW Finland.

Variable	Winter	Spring	Summer	Autumn	Year
Average temperature	++	++	+	++	++
Precipitation	+	+	/	+	+
Thermal season length	--	+	+	+	*
Maximum daily temperature	++	++	+	++	++
Number of frosty days	-	--	-	--	--
Snow	--	--	*	--	--
Intensity of heavy rainfall	+	+	+	+	+
Wind speed	+	+	/	/	/
Amount of debris flow	--	--	*	*	--

Extract of the table in the FCCP report evaluating changes in climate variables in SW Finland towards the 2050s (Gregow et al. 2021). The symbols have the following meaning: '++' increasing/increasing at an alarming rate, '+' increasing/growing, '/' no significant change, '()' change uncertain, '—' decreasing significantly, '-' decreasing, and '' not known or insignificant.*

Concerning weather and climate events, the report finds the past warming to continue, with a projected rise in average temperature of +1.8-3.0 °C by mid-century. Daily maximum temperatures will increase in all seasons while the number of frost days and average snow depth will decrease. Annual precipitation is expected to increase by 6-10% until 2050 and heavy rainfall is expected to intensify.

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The assessment of **flood risks** differentiates between inland watercourse, heavy rainfall associated and seawater flooding. The current risk of inland watercourse flooding is moderate and climate change is not projected to cause a major change in the region by 2050. However, the impact may vary by river basin, from a reduction in flood risk due to a decrease in spring floods to an increase in heavy rainfall and winter floods. Main risk areas in the region are Salo on the Uskelanjoki and Perniö along the Perniönjoki branch of the Kiskojoki. Flooding in these highly populated areas can jeopardize road transport links. Flash floods already pose a relatively high risk in SW Finland due to the high population density, the high number of paved surfaces and the topography. With increasing frequency and intensity of heavy rainfall, the risk of flash floods is expected to increase further in the future. The Turku coastal area is the central major seawater flood risk area in the region. Flooding events are rare but affect five hard-to-evacuate sites, as well as food and medical industry locations and sites subject to environmental permits. Climate change is not expected to change the likelihood of high sea levels in the Archipelago Sea substantially by 2050 and thus seawater flood risk is assumed to remain significant but not aggravating. Towards the end of the century, sea levels are projected to increase but these estimates are subject to considerable uncertainty.

According to the FCCP report, the **Archipelago Sea** is very vulnerable to climate change impacts caused by slow onset trends in marine temperature and salinity parameters as well as anthropogenic pollutant entry due to flooding. Rising sea surface temperatures and decreasing salinity threaten the Archipelago ecosystem, worsening the poor oxygen status of seabeds and causing stress to marine flora and fauna. Additionally, increased nutrient pollution from agriculture deteriorates the surface water status which, in combination with rising temperatures and decreasing salinity, i.a. leads to increased blue-green algae blooms.

Zooming further in on the region's largest city and administrative seat, the **Turku Climate Plan 2029** (Turku City Council 2018) carried out an extensive analysis of climate change risks and vulnerabilities. It follows the Sustainable Energy and Climate Action Plans (SECAP) guidelines (European Commission. Joint Research Centre. 2018) providing signatories of the Covenant of Mayors for Climate and Energy with a set of methodological principles, procedures and best practices. Concerning risk and vulnerability assessments, the guidelines recommend two different methodological approaches based on city size. For small to mid-size cities the indicator-based assessment consists of five steps: 1. exploratory analysis, 2. identification of climate hazards, 3. selection of indicators, 4. data gathering and processing and 5. assessment of vulnerability score. In Turku, the exploratory analysis was based on pertinent publications on city, regional and national level. Subsequently, risks posing a threat to the city were identified and evaluated with the help of expert interviews.

The Turku Climate Plan identifies two major sets of climate change related risks: **risks related to water bodies and water management, and risks caused by changes in ecosystems**. The future precipitation shift from summer to winter months is expected to increase nutrient pollution and consequently eutrophication of water bodies, river erosion and river bank failure potentially damaging

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urban infrastructure, and the need for irrigation during dry summer periods. In combination with a lack of green areas and absorption surfaces in the city, runoff water additionally poses a significant risk. Finally, an increase in intensity and frequency of storms together with rising sea levels was considered to increase the risk of flooding in Turku. Concerning ecosystems, climate change poses a significant threat to biodiversity, severely challenging green and blue infrastructure planning. The spreading of invasive species and diseases does not only affect ecosystems but also the urban population, especially vulnerable groups.

Building on the 2018 vulnerability assessment, the **2022 update of the Turku Climate Plan** (Turku City Council 2022) revises and amends the identified climate risks based on recent national material, local explanations and expert assessments. The update expands the underlying methodology providing definitions of the key concepts according to the IPCC (2014) and listing identified city-level vulnerability and exposure factors in risk maps. In addition to the two sets of risks already identified in the 2018 assessment – risks related to the water cycle and water management, and risks from ecosystem change – the update also includes **risks related to heat and drought**. The most significant climate change related threats in these clusters are heavy rainfall, flash and seawater flooding, and changes in the freeze-thaw cycle; biodiversity loss, forest diseases and pests; prolonged periods of heat and drought and the heat island effect.

In addition to these two main sources on climate change risks in SW Finland, the FCCP report and the Turku Climate Plan, the **ESPON climate dataset** (see 2.2.3) provides information on regional climate risks and the underlying components of hazards, exposure, vulnerability, sensitivity and adaptive capacity. For the baseline scenario (1981-2010), ESPON identifies the effects of droughts on agriculture and forestry to be the most significant risk, followed by impacts of flash and river flooding on cultural heritage and population, and environmental consequences from wildfires. Applying the high emission scenario (RCP8.5, 2070-2100) to the hazard component, droughts remain highly relevant but otherwise the ranking shifts: The impacts of coastal flooding on infrastructure and heat stress on population increase distinctly in relevance and become key risks while river and flash flooding as well as wildfires do not gain significance. The high significance of droughts on the primary sector stems from both high hazard indication and exposure. In the baseline scenario, the high ranking of flash floods is due to the hazard indicator; river floods on the contrary pose a material risk due to their high exposure. Shifting relevance under the RCP8.5 scenario results from shifting significance of the underlying hazards: until the end of the century coastal flooding and heat stress are expected to increase considerably. This analysis of future risks must be viewed with caution, as the other underlying factors (i.e. exposure, vulnerability and adaptive capacity) are only considered in their baseline version though they will change significantly until the end of the century. However, the scenario analysis shows which hazards result in high risks if exposure and vulnerability are not reduced and thus indicates where adaptation measures gain relevance under a future changing climate.

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Summary

Despite substantially different methodological approaches and setting aside diverging or unclear definitions of hazards and risks, the results of the analyses performed on the regional level and the ESPON project point in the same direction. **All assessments identify flooding as a major climate change risk in the region.** The analysis of the most pertinent form of flooding varies slightly but both flash and coastal floods are seen as key risks now and in the future. **Heat stress, drought and ecosystem deterioration are identified as major future risks in two of the three sources**. The FCCP report however falls short of including heat and drought in its analysis and thus runs behind the current assessment. Only the recent update of the Turku Climate Plan includes heat and drought as major risks (Turku City Council 2022). The focus of regional adaptation policies on flooding as the central climate change risk which is also reflected in the measures planned within RESIST: the actions within RESITS aim at increasing the water retention capacity of the region to restore the water balance, which is planned to affect both floods and droughts.

3.1.2.2 Qualitative assessment of the regional CRA

Methodologically, the **FCCP report** does not follow a standard CRA scheme but collects and compiles existing information on climate change impacts and risks on the national and regional level. Most shortcomings thus stem from the lack of a clear climate risk analysis framework. Already concerning the definition of physical climate risk, the report does not refer to the common understanding of these risks as a function of a. hazards, b. exposure and c. vulnerability (IPCC 2022). Hence, it is not clearly indicated where the term 'risk' is used interchangeably for climate events and in how far exposure and vulnerability are considered in risk statements. Nevertheless, the report fulfils several requirements of a sound CRA by covering multiple scenarios (RCP2.6, 4.5 and 8.5), by considering both slow onset trends in temperature and rainfall as well as extreme events such as heavy rainfall and especially flooding, and by highlighting uncertainties and knowledge gaps. The report however does not systematically consider a wide variety of possible hazards and does not outline impact chains. For a comprehensive analysis, the assessment should rely on a clear risk framework integrating further climate and weather events and systematically analysing factors of exposure and vulnerability. The FCCP report serves as a good starting point for a further detailed assessment of both climate change risks and adaptation needs as it highlights major impacts and identifies knowledge gaps.

The climate change risk and vulnerability analysis in the **2018 version of the Turku Climate Plan** 2029 (Turku City Council 2018) also does not apply a clear risk framework and does not perform all of the SECAP proposed steps. Comprehensive expert knowledge is not consolidated with further municipal (spatial) data and factors of exposure and vulnerability remain unclear. On the other hand, the report touches on a wide range of climate-related hazards, considers different time frames and includes a rating of the reliability of the assessment. The analysis partially outlines impact chains and, for some risks, points out more or most affected regions in the city.

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Most of the shortcomings of the first initial assessment are addressed in the **2022 update of the Climate Plan** (Turku City Council 2022), underlining that a climate risk assessment (CRA) is an on-going and recurring process. The 2022 update provides a clear risk framework and points out city-level vulnerability and exposure factors for each of the major climate hazards. The list of considered hazards is expanded significantly and the most vulnerable city sectors are identified. The terms 'hazard' and 'risk' are still sometimes used interchangeably and thus the level of aggregation is not always clear. This might be resolved in the further development of the assessment: The City of Turku already plans its next steps, including work on the definition of monitoring indicators and further analysis of vulnerabilities.

The largest need to performing a comprehensive CRA in LSD1 lies in a clear definition of the underlying risk framework which differentiates between hazards/climate events and risks. This would also facilitate a broader analysis of vulnerable groups and the identification of cause-effect-relationships and impact chains. The update of the Turku Climate Plan already integrates a wide range of climate-related hazards, which would similarly be desirable for the assessment on the regional level.

3.1.3 Adaptation measures

3.1.3.1 Existing plans and measures

Important policy documents at national level

Finland's first **National Strategy for Adaptation to Climate Change** was adopted in 2005. Besides describing possible future climate change scenarios and its impacts on 15 sectors, it outlines actions and measures to improve the capacity to adapt to future climate change (Ministry of Agriculture and Forestry of Finland 2005). It was superseded by the National Adaptation Plan 2022 (NAP) in 2014, implementing the EU Strategy on Adaptation in Finland. The NAP formulates three key objectives in the field of social and institutional climate adaptation: integrating climate adaptation into planning, providing access to climate change assessments and management methods, and enhancing adaptive capacity through capacity building. Corresponding measures to reach the goals thus focus on soft actions such as mainstreaming climate adaptation into national and international strategies, supporting research and development as well as intensifying communication, education and training (Ministry of Agriculture and Forestry of Finland 2014). As the time period covered by the NAP expired, a new Adaptation Plan was adopted on 15 December 2022, guiding the adaptation actions until 2030 (Suomen valtioneuvosto 2022). The so-called **KISS 2030** (from "Kansallinen ilmastonmuutokseen sopeutumissuunnitelma") sets out a vision and three goals towards which adaptation work will be taken in the long term. Two chapters are devoted to the analysis of vulnerable population groups as well as institutional vulnerability.

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Long-term prosperity and security in a changing climate are meant to be ensured by 1. building a strong will among society's actors to adapt, 2. establishing effective means to assess, prevent and manage climate change risks, and 3. increasing adaptive capacity. These goals are backed by 24 climate change adaptation objectives and corresponding actions, ranging from strategic planning and anticipation to protecting and promoting health. All measures include a description of responsible parties, time frame and funding. The new target structure in KISS 2030 shows the advancement of the national adaptation strategy from a rough description of possible measures in relevant sectors in 2005 to a clear vision and objective-based actions in 2022. In addition to this advancement in terms of strategy and target setting, the FCCP report also points to a shifting baseline in climate adaptation as successful actions in the past already reduced the threat of certain hazards, especially flooding, in former high-risk areas (Gregow et al. 2021).

In the current National Adaptation Plan, objectives 16-18 "Managing climate risks at regional and local level" are particularly relevant for regional adaptation in SW Finland. In this context, KISS 2030 diagnoses two major gaps in adaptation planning: the substantially larger role of mitigation and the focus on very few sectors, mainly technical rainwater and stormwater management. On the other hand, central actors and levers for regional and municipal adaptation are identified including the key role of the Centres for Economic Development, Transport and the Environment (ELY Centres) as well as regional forums for cooperation and coordination on preparedness and safety. Proposed measures focus on developing guidance for regions and municipalities on risk assessments and implementation of adaptation, mainstreaming climate adaptation into national and regional policies and strengthening vertical cooperation (Suomen valtioneuvosto 2022).

Overview of relevant policy documents at regional and municipal level

Regional climate strategies and programmes were developed in the early 2010s but focused mainly on climate change mitigation (Gregow et al. 2021). This trend continues in the most recent climate policy documents in SW Finland. The **Climate Roadmap** states the need for climate adaptation in the region but out of 21 key topics with several corresponding actions, only three measures concern climate adaptation: improving water management of agricultural land, increasing research and pilots in climate adaptive construction, and identifying the climate change impacts and opportunities for stakeholders in river basins (Varsinais-Suomen liitto et al. 2023). Similarly, the **SW Finland Regional Strategy 2040+** identifies threats of climate change to the water cycle, the built environment, flood risk management and the food sector but only marginally includes adaptation measures in its Regional Programme (Varsinais-Suomen liitto 2021). However, sector-specific strategies such as the Regional Forest Programme (Suomen metsäkeskus 2020), the Water Management Strategy for Western Finland 2050 (Etelä-Savon ELY-keskus 2021) and the Regional Stormwater management plan for the municipalities Turku, Kaarina, Lieto, Raisio and Rusko (City of Turku et al. 2014) develop adaptation measures to selected hazards. **This fact points to the largest gap in existing regional climate change adaptation: the need for consolidation of existing measures and integration into a cross-sectoral strategy.**

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Consolidating the overall view of adaptation measures and continuous functioning of regional collaboration are also identified as the main challenges concerning climate adaptation in the **Turku Climate Plan 2029** (Turku City Council 2018). Building on the measures formulated in 2018, the 2022 update of the Turku Climate Plan largely extends the scope and systemizes proposed measures. The plan contains actions for the risks identified as most relevant for the City of Turku, i.e. water and water management, ecosystem change as well as heat and drought (also see 3.2.2.1). The majority of the measures are of general nature, presenting more of a goal to be achieved and lacking detailed and concrete elaboration. However, the advancement of the Turku Climate Plan in terms of risk analysis (see 3.2.2.1) and adaptation action planning is already moving towards a more systematic adaptation management. Formulating specific objectives, establishing – as planned – a related monitoring and specifying concrete measures will promote climate adaptation in Turku further. This will also allow for a systematic consideration of gender-sensitive approaches and the needs of vulnerable communities. The focus on NbS should be maintained and strengthened further.

3.1.3.2 Planned adaptation measures within RESIST

Planned adaptation measures within RESIST focus on NbS for stormwater and sustainable water management in three demonstration sites. The sites were chosen to cover a variety of land use groups (urban residential, urban industrial, rural), main stakeholders (citizens, local companies, farmers) and water management challenges (water quantity, water quality).

In the **Rauvolanlahti residential area**, implementing nature-based stormwater solutions shall support ecosystem services in the drainage basin which discharges to a NATURA 2000 reserve area. Rather than addressing individual problems, the project will develop the area in a watershed approach. Activities include drafting of the drainage-basin based stormwater plan in co-creation with local citizens and restauration of main ditches using NbS. Additionally, the ecosystem services of stormwater retention, biodiversity and recreation will be assessed in a CBA to improve knowledge on the effectiveness of NbS and increase motivation of multiple rural and urban stakeholders to design and invest in NbS.

The region has identified **three major challenges encountered at site** and is currently developing strategies to tackle these:

- **Lack of space** in the built-up area: identify where NbS are most profitable to replace grey infra-structure
- **Engaging and involving users** and addressing their needs: organise co-creation planning with citizens, e.g. through surveys and workshops
- **Sediment-release and nutrient pollution from clay soils** during implementation: develop in-novative solutions, e.g. by ditch meandering or mosaic wetland

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The stormwater system in the **Oriketo industrial area** will be renovated and redesigned based on innovative technical solutions and collaboration with the local businesses at site. While precising the technical renovation plans, the suitability of NbS will also be assessed. The aim is to negotiate and plan a joint stormwater treatment solution reducing hazardous pollution in the area.

Major challenges encountered at site and coping strategies are similar in nature to the Rauvolanlahti area:

- **Lack of space** in the industrial area: identify problem areas and assess effectiveness of possible solutions
- **Engaging and involving businesses** in the region: showcase benefits (reduced sewage charges, greening company image) and co-create best solutions in workshops
- **Water quality management**: develop innovative solutions for management of stormwater quality and hazardous substances with focus on NbS and identify further financing options

In the **rural small-scale drainage basin of Savijoki river**, NbS will be implemented in the sub-catchment to restore the hydrological balance, abate effects of floods and droughts and reduce nutrient releases to the vulnerable Archipelago Sea. Activities include engaging in a dialogue with stakeholders, establishing a drainage-basin specific multi-beneficial water retention plan and assessing the cost-benefit-effectiveness of NbS.

Site visits and landowner meetings gave valuable information about the characteristics of the river basin as well as the landowners interest and insight to climate change impact and adaptation at the pilot site. Additionally, modelling of a sub-catchment area by the University of Turku helped identify the most prominent impacts in the area and identify strategies to address these:

- **Increase in flooding** with subsequent nutrient run-off to the Baltic Sea as agricultural fields reach the river bank **as well as** increased **droughts** in the future: to address both extremes, water retention capacity must be increased substantially
- Mainly **privately-owned land**: use model outputs to assess functionality and suitability of different NbS before implementation and support participatory planning by demonstrating the NbS potential

As planning has progressed since the beginning of RESIST, the region has identified major challenges for the pilot sites and is working on solutions to tackle these. Additionally, the results of this needs assessment point to some overarching issues that should be addressed within the project (see 3.1.3.3). Both knowledge transfer and exchange between regions as well as support by adelphi and other partners in the RESIST consortium can facilitate joint work on solutions (see 3.1.6).

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3.1.3.3 Support needed

In addition to the challenges determined for the individual sites (see 3.1.3.2) where the region has already developed strategies to tackle these, it would be helpful to address the following issues identified based on this needs assessment:

- Considering **gender-sensitivity, vulnerable groups and social equity** impacts: Current planning does not point to an explicit consideration of vulnerability factors such as race, class, sexual orientation and identification, national origin, and income inequality. Planned dialogue and co-creation activities provide an excellent basis to include the needs of particularly vulnerable population groups and design the measures accordingly. The analysis of vulnerable groups in KISS2030 could be a starting point.
- **Co-creation with stakeholders**: The region aims at engaging citizens and landowners in the co-creation of the planning and implementation of the activities. Integrating a process for building capacity and engaging stakeholders successfully will lead to a better understanding of the benefits of NbS for water retention among the actors and enable a multi-beneficial watershed planning.
- **Avoiding maladaptation**: The matter of maladaptation can be addressed in the further process, based on the self-assessment checklist developed within the project REGILIENCE as a great tool to evaluate the maladaptation potential of planned adaptation actions (Institute for European Energy and Climate Policy (IEECP) et al. 2023; see 2.1.2).
- Exploiting the **transformative potential**: The planned project activities offer several levers to develop a more transformative approach to adaptation. Results on the benchmarking study of regulatory measures can inform policy changes to improve spatial regulation for water retention and infiltration. Developing innovative NbS and inclusive co-creation processes as well as the results of the CBA showcase the potential of nature-based adaptation and can provide momentum for upscaling solutions beyond the pilot sites and improve financing for NbS.
- Supporting and showcasing **digital tools for innovation**: Visualizing modelling results and integrating simulated scenarios into the Graphical Digital Twin (GDT) to demonstrate the NbS potential and support participatory planning.

adelphi can offer support in several realms, i.a. concerning integrating considerations of particularly vulnerable population groups, communicating with and convincing stakeholders, avoiding maladaptation and realising the potential of digital tools. The regional partners pointed out that they are also very interested in the adaptation action platform that KU Leuven is currently establishing to help regions access relevant information on adaptation measures, data and tools through an easy to use interface. In this context, KU Leuven will identify similar practices and initiatives in other regions of Europe and provide a mechanism to compare different adaptation projects. The immersive GDT developed by AugmentCity was met with great interest. Visualizing planned adaptation solutions can help convince stakeholders to support the measures and enable vivid exchange and

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co-creation. Additionally, FASTTRACK could help map and endorse private investment opportunities in Finland. Through transformative social innovation and reflexive regional change processes guided by ZSI, the regional partners can be supported in exploiting the transformative potential that lies within RESIST.

3.1.4 Stakeholders and community engagement

The necessity of stakeholder and community engagement to support successful implementation and future up-scaling of the adaptation measures is uncontested. In the context of capacity building and transferability, it is well designed that all three demonstration sites concern different groups of actors. The regional partners have identified key stakeholders and started engagement formats with different groups. In Rauvolanlahti key stakeholders besides the city of Turku are the 4,500 inhabitants of the area. The concerned actors in Oriketo are local companies and the regional ELY centre which is responsible for a wide range of tasks relevant to climate change adaptation, especially in the area of business and industry as well as environment and natural resources. In the rural catchment of the Savijoki river, main stakeholders are farmers and forest owners, but also citizens and the ELY centre. Currently, there is no indication of major opposing interests but challenges remain to convince private landowners by creating a win-win situation through well-designed adaptation measures.

In Rauvolanlahti, residents, recreational users, a club for small-scale farming, and potentially residential clubs and birdwatchers will be involved in the process. The first step is to conduct on-site surveys on recreational use of the site including questions on the personal background, i.e. gender, age, professional background and education which also holds potential for considering needs of vulnerable groups. Additionally, the regional partners plan focus group discussions with vulnerable groups that cannot access surveys such as small children and elderly people. The Oriketo pilot site involves collaboration with local businesses to discuss innovative measures for the open area. The companies are already marginally managing stormwater on their own and current discussions evolve around showcasing the benefits of nature-based management and co-creating solutions in order to convince the businesses to expand their activities and support implementation. Involving the main stakeholders in the Savijoki area, the private landowners who are mainly farmers, SW Finland has begun with field visits and first meetings to learn about their attitudes and needs. Further engagement is planned to convince and involve them in participatory planning of site-specific NbS.

Beyond the three pilot sites, the regional partners expressed the need for more regional coordination. They plan to have meetings and workshops with national ministries of e.g. agriculture, forestry, environment etc. to build on national experience and knowledge on a regional level, but also with regional stakeholders such as associations of farmers or the Finnish Forest Centre. Furthermore, other municipalities in the region were identified as additional potential stakeholders as they have previously expressed interest in Turku's plans. However, stakeholder involvement and community engagement are not planned to become a more formalized commitment in the area. Without this

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institutionalization, it will prove difficult to establish long-term collaboration beyond current measures and pilot sites.

3.1.5 Capacity and capacity constraints

Financial capacity is generally identified as one of the most pertinent constraints on climate change adaptation. Within RESIST, LSD1 is sufficiently equipped but lack of funding generally plays a vital role, especially as NbS are perceived as more expensive than traditional grey infrastructure. In Oriketo, financial contribution of local businesses is hoped for but insufficient understanding of the multiple benefits and value of ecosystem services that NbS can provide impedes private investment. The regional consortium states that both more public funding is needed for climate change adaptation as well as incentivising private sector funding. Planned changes in legislation concerning water quality might already provide such an incentive in the context of sustainable industrial and agricultural water management. CBA in the Rauvolanlahti catchment shall build the basis to overcome general reservations about NbS and help promote the wider uptake of these solutions.

As far as organizational or institutional capability is concerned, several challenges were identified at regional workshops and municipal surveys in the context of the Government analysis of adaptation in Finland (Hildén et al. 2022):

- **Unclear responsibilities and roles.** The unclear division of work between regional adaptation actors, underdeveloped cooperation between regions, sectors and relevant stakeholders as well as different perceptions of the role of regional councils and ELY centres impede effective adaptation policy.
- **Lack of political regulation.** An absence of legislative obligation, gaps in policies and regulation, and the voluntary nature of guidance hinder broad and concordant adaptation work.
- **Dominance of short-term projects.** As adaptation work is often project-based, implementation, continuity, monitoring, learning and knowledge sharing is not secured, and own funding and resources are required.
- **Lack of detailed information and guidelines.** In terms of available information, there is a lack of high-resolution regional and local data, and only incomplete or superficial knowledge on costs and benefits of climate change impacts and adaptation action, especially in the context of innovative NbS.
- **Fragmentation of monitoring and evaluation of effectiveness.** No comprehensive, common monitoring framework exists and assessments of the effectiveness of adaptation measures follow different approaches.

The regional partners confirmed that all of the above-mentioned challenges were areas of concern within their work, several of which they are hoping to address within the project. Additionally, they found a lack of awareness for climate change impacts and the necessity to adapt, insufficient know-

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how on NbS as well as fragmented ownership of land and poor capacity of local water protection associations/private landowners to apply for national funding to hamper regional climate change adaptation.

Based on this analysis of constraints, LSD1 has put an explicit focus on addressing several of these challenges within RESIST. Stakeholder engagement, CBA and the general promotion of NbS can help increase adaptive capacity regarding awareness raising and knowledge building. At the same time, certain policy and governance constraints can only be removed in a coordinated effort on the regional and national level. The greatest challenge to creating more systemic solutions is bridging the gap between existing individual measures and establishing a long-term cross-sectoral adaptation strategy. Impulses from the co-creation processes and the results of the CBA can provide a momentum for upscaling solutions but institutional and policy innovations are needed to allow for more profound transformations.

3.1.6 Results

In SW Finland, climate change causes a considerable change in the region's hydrological balance. Coastal flooding and stormwater runoff are major climate risks, along with SLR and drought (Table 3). Various regional groups are exposed to and affected by climate hazards, including urban and rural population and industrial commerce. Stakeholder characteristics depend upon the pilot site, with residents and local businesses in the urban regions and landowners in the rural regions as crucial actors.

Addressing coastal flooding and runoff risks by integrative adaptation measures can contribute to reducing drought impacts and ecosystem degradation. Accordingly, NbS are prioritised in the demonstration sites, as they offer risk reducing potential while providing additional co-benefits. In the Rauvolanlahti residential area, measures to improve stormwater management include restoring ditches and creating green water basins. Oriketo will profit from innovative solutions to water quality management. In the Savijoki area, a co-created water retention plan can help restore the hydrological balance and reduce nutrient release. Performing an ex-post CBA allows to evaluate the effectiveness of the measures and can create a momentum for cost-effective NbS.

Table 3: Climate impacts, planned adaptation measures and relevant stakeholders in SW Finland.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Coastal flooding and stormwater runoff **Long-term SLR**	Population Leisure visitors	**Rauvolanlahti** residential area: NbS for stormwater quality and quantity management	Residents Landowners

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		- Developing a drainage-basin based stormwater plan - Restauration of main ditches using NbS - Assessing the cost-benefit-effectiveness of NbS	
Coastal flooding and stormwater runoff **Long-term SLR**	Industrial commerce	**Oriketo** waste management and industrial area: innovative solutions to stormwater quality management, NbS along the ditch	Local businesses
Coastal flooding and stormwater runoff **Long-term SLR** **Droughts** **Soil erosion**	Rural population	**Savijoki** river small-scale drainage basin: NbS for restoring hydrological balance, reducing nutrient releases to the Archipelago Sea - Developing a drainage-basin specific multi-beneficial water retention plan - Assessing the cost-benefit-effectiveness of NbS	Residents Landowners (mainly farmers and forest owners)

Challenges and support

Major challenges evolve around ensuring inclusive and collaborative stakeholder engagement, developing innovative NbS under spatial constraints, and overcoming obstacles from multi-level governance (Table 4). For upscaling and long-term success, the project needs to explore the potential of digital solutions, integrative long-term planning and visions for transformative adaptation.

Table 4: Challenges, needs and support opportunities in SW Finland.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Addressing vulnerable groups and social equity impacts, including the gender dimension	Vulnerability assessment Mapping of needs and interests of stakeholders	

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Enhancing a comprehensive risk understanding		
Designing inclusive and collaborative stakeholder engagement processes	Provide guidelines for inclusive stakeholder engagement (together with ESF) Support design and implementation of formats	Best practice exchange on citizen engagement
Convincing stakeholders and community of necessity of adaptation and benefits of NbS	Communication toolkit and products to showcase benefits of NbS for adaptation and beyond (together with REVOLVE) Support usage of modelling results and scenario simulation in GDT for stakeholder engagement and decision-making (together with AugmentCity)	
Multi-level governance: Unclear responsibilities and roles of regional actors, sectors, stakeholders, regional council	Provide guidelines on integrative and targeted planning and develop policy recommendations	
Ex-ante evaluation of measures concerning avoidance of maladaptation	Assistance to use self-assessment REGILIENCE tool / Workshop on screening for maladaptation	
Fragmentation of monitoring and evaluation of effectiveness	Support the development of a monitoring framework (together with KU Leuven)	
Dominance of short-term projects	Roadmap for adaptation measures and long-term management of solutions	
Integration of measures into a cross-sectoral adaptation strategy	Assist in developing a roadmap for a cross-sectoral adaptation strategy	
Lack of detailed information and guidelines on NbS **Lack of clear political regulation**	Help transfer results of benchmarking study and develop policy recommendations	

Potentials for transfer

As already pointed out, cross-regional transfer of approaches, experiences and best practices presents a key lever for tackling common challenges and learning from each other and is therefore

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an important element of the transfer framework. In this regard, SW Finland can contribute expertise in several fields to the twinning regions in LSDT1 and beyond this regional cluster, such as modelling, valuation of NbS and stakeholder engagement frameworks (Table 5).

Table 5: Expertise and transfer potentials in SW Finland.

Strengths and expertise	Topics of interest	Transfer with other regions
Hydrological numerical modelling	Investigate and demonstrate opportunities of NbS in water retention, e.g. in an agricultural catchment	Support hydrological modelling, e.g. for Normandy
Assessment of regional policies	Innovative urban policies such as Green and Blue Factor	Share methodology and results of benchmarking study
Economic valuation of NbS		Share experience with CBA approach
Stakeholder engagement from Quintuple Helix	Experience on how to motivate stakeholders and decision makers	Exchange on target group specific stakeholder engagement
	Planning water and climate resilience at the level of the catchment	
	Investment models for NbS	
	Synergies with nature conservation/NATURA 2000 reserve areas	Exchange with EMT

Going beyond RESIST

RESIST aims at developing innovative solutions that can be scaled up from individual measures planned in the regions and assist systemic adaptation beyond the project context. For LSD1, RESIST is both an opportunity to explore co-created nature-based sustainable water management solutions in different land use and stakeholder contexts as well as the chance for capacity building feeding into further advancement of climate adaptation in SW Finland.

In order to exploit the full potential, it is also vital to understand how climate change adaptation can be integrated within existing frameworks or where policy reforms are necessary. The new Finnish Climate Change Act (Ministry of the Environment of Finland 2022) was planned to include an obligation for municipalities to draw up climate plans that set mitigation targets and corresponding

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measures. However, this suggestion was withdrawn and would not have included climate adaptation in the obligation.

Similarly, the revision of the Land Use and Building Act (Ministry of the Environment of Finland 2023) focused on bringing climate change mitigation comprehensively into construction legislation but neglected climate change adaptation. However, regional and local land use planning are powerful levers to systematically integrate and scale up NbS. Mainstreaming climate adaptation into Regional Plans and Local Master Plans is a prerequisite for systemic adaptation. Generally, regional and local development strategies such as the Regional Programmes should integrate climate change adaptation thoroughly. The overall goal should be to look beyond individual adaptation measures and aim for a comprehensive approach that encourages progress in governance as well as access to finance, analytics and technology.

RESIST offers several avenues towards more systemic and transformative adaptation: profiting from the growing regional coordination and collaboration within RESIST to institutionalize vertical exchange and local stakeholder and community engagement, using the results of the CBA to convince central actors of creating financial framework conditions of public and private investment for NbS, and finally advocating for the further integration of climate change adaptation into climate legislation, regional and local development strategies and land use planning. Analysis and development of new regulatory tools is thus a core component of the regional work.

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3.2 Needs assessment Normandy

3.2.1 Introduction

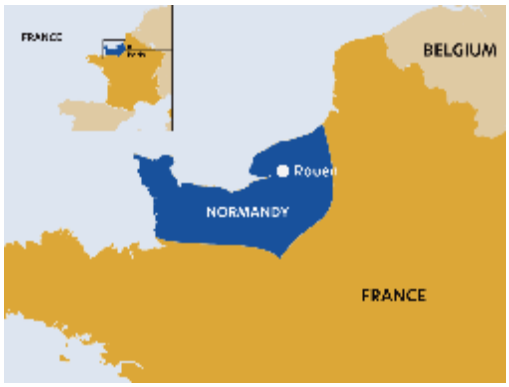

Figure 3: Location of Normandy.

Located in north-west France on the banks of the Channel (Figure 3), the region Normandy covers an area of 29,906 km² with a population of around 3.3 million people. In terms of economic activity, it is categorized as a European Regional Development Fund (ERDF) transition region with major business sectors in the fields of automotive industry, oil and related products, aviation, pharmacy, agri-food, cosmetics, energy, transport and logistics (Préfet de la Région Normandie 2023). Normandy is an ancient geographical and cultural territory which shaped the region's historic heritage, landscape and climate.

The region is characterized by a temperate oceanic climate with mild winters and moderately warm summers (Préfet de la Région Normandie 2020). However, the temperature increase of the past decades led to an increase in the number of summer days, hot and extremely hot days while frost and cold days decreased and extremely cold days nearly disappeared, especially in areas under oceanic influence. Between 1970 and 2020 annual temperature increased by 1.8 °C, with the rising trend in heat affecting the intracontinental areas more severely than the littoral as the influence of the Channel limits intensity and duration of heat waves (GIEC Normand 2020b). The 600 km coastline is highly vulnerable to erosion and flooding. Two thirds are already eroding today, showing a severe retreat of sedimentary cliffs (GIEC Normand 2020h). Annual precipitation is around 860 mm per year indicating no statistically significant trend in the past, except for less precipitation in form of snow (GIEC Normand 2020b).

3.2.2 Climate risks

3.2.2.1 Regional climate risk assessments and identified risks

The region of Normandy has commissioned a group of 23 researchers and experts to assess its climate risks, the so-called **GIEC Normand** (Groupe d'experts Intergouvernemental sur l'Evolution du Climat). The expert group provides the knowledge base for understanding the potential impacts of climate change in Normandy and informing political action (GIEC Normand 2020b). Results of their assessments are summarized in concise **syntheses** which present the central documents on climate risks in the region. Currently, syntheses exist in the fields of meteorological parameters, water, biodiversity, agriculture, air quality, coastal systems, health and fishing (GIEC Normand 2020b, 2020c, 2020a, 2020g, 2020e, 2020h, 2020f and 2020d). Addition of further topics, i.a. on socio-economic and psychological impacts, are planned for 2024.

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The analysis is based on meteorological data, both from Météo-France for the historical period and from the Centre National de Recherches Météorologiques for future climate projections up to 2100, as well as multiple hydrological modelling projects and impact models, and a review of previous studies carried out in Normandy (GIEC Normand 2020b). Concerning future developments, the GIEC Normand considers the scenarios RCP2.6 and RCP8.5 (Table 6).

Table 6: Selected climate indices and their trends in the region Normandy.
Reference period 1976-2005, and short- to long-term future under scenario RCP8.5 (GIEC Normand 2020b).

	Reference period (1976-2005)			Short-term future (2021-2050)			Mid-term future (2041-2070)			Long-term future (2071-2100)		
	mean	min	max	mean	min	max	mean	min	max	mean	min	max
Mean temperature (°C)	**10.2**	9.1	11.4	**11.3**	10.1	12.3	**12.1**	11.0	13.1	**13.7**	12.6	14.6
		baseline		+1.1	+1.0	+0.9	+1.9	+1.9	+1.7	+3.5	+3.5	+3.2
Frost days	**34.5**	5	67	**22.9**	3	48	**16.9**	1	40	**11.5**	1	28
		baseline		-11.6	-2	-19	-17.6	-4	-27	-23.0	-4	-39
Hot days	**13.6**	0	26	**20.2**	2	39	**33.2**	3	58	**54.3**	9	87
		baseline		+6.6	+2	+13	+19.6	+3	+32	+40.7	+9	+61
Annual precipitation (mm)	**859**	670	1126	**894**	670	1156	**850**	633	1101	**775**	587	996
		baseline		+35	+28	+30	-9	-9	-25	-84	-55	-130
Heavy rainfall days	**4.0**	1	10	**4.8**	2	10	**4.9**	2	10	**4.8**	2	10
		baseline		+0.8	+1	0	+0.9	+1	0	+0.8	+1	0
Consecutive dry days	**22.4**	19	25	**23.9**	22	29	**26.5**	23	30	**29.5**	25	35
			baseline	+1.5	+5	+4	+4.1	+4	+5	+7.1	+6	+10

Diminishing surface and underground reserves, deteriorating water quality and more frequent and intense flooding are threatening Normandy's **water resources**: Annual river flow is expected to decrease by 10 to 30% in the Seine basin, mainly in summer. Similarly, groundwater recharge could fall by 15 to 30%, reducing groundwater levels substantially. Heavy rainfall and subsequent run-off and soil erosion increase the turbidity and contamination of watercourses; low water levels reduce the dilution of pollutants. As a result, water supplies will become problematic at certain times of the year. Additionally, SLR in coastal areas leads to salinisation and consequent reduction in availability of drinking water (GIEC Normand 2020c).

SLR also increases the risk of **coastal flooding and erosion**, which is already severe today, threatening seaside economic activities and critical infrastructure. Inland consequences of rising sea levels are flooding from storms and increasing water tables, and blocking of river flows (GIEC Normand 2020h). Due to water acidification, rising surface temperatures, reduced phytoplankton production and reduced nutritional input from coastal rivers as well as silting up of estuaries, climate change severely menaces **fishing and aquaculture** in Normandy. Species most important to Normandy's fishing industry today could suffer a sharp decline or even disappear (GIEC Normand

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2020d). **Coastal and terrestrial ecosystems** are under severe pressure, not least from climate change. Rising temperatures and changing precipitation patterns impact the distribution of species and their habitats and the life rhythms and reproduction cycles. This can lead to the destruction of natural habitats and loss of biodiversity, with consequences for human livelihoods and economic activities (GIEC Normand 2020a).

Greater exposure of soils to erosion, run-off and the formation of an impermeable crust on the (sub-)surface of soils can lead to a decline in soil quality, damage to fields and mudflows. This will have a severe impact on the **agricultural sector** in Normandy, together with changes in crop yields due to climate change and heat stress in livestock (GIEC Normand 2020g). As the frequency and intensity of heatwaves increase in the future, people in Normandy could suffer more from heat stress, especially vulnerable groups such as the elderly, children and outdoor workers. Furthermore, rising temperatures foster the development and spreading of vector-borne diseases, and the cumulative effects of reduced rainfall, warmer water and increased flooding give rise to viral and bacterial diseases (GIEC Normand 2020f). Deteriorating air quality can have *health impacts*, particularly on cardiovascular and respiratory diseases. However, future trends are unclear due to the complex interplay of anthropogenic and climatic influences (GIEC Normand 2020e).

In addition to the syntheses by the GIEC Normand, the Regional Scheme for Planning, Sustainable Development and Territorial Equality (SRADDET) identifies the following major climate risks in the region as a basis to determine areas of intervention and propose corresponding measures (Région Normandie 2019, 2020):

- The predicted retreat of the coastline and the risk of marine submersion for Normandy's sea-front,
- Increased exposure to storms and hurricanes, as well as elevated risk of flooding and landslides, impacting inhabitants, housing and infrastructure, and thus continuity of economic activities,
- Increased frequency of heat waves and drought, with a lasting impact on the development of natural areas and populations as well as agricultural land and activities,
- The relevance of the SRADDET as a regional framework document in terms of regional planning, and particularly the fight against climate change and adaptation to it, will be analysed in more detail in section 3.2.3.1.

3.2.2.2 Comparison with ESPON data

While the ESPON CLIMATE dataset does not provide as comprehensive an assessment as that published by the GIEC Normand, it is a source of comparable data across regions and thus very valuable to the analysis within RESIST. In addition, the ESPON CLIMATE data, with its clear distinction between the risk components of hazard, exposure and vulnerability, complements the

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picture drawn above, in particular with regard to the interplay between the occurrence of climate extremes and the region's vulnerability towards these.

For the ESPON analysis, the region of Normandy is further divided into its five Departments, namely Calvados (FRD11), Manche (FRD12), Orne (FRD13), Eure (FRD21) and Seine-Maritime (FRD22). Considered hazards are heat stress, droughts, different types of flooding (river, coastal and flash floods) and wildfires. In the baseline scenario (1981-2010), all five departments are moderately affected by droughts and flash floods. In Eure and Orne wildfires also play a smaller role. Coastal and river flooding as well as heat stress are currently not very relevant. However, drought exposure of the primary sector and heat exposure of the population are comparatively high, with the Department Seine-Maritime most exposed to all hazards. Vulnerability is highest concerning the impacts of river flooding on the population, followed by heat stress. The aggregation of these factors indicates a moderate risk of river flooding for the population, flash flooding for the cultural sector and drought for the primary sector in all five departments.

Under the high emission scenario RCP8.5 until the end of century (2070-2100), all considered hazards gain relevance, with coastal flooding affecting the region severely, followed by heat stress. Wildfires, drought and flash floods are generally associated with a medium high occurrence, with slight differences between departments. Compared to the baseline, river flooding plays a larger role but still is the least relevant hazard. Under the dataset's assumption of unchanged exposure and vulnerability, these changes in the importance of the hazards cause all the risks considered, i.e. droughts on primary sector, heat stress on population, coastal flooding and river flooding on infrastructure, river flooding on population, flash flood on the cultural sector, and wildfire on the environment, to rise to a medium to medium high level of concern. Most pronounced are effects of heat stress and river flooding on the population, closely followed by the other risks considered.

By focusing on five key risks, the ESPON dataset cannot capture regional specificities such as the threat of climate change to coastal erosion or fisheries. However, the results support the analysis that heat stress and coastal flooding will become increasingly important in the future. Simultaneously, the risks associated with drought, wildfires as well as river and flash floods should also not be neglected.

3.2.2.3 Potential improvements for climate risk information

The syntheses by the GIEC Normand provide a detailed dossier of climate change impacts in Normandy concerning meteorological hazards, water, coastal systems, biodiversity, agriculture, fishing, air quality and health in eight concise synthesis reports with appealing visualization. The analysis is based on two RCP scenarios that reflect a broad bandwidth of possible climate futures, and looks at medium- as well as long-term changes. It considers both extreme events and slow onset changes of a wide range of climate-related hazards. Data sources are clearly stated and

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uncertainties extensively discussed. The assessment is not based on climate impact chains but cause-effect relationships are debated in the text.

The analysis could benefit from further improvement concerning the underlying risk framework. Currently, the assessment does not strictly differentiate between risk, exposure, sensitivity and vulnerability. The syntheses demonstrate how hazards interact and result in impacts on human and natural systems. However, there is only superficial analysis, if any, of the sensitivity or susceptibility of these systems to harm and their coping or adapting capacities. Furthermore, the division into separate syntheses on specific topics complicates the assessment of compounding and cascading risks.

A more detailed evaluation of vulnerabilities, especially concerning vulnerable population groups, could lead to their needs being taken more into account when planning adaptation measures and prevent maladaptation. Similarly, a more integrated view of cross-cutting risks could promote synergies between sectors and reduce the risk of maladaptation. However, these suggestions are cherries on the cake. The syntheses by the GIEC Normand offer a comprehensive and vividly presented review of climate risks in Normandy, thus establishing a sound knowledge base for developing adaptation measures in the region.

3.2.3 Adaptation measures

3.2.3.1 Existing plans and measures

Important policy documents at national level

France is presently drafting its third **National Climate Change Adaptation Plan (PNACC)**, scheduled for release by the end of the year (République Française 2023). The current plan PNACC-2 covers the period 2018–2022 with the general objective to implement necessary actions to adapt mainland France and overseas departments until 2050 (Ministère de la transition écologique et solidaire 2018). Contrary to the third PNACC which works with the hypothesis of a 3 °C global warming, PNACC-2 was established under the assumption of limiting temperature rise to the Paris agreement 2-degree-goal. It identifies six fields of action including governance, knowledge and information, prevention and resilience, economic sectors, nature and environment, and international action. These six fields are broken down into 29 themes and 389 operational measures.

A large focus lies on strengthening the governance and monitoring framework, improving knowledge on the impacts of climate change and raising awareness in a variety of public and private sectors. In all these fields, the plan makes several references to the regional level which also point to potential current deficits in adaptation governance. Planned actions include:

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- Increasing coordination between the local to national level by creating a network of regional committees during establishing or revising regional plans,
- Mainstreaming adaptation into jurisdiction, norms and technical standards at all levels,
- Promoting and implementing spatial reorganisation of the coastline at relevant territorial scales together with regions.

The status of implementation and financial resources spent were assessed in the mid-term evaluation of PNACC-2 (Ministère de la transition écologique 2021). Of the 389 operational measures 106 were completed, 225 were in implementation, and 58 had not been started in 2021. Meanwhile the budget had increased from € 300 million to € 8.2 billion to finance implementation of additional measures deemed necessary. The mid-term review also provides an overview of current needs and gaps in national and regional adaptation efforts:

- Removing data constraints and improved monitoring on national level,
- ,
- Stronger incentives for both public and private players to take into account the impacts of climate change,
- Necessity for strengthening the coherence and effectiveness of adaptation policies conducted at national, regional and local levels,
- Limited visibility of climate adaptation in the SRADDETs, decoupled from the objectives; and implementation of adaptation actions left to sub-regional local authorities,
- Lack of operational measures and monitoring of adaptation in the PCAETs, and
- Lack of regional or local climate data and knowledge.

Beyond these issues identified in the mid-term evaluation, one additional structural obstacle to effective implementation and mainstreaming of climate adaptation should be highlighted: PNACC-2 is not legally binding. This also applies to other highly ambitious documents at national level that include the cross-cutting issues of biodiversity and adaptation, but have limited or no binding legal scope (Paillat 2023).

A third version of the PNACC will be published in autumn 2024. It will cover the fields health, economy, agriculture, infrastructure and essential services resilience, as well as natural habitat protection. As mentioned above, it is based on building resilience in a 3 °C world and planned to be more ambitious and establish concrete measures.

In addition, the French government recently launched an initiative to support territories in implementing ecological planning at regional level (Prémière Ministre 2023). The concept of ecological planning (“planification écologique”) aims at tackling the five major challenges of the ecological transition, i.e. climate change mitigation, climate change adaptation, biodiversity

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preservation and restoration, resource conservation, and pollution reduction. The territories are asked to organize regional Conferences of the Parties (COPs) to identify the regional levers and coherently integrate ecological planning into territorial policies. The process is supported by tools for diagnostics of major levers and pre-formatted action tables that can serve as a convenient basis for discussion. Furthermore, the integrated approach of ecological planning enables to connect climate change adaptation to other related topics of ecological transition and strengthen the role of NbS. As the process has just started with Normandy Region currently organizing the conference, synergies with the RESIST project could be highlighted to realise the potential for climate adaptation.

Overview of relevant policy documents at regional and municipal level

The above-mentioned **Regional scheme for planning, sustainable development and territorial equality (SRADDET)** constitutes a reference framework for the action of the Region and its inhabitants in terms of regional planning. It aims at adapting the region to the challenges and changes underway (demographic change, climate change, digital revolution, etc.) and promoting sustainable development in environmental, social and economic dimensions. The SRADDET is made up of three documents: a. a report, setting out the regional strategy and objectives, b. a leaflet, containing the rules the SRADDET sets itself to implement the objectives as well as planned monitoring and evaluation measures, and c. appendices with supplementary information (Région Normandie 2019, 2020).

According to the law on the new territorial organisation of the Republic (NOTRe) (2015) the SRADDET shall cover eleven obligatory subjects from achieving balance and equality between regions to waste management and prevention. In contrast to combatting climate change, adaptation is not explicitly stated as one of the legally required topics but could be integrated into the topics of infrastructure siting, efficient use of space as well as protection and restoration of biodiversity. Despite this shortcoming in the legal basis, the region of Normandy decided to specifically address climate change adaptation as one of the six main strategic objectives that are transversal to all the fields of the SRADDET (Région Normandie 2019, 2020). These six over-arching objectives are broken down into numerous thematic and specific regional goals, e.g. reducing natural risks related to water and preventing impact of climate change and rules, as well as rules such as “In coastal, retro littoral and estuarine areas, allow development and construction only if they are adapted to the foreseeable natural risks on the horizon of 2050 (flooding, marine submersion, erosion, retreat of the coastline)".

The six main areas of intervention identified in the SRADDET are the coastline, where risk of flooding increases with rising sea level; the rivers and estuaries which are particularly vulnerable to climate change impacts and human activities; agriculture, affected parallelly by rising temperatures and changes in precipitation; forestry, impacted from changing precipitation, prolonged drought and new pests and diseases; water resources, with areas most at risk located in the Armorican massif, but the question of resource allocation during dry periods in regions with growing population also

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affecting the western Normandy; and urban areas, as development and urban planning documents must anticipate and reflect the changes. Concerning this last field of action, the SRADDET points out the central role of urban development choices and planning documents to preserve and strengthen ecosystems and sensitise the general public and elected representatives. More specifically, the SRADDET recommends considering expected changes in sea level and frequency of flooding and submersion events when defining zones to be urbanised (for settlement, economic activities, etc.) as well as integrating concerns of clay shrinkage and swelling, stress on water resources and urban heat island effects into city planning.

However, it is noted that planning documents do not address these issues adequately: When it comes to e.g. flood risk management or considerations concerning the necessary relocation of housing or economic activities, the current perimeters do not necessarily correspond to those of planning documents. Regulations are often outdated or overtaken by climate change reality.

In this context, the SRADDET points out that administrative boundaries do not always address the issues identified. Examples include changes to the coastline, flood risk or water resource management, where broader approaches need to be developed, and therefore cooperation on the scale of the issues to be addressed: a coherent approach on the scale of a catchment area, from the source to the mouth of a river, work on the scale of the hydro-sedimentary unit, etc.

The law NOTRe requires the President of the regional council to present a report on the implementation of the SRADDET six months after its adoption (2015). In this context, the region set up a monitoring and evaluation system that helps assess the progress towards and achievement of the objectives, the contribution from regional stakeholders to its implementation as well as developments in the region resulting from its realisation (Région Normandie 2021). The review is built around 78 monitoring indicators relating to major issues defined in the objectives and rules of the SRADDET, complemented by 15 indicators providing additional context information to a allow a more comprehensive overview of the regional situation. Unfortunately, the indicators do not relate to the six major objectives formulated in Normandy's SRADDET but to the eleven obligatory subjects of which climate adaptation is not an explicit part (see above). However, several indicators can be used to assess different aspects of adaptation, such as the amount of local authorities with sustainable development strategies dealing with climate risks, density and accessibility of health facilities, amount of local water management strategies, amount of revised urban planning documents, terrestrial and marine protected areas, and fragmentation of water courses and (semi-) natural areas.

Six months after the adoption, such an assessment cannot be exhaustive. However, it can reveal first successes and short-term obstacles. Besides, building a systematic monitoring system from the start makes a strong case for the Normandy. Concerning integration of adaptation into municipal planning and access to health facilities no results were available. In terms of revision of urban planning documents, the region supported local actors in diffusing knowledge on the SRADDET and

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analysing the status quo of current documents. Regarding the fragmentation of water courses, the 2020 status was analysed to create a baseline for further monitoring. Similarly, the report assessed the status quo of water management strategies in 2021. 16 intercommunities were implementing strategies with an additional three under development.

The subject of adaptation is clearly represented in the SRADDETs and widely mentioned at the level of objectives, with references to numerous varied levers. However, it is markedly less mentioned in the rules, and most of these rules relegate to measures taken by local authorities and thus depend on the ambition shown for adaptation in the SRADDET to be translated into local policies. Furthermore, the SRADDET does not refer to the PNACC and thus fails to create a relationship between national and regional adaptation policies. Similarly, the SRADDET could establish a stronger link to existing sectoral approaches to foster coordination of objectives and rules, and working towards a cross-sectoral vision. Climate change adaptation is well integrated at a conceptual level but has room for improvement concerning definition at an operational level.

In order to strengthen climate change adaptation in the SRADDETs, assessments of regional climate risk, such as provided by the GIEC Normand (see 3.2.2.1), should be integrated prior to the preparation phase to give a clearer picture of the impacts and enable these issues to be incorporated consistently. Given that climate change is a cross-cutting objective of the strategies, and that the development of adaptation measures requires a multidisciplinary approach, it would be appropriate to either reread the whole document with a clear vision of climate change adaptation or ideally plan from the outset a structure in which adaptation is a guiding principle. Additionally, to make the SRADDETs more effective and operational, the strategic objectives should be translated into more concrete actions. Setting up a monitoring and evaluation system as in the Normandy is a valuable starting point for assessing the implementation. However, to enable a more meaningful monitoring, the objectives and rules must be associated with quantified data and timetables for implementation which can then serve as a benchmark to assessing the progress in implementation and execution.

The goals and rules stated in the SRADDET are interlinked with territorial and local planning as they guide the **territorial climate-air-energy plans (PCAETs)**, and through them the local urban development plans and all the activities of the territory. In terms of legal scope, PCAETs have an obligation of compatibility with the general rules of the SRADDET and an obligation to take the objectives of the SRADDET into account.

The PCAETs translate regional, national and international objectives concerning energy, climate and air quality into targets at the level of intercommunities. The plans define a. strategic and operational objectives to mitigate and adapt to climate change, and b. a programme of actions to reduce greenhouse gas (GHG) emissions and energy dependency, improve energy efficiency, increase renewable energy production, control energy consumption, while helping to adapt to climate change in the short, medium and long term (Olei 2020). They must include an assessment of the current situation in terms of carbon footprint and the area's vulnerability to climate change, quantified targets

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based at least on national and European references, strategic and operational objectives both for mitigation and adaptation, and a scheme for monitoring and assessing the measures initiated.

The current status of the PCAETs (as of December 2022) is visualized in Figure 4. 14 intercommunities have already adopted a plan, 17 were in regulatory consultation. In 20 intercommunities PCAETs were under development in December 2022, four obliged intercommunities were not engaged (yet).

A recent study within the project Life intégré ARTISAN aiming to contribute to the implementation of PNACC-2 and France's Biodiversity Plan analysed the relevance of climate change adaptation and NbS in the PCAETs (Salmon et al. 2021). Generally, most of the adaptation measures proposed are so-called soft or upstream solutions, i.e. organisational, strategic, institutional or regulatory. The majority of NbS suggested in the PCAETs refer to urban development, water, agriculture and forestry. In the urban context, the measures mainly address risks from rising temperatures such as heat waves and the urban heat island effect through greening and renaturation of public spaces, and to a lesser extent increased runoff and surface permeability. When it comes to quantitative and qualitative water management, several PCAETs rely more on grey infrastructure than NbS. Concerning agriculture, the focus is on flooding, drought and erosion. Envisaged measures encompass planting hedges, diversifying crops and preserving and restoring wetlands. To mitigate the impacts of climate change on forests, especially disappearance of species and loss of biodiversity, the PCAETs refer to preserving the green-blue network (Salmon et al. 2021).

What is lacking, however, is a clear operationalisation of the measures, with specific and adequate funding, reliable indicators and long-term monitoring and evaluation. In other fields of action besides those mentioned above, the PCAETs do not establish an explicit link to climate change adaptation. It is unclear whether the local authorities were aware of its relevance and took it into account when drawing up the plan. Several intercommunities do not see adaptation as their main area of concern and do not integrate measures due to budgetary reasons. The PCAETs addressing climate change adaptation and NbS rarely introduce a new dynamic or new solutions, but mainly rely on measures already implemented or planned. Often, these measures are projects, plans or complementary strategies of joint players in the field (agricultural plans, projects to combat salinization, forestry charters) (Salmon et al. 2021). This integrative approach can allow adaptation actions to be visible and firmly anchored in the region. However, the PCAETs need to facilitate this integration by embedding the different sectoral strategies in an over-arching vision.

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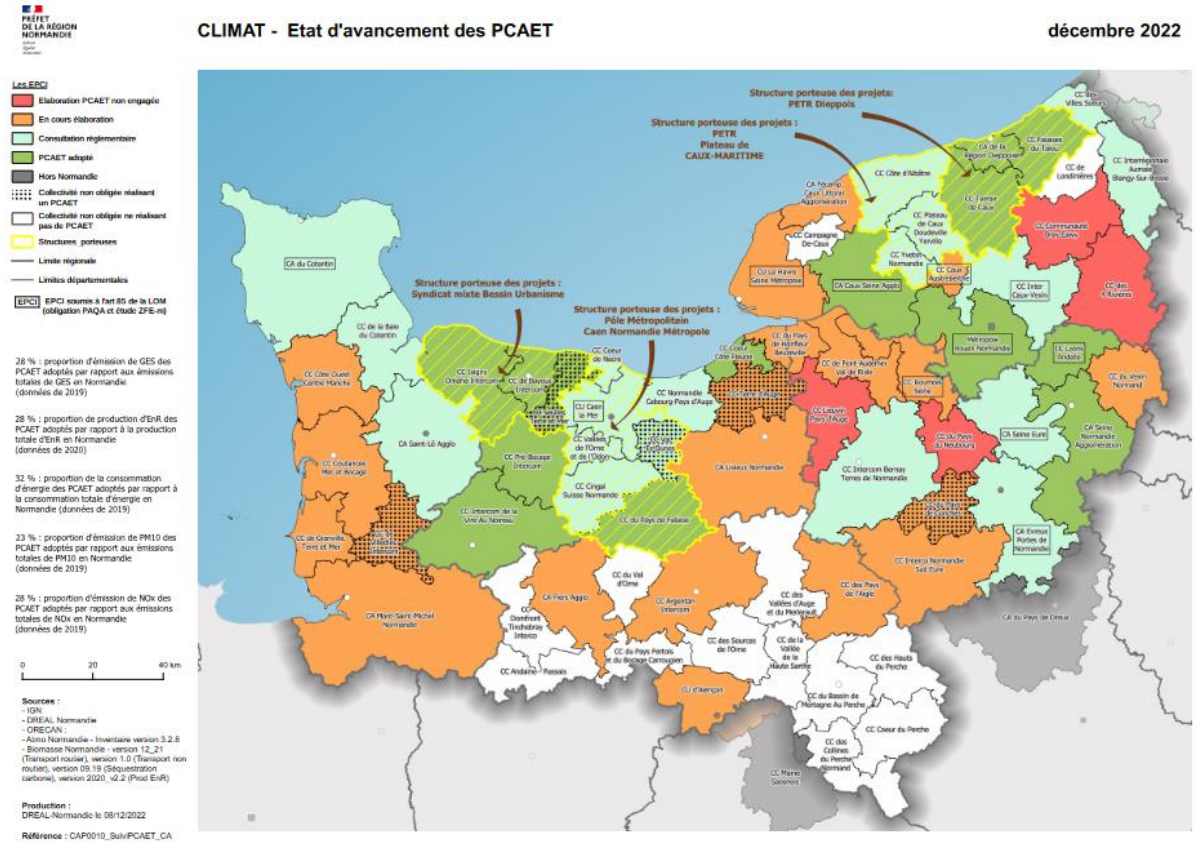

Figure 4: Current status of PCAETs in the Norman intercommunities (Préfecture de la Région d'Île-de-France 2022).

Legend: red – no elaboration yet, orange – under development, mint – regulatory consultation, green – adopted PCAET, dotted – non-obliged community realising a PCAET, white – non-obliged community not realising a PCAET, yellow border and diagonal lines – intercommunities with support structures.

In the hierarchical organization of the planification documents, the **territorial coherence plan** (SCoT) acts as a pivot between national plans, regional plans, especially the SRADDET, and the local and inter-municipal urban development plans (PLU, PLUi). It must be compatible with a majority of higher-level documents and take into account the objectives of the SRADDET. Lower-level documents must be compatible with it or take it into account, such as the PCAET and the PLU/PLUi. The NbS proposed for the territories must be compatible with the requirements of these documents.

As the focus of the measures taken within RESIST lies on water resources (see section 3.2.3.2), it is worthwhile to also briefly consider the **Master Plan for Water Development and Management (SDAGE)**. It is a planning tool for water resource and aquatic ecosystem management at the level of large catchment areas. For the Seine basin and coastal rivers in Normandy, the SDAGE covering the period 2022-2027 was adopted in March 2022, accompanied by a programme of measures

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(Préfecture de la Région d'Île-de-France and L'agence de l'Eau Seine-Normandie 2022b, 2022a). The plan sets out fundamental guidelines and associated objectives and the necessary provisions to fulfil these. It is the political framework instrument for the basin's water policy, aiming order to ensure a balanced and sustainable management of water resources. Administrative decisions in the water sector and regional planning documents must be compatible or rendered compatible with the SDAGE, i.e. must not present any major contradiction or conflict with its objectives, guidelines and provisions (Préfecture de la Région d'Île-de-France and L'agence de l'Eau Seine-Normandie 2022b).

Concerning climate change adaptation, the plan recurs to the major risks identified in the basin adaptation strategy in 2016 including reduced river flows, increased pressure on water demand and greater concentration of pollutants, increased risk of run-off due to heavy rainfall and sealing, saline intrusion into freshwater, threatening the drinking water supply of coastal towns, and erosion of the coastline and risks of flooding (L'agence de l'Eau Seine-Normandie 2016).

According to the strategy, priority should be given to no-regret measures which are beneficial regardless of the extent of climate change, flexible, inexpensive and resource-efficient. They should further be multifunctional, benefitting mitigation, in solidarity between the different local stakeholders, and avoid maladaptation. Building on the adaptation strategy, three of five fundamental guidelines explicitly refer to adaptation and increasing resilience in terms of balanced management of water resources, restauration and preservation of ecosystems and biodiversity, and sustainable management of the coastline (Préfecture de la Région d'Île-de-France and L'agence de l'Eau Seine-Normandie 2022b). In the programme of measures, climate change adaptation is seen as a cross-cutting topic. Hence, the majority of the actions contribute to adaptation, with varying degrees of effectiveness depending on the field and the technical choices made during implementation. The proposed measures are of two kinds: direct environmental actions such as re-establishing ecological continuity, limiting surface sealing and restoring flood expansion, and secondly knowledge or governance measures, such as promoting research and development or translating guidelines into local water development and management plans (Préfecture de la Région d'Île-de-France and L'agence de l'Eau Seine-Normandie 2022a).

Addressing climate change adaptation as a cross-sectoral topic in the SDAGE and corresponding programme of measures is a strong lever for increasing resilience of water masses and ecosystems, especially as the plan has a distinctive legal status. Concerning certain topics, the plan formulates clear, measurable targets, e.g. on the ecological status of water bodies or the reduction of nitrate concentration, that could be monitored and evaluated to track the success of proposed measures. However, the SDAGE also points out that achieving the set targets implies a breakthrough that requires sectoral public policies dealing with water topics to take these issues into account and contribute accordingly.

Beyond the actions already taken by the region through its competences and policies set out in the SRADDET and additional sectoral strategies, Normandy strives to contribute further to climate

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change adaptation. Hence, **Normandy Region** put forward a **climate action plan** with 34 proposals aiming at mitigating and adapting to climate change in Normandy which was adopted by the Regional Council in December 2022 (GIEC Normand 2022). The plan covers eight main topics, from renewable energies and energy efficiency to research and development. One of the eight topics is explicitly dedicated to climate change adaptation, "Adapting activities to the consequences of climate change", and several topics either explicitly or implicitly refer to adaptation.

Actions under the header of adaptation are of two kinds: half of the measures are more in the nature of objectives or overarching guiding principles (improving the resilience of fish farms, resilient design and development of public spaces). The remaining actions are a list of three concrete support programmes, namely "Norman Coastline", "Tomorrow's water in Normandy" and "Territorial Strategy and Climate", launched after the adoption of the plan by the Regional Council in July, May and April of 2023, respectively.

Besides, climate change adaptation is mentioned when referring to new agricultural and forestry practices, in all actions under the topic of innovation and research, as well as in measures concerning professional training and raising awareness. Out of 34 actions, 18 address questions of climate change impacts in terms of capacity building and increasing resilience. In contrast to other regional strategies dealing with climate change, which mainly focus on reducing GHG emissions, the action plan accomplishes to consider climate mitigation and adaptation jointly in a number of cross-cutting themes. Additionally, by establishing corresponding funding opportunities, it pre-empts and remedies one of the biggest obstacles usually put forward against climate adaptation.

However, the action plan lacks a clear target architecture based on which over-arching goals and concrete measures could be deduced. It does not differentiate between different types or depths of actions and fails to link proposed measures to the major impacts identified in its 2020 syntheses (GIEC Normand 2020a–2020h).

3.2.3.2 Planned adaptation measures within RESIST

Planning of adaptation measures is still in its early stages. In collaboration with the French Centre for Studies and Expertise on Risks (CEREMA) and the French Biodiversity Agency (OFB) the region will implement measures focusing on water management in three pilot sites. Initial starting point for site selection were a set of criteria including factors such as: existing problems relating to erosion and run-off, pollutant transfer, flooding and heat islands, all of which are exacerbated by climate change; favouring a catchment area approach; presence of local partners to involve in the pilot area. The regional consortium is currently in the process of identifying sites and organizing meetings with elected representatives to discuss propositions. Potential sites cover different problematics, spatial scales and thus varied possible adaptation solutions.

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At the current status, the largest challenge is to convince local and regional stakeholders to participate in RESIST. Within the project, the region cannot support local financing of NbS. Hence, essential stakeholders and the wider community need to be convinced of the necessity and benefits of implementing adaptation solutions within RESIST, especially concerning the suitability of NbS – despite common misconceptions of NbS as inefficient or expensive and structural obstacles (lack of reference system, regulatory complexity, incompatibility with external technical standards). According to the region, the largest added value for stakeholders participating in RESIST would be a vulnerability assessment and a cost-benefit analysis (CBA). Carrying out these analyses would also address two of the main challenges in the further implementation of adaptation measures: integrating potential impacts for most vulnerable groups, and showcasing the benefits of the planned measures beyond adaptation. Adding to this, an ex-ante assessment of the measures can also help anticipate possible side effects and avoid maladaptation. Showcasing the benefits can be supported by employing the GDT in stakeholder discussions and participatory planning.

3.2.3.3 Support needed

Normandy could benefit from support for the planning, design and implementation of measures in the following areas and focal points:

- **Facilitate stakeholder engagement.** The integration and engagement of actors relevant to respective activities was identified as a key challenge in the successful implementation of adaptation actions. Stakeholder consultations enhance the update and implementation of measures, and CBA of NbS ensure long-term acceptance and potentially also facilitate the investment of private sectors. In this context, adelphi can contribute in assessing and integrating potential impacts for highly vulnerable groups and incorporating the gender dimension into adaptation action. By ensuring the inclusion of vulnerable communities, the acceptance and equity of adaptation actions is increased.
- **Initiate an integrative and targeted planning.** The expertise and assistance by the RESIST consortium can ensure that adaptation activities maximize their positive impact and effectiveness. Linking individual measures can create additional positive effects and increase co-benefits, both concerning adaptation goals and positive social impact. Systemic planning strengthens the coherence and impact of adaptation policies across scales and sectors. At the same time, it makes sure that measures are not inadvertently leading to negative side effects or exacerbate vulnerabilities. Robust screening processes and ex-ante assessments of adaptation actions identify and mitigate potential unintended consequences, thus leading to more sustainable and climate-resilient outcomes.
- **Leading the pathway to transformative and innovative adaptation on the basis of NbS.** Through RESIST, ecosystem-based approaches to adaptation are fostered, which provide additional synergies and co-benefits between and beyond measures. NbS offer no-regret measures that are cost-effective, flexible and resource-efficient, which is in alignment with the priority stated in the SDAGE. Knowledge-sharing and capacity-building will

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facilitate the implementation of innovative measures that shift adaptation to fostering long-term solutions and addressing the root causes of climate risks.

- **Enhancing the climate risk understanding.** Although the existing regional CRA rest upon a sound knowledge base, improvements can be made that increase the integrity of adaptation schemes. This concerns updating the underlying risk framework to include the latest standard of knowledge according to the IPCC AR5/AR6 (2014, 2022); the inclusion of notions regarding cascading and compounding risks; the adjustment of parameters to the current reality of climate change; and the in-depth evaluation of sensitivities, especially those of highly vulnerable groups within the population.

3.2.4 Stakeholders and capacities

At this early stage, without knowing the final pilot sites, it is not possible to carry out a detailed analysis of the key stakeholders involved. Once the sites have been decided, this creates great leeway for designing engagement formats for the different actors, i.e. industrials, farmers, urban planners, elected representatives, civil society, etc.

In this context, the region can build on past stakeholder processes for the regional littoral adaptation strategy “Notre Littoral pour Demain” which has made it possible to mobilize and support the elected representatives, so that they commit to sustainable and integrated management of the coastline. Within RESIST, the region is currently planning meetings between the environmental vice-president and elected representatives in the potential sites. The subsequent process of stakeholder engagement can be supported by adelphi.

As mentioned above, the region cannot provide local funding for pilot sites within RESIST. However, the ERDF as well as the State-Region planning contracts (“contrats de plan État-Région”) can close this gap. Following the GIEC Normand climate action plan (see 3.2.3.1), the region established the programme “Adaption du littoral” (“Coastal adaptation”) co-financed with ERDF funds which aims at enabling communities to adapt to coastal risks linked to flooding and the retreat of the coastline under the combined effect of rising sea levels and erosion. Additionally, it might be interesting for smaller communities to help them attract private funding. In the long-term, the region is also planning on setting up a participatory funding platform which supports smaller projects with 50% public and 50% participatory funding. Besides creating a low-threshold funding opportunity, this also raises awareness for climate adaptation in the region and enables involvement of citizens. In terms of structural constraints, the region pointed out that the strict legal framework for the allocation of funds in France is based on competition, making it difficult to support suitable projects without going through this arduous process. To make the implementation of adaptation measures more attractive, this process would have to be simplified.

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In addition to these financial capacity constraints, the region also faces institutional and governance challenges that hinder systematic adaptation. There is still in-depth information lacking with regards to the vulnerabilities of population, properties, systems, etc. on varying time scales. Furthermore, the societal communication and information sharing about climate-related impacts and adaptation measures is key, however, this is complicated for certain shares of the population that are not yet integrated into ongoing debates, but who are often most vulnerable to climate-related risks. In terms of institutional capacities and collaboration, there is lacking coordination between the various relevant stakeholders and actors in the Normandy, and the lack of critical resources, such as time and qualified personnel, combined with institutional inertia, is hindering the regulation and implementation of an effective and integrative adaptive scheme.

As the existing administrative boundaries are not always sufficiently scaled to address climate-related issues effectively, broader approaches and cooperation across scales are necessary. This is particularly relevant for coastline changes, flood risks, or water resource management in large-scale basins, where coherent policy approaches from the headwaters / sources to the mouth of the river are needed. Yet, due to the uneven distribution of institutional responsibilities (e.g. the regional competences of biodiversity topics, or the coordination of water-related issues by the prefecture of the Departments), cross-sectoral coordination on climate change issues and adaptation is so far not taking place. This systemic and integrative planning is key for the translation of national and regional policies into action and the successful on-site implementation of adaptation measures.

Furthermore, regulations are partially contradictory in terms of their objectives and implementation. Current parameters do not necessarily correspond to those of planning documents, there is a limited scope of the existing documents treating adaptation, and objectives might be outdated or redundant in the light of climate change reality.

3.2.5 Results

River flooding and biodiversity and ecosystem degradation are the major climate risks identified in Normandy (Table 7). The groups affected are highly site specific, mainly residents and landowners, but also local businesses and visitors. Planned measures to reduce climate impacts include integrated management of rainwater and discharge quality, as well as clearing of streams and renaturation projects. There is a wide array of potentially relevant stakeholders for project implementation, depending on the site-specific context.

Table 7: Climate impacts, planned adaptation measures and relevant stakeholders in Normandy.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities

River flooding **Biodiversity degradation**	*depending on sites, potentially:* Residents Leisure visitors Local businesses Landowners	*depending on sites, potentially:* Renaturation Restoring watercourses and their functions Rainwater management Quality management of discharged water	*depending on sites, potentially:* Residents Municipality Local public agencies (architecture, landscape) Intercommunity Mixed union of the respective watershed Normandy Region Water basin Agency Civil society Local businesses and industries Landowners

Challenges and support

The largest challenge regarding the implementation of planned measures in Normandy concerns stakeholder engagement and inclusive planning (Table 8). In-depth information on the vulnerabilities, as well as public communication and engagement of all relevant stakeholders is key to design inclusive measures and create acceptance. adelphi can both support the analysis of vulnerable groups as well as the process of stakeholder and community engagement once the pilot sites have been decided. Based on this, adelphi can help communicating with and convincing stakeholders that might be opposed as well as integrating the consideration of vulnerable population groups and their needs in the design of the adaptation measures. Integrating RESIST's work on social and digital innovation supports these efforts and creates scope for adaptation beyond the pilot sites. In addressing the challenges and needs, Normandy can benefit from citizen engagement practices and modelling expertise in SW Finland and EMT. An implemented CBA for NbS in SW Finland can serve as a good practice example for this type of analysis and lessons learned by the Finnish partners would be very valuable to Normandy, especially with SW Finland's diverse range of pilot sites. Furthermore, the region would benefit from experience on stakeholder mapping and planning of the involvement, from identifying goals and understanding priority stakeholders to integrating the results in the intended use. As the concepts of vulnerable population groups and gender-sensitivity have not been in the focus of Normandy's action planning, it would be helpful to learn from best practices in regions which have identified major vulnerabilities in the population, including concerning gender, and developed approaches to address these.

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Table 8: Challenges, needs and support opportunities in Normandy.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Addressing vulnerable groups and social equity impacts, including the gender dimension **Enhancing a comprehensive risk understanding**	Vulnerability assessment Mapping of needs and interests of stakeholders	
Designing inclusive and collaborative stakeholder engagement processes	Provide guidelines for inclusive stakeholder engagement (together with ESF) Support design and implementation of formats	Best practice exchange on citizen engagement
Convincing stakeholders, especially political actors, of necessity of adaptation and benefits of NbS	Communication toolkit and products to showcase benefits of NbS for adaptation and beyond (together with REVOLVE) Support usage of modelling results and scenario simulation in GDT for stakeholder engagement and decision-making (together with AugmentCity)	
Lack of data necessary for flood modelling; not sufficient expertise in flood modelling	Assistance with data collection by KU Leuven	Numerical modelling expertise in SW Finland and EMT
Multi-level governance: Unclear responsibilities and roles of regional actors, sectors, stakeholders, regional council	Provide guidelines on integrative and targeted planning and develop policy recommendations	
Ex-ante evaluation of measures concerning avoidance of maladaptation	Assistance to use self-assessment REGILIENCE tool / Workshop on screening for maladaptation	
Financial constraints	Provide overview of financing options Map and endorse private investment opportunities (together with FASTTRACK) Facilitate exchange on private investments in other EU regions (together with SERN)	

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Lack of detailed information and guidelines on NbS **Lack of clear political regulation**		Extension of SW Finland benchmarking study to Normandy

Potentials for transfer

Several ways exist in which Normandy may support other regions (Table 9). Normandy has developed selection criteria to identify pilot sites and localize NbS applications which could be share with other regions to support identifying suitable locations for (NbS) measures and systematically examine the assumptions that lie behind site selection. Additionally, the regional consortium has strong expertise in the context of climate adaptation and biodiversity.

Table 9: Expertise and transfer potentials in Normandy.

Strengths and expertise	Topics of interest	Transfer with other regions
Stakeholder engagement from Quintuple Helix		Exchange on target group specific stakeholder engagement
Nature-based adaptation solutions and biodiversity		Exchange with EMT, share expertise i.a. with SW Finland
	Designing suitable NbS to increase resilience of territories to climate change in the field of water	
	Planning water and climate resilience at the level of the catchment	
	Investment models for NbS	
	Cost-benefit analysis of NbS	Transfer of experience from Central Denmark, SW Finland

Going beyond RESIST

To enable a comprehensive adaptation scheme going beyond the planned measures within RESIST, Normandy can draw from various regional strategies for sustainable development, climate change mitigation and adaptation. However, to realise the full potential and set out on the path towards transformative adaptation, the region would benefit from establishing a comprehensive, cross-sectoral climate adaptation strategy. This strategy should be built on a clear target architecture based on which over-arching goals and concrete measures can be deduced. It would differentiate between

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different types or depths of actions, integrate existing sectoral approaches and link proposed measures to the major impacts identified in the GIEC Normand syntheses.

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3.3 Needs assessment Eastern Macedonia and Thrace

3.3.1 Introduction

The Eastern Macedonia and Thrace (EMT) region is located in north-eastern Greece, encompassing the islands of Thasos and Samothrace, as well as the eastern part of Greek Macedonia and the western part of Thrace (Figure 5). The region covers 14,157.76 km, and it shares borders with Bulgaria to the north and Turkey to the east; it is divided into six regional units and 22 municipalities. The most prominent cities are Alexandroupolis, Drama, Kavala, Xanthi, and Komotini, which serves as the region's capital. EMT has a population of 608,000 people, representing 5.6% of the Greek population. The agricultural sector employs the greatest number of individuals in the region. Unfortunately, the region has experienced a decline in GDP over the last six years, coupled with an increase in the unemployment rate, which stands at 22.8% of the population (2023). The ERDF has identified Eastern Macedonia and Thrace as one of the poorest regions in Europe, thus indicating its underdevelopment. The terrain of the region is markedly varied, featuring numerous mountains and plains, along with a lengthy coastline spanning 480 km. Additionally, it boasts an abundance of rivers, deltas and wetlands.

Figure 5: Location of Eastern Macedonia and Thrace.

The region has experienced significant exposure to the impact of climate change. In recent years, the prefectures of Evros, Rhodope and Xanthi have endured severe flooding, resulting in numerous economic losses to residential and agricultural areas. The substantial variability of precipitation generates various water risks such as inland flooding and coastal erosion. Rising temperatures are aggravating hazards such as water shortage and drought, and are also associated with the severe wildfires the region was encountering this summer (2023).

3.3.2 Climate risks

3.3.2.1 Regional climate risk assessments and identified risks

The main document addressing climate risks in the EMT region is the **Regional Adaptation Action Plan (RAAP)** of April 2022 (Envirometrics 2022). The report aims to provide a comprehensive picture of existing and future climate-related risks for the region. It starts by identifying relevant climate hazards in the region based on which a vulnerability assessment is conducted. These findings subsequently feed into the impact assessment for the region, which is differentiated by sector and activity, and finally lead to the identification of appropriate adaptation measures.

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The **analysis** of climate risks for EMT is based on the simulation of regional climate models in the **framework** of EURO-CORDEX. In line with the IPCC AR5 and the European Environment Agency (EEA), the numerical climate models provide parameters of temperature, drought, wind, heat waves, cold intrusion/frost, SLR and waves. Climate risks are assessed for the RCP4.5 and RCP8.5 scenarios following guidelines of the AR5 (IPCC 2014). Climate risks are assessed for the mid-century period (2021-2025) and the end-of-century period (2071-2100). In the analysis, the six regions of Evros, Thasos, Rhodope, Xanthi, Kavala and Drama are considered individually to present a differentiated picture of the region.

The analysis examines a range of severe climate risks for the region, distinguishing between **long-term changes in average climate** and the frequency and intensity of extreme weather events. According to RCP4.5, average temperature is expected to increase by 2.2 to 2.6 °C by the end of the century, while under RCP8.5, temperature rise is projected to 3.6 to 4.6 °C. This will particularly affect areas far from the sea, such as Drama and Evros. Precipitation is expected to decrease throughout the year. In both scenarios the greatest decrease in precipitation is estimated for the regions of Xanthi and Kavala, with an average decline of 5% and 11% by the middle of the century.

As far as **extreme weather phenomena** are concerned, EMT will face an increase in maximum precipitation, wildfires, droughts and hot summers. Regarding droughts, it is anticipated that the number of days with less than 1 mm of precipitation will rise from 10 to over 70 by the end of this century in almost all parts of EMT. However, until mid-century the six regions reveal a differentiated picture: the maximum duration of drought will increase by up to 20 days in Drama and most of the Evros regional unit, and decrease by up to 20 days in Kavala and Rhodope. Regional differences also show when analysing the maximum amount of precipitation occurring within 48 hours: while for Evros, Thassos and Samothrace an increase of 10 to 20% is expected, for the southern regions a decrease of 10% is estimated. In the long term, heavy precipitation will increase in a significant part of the region by the end of the century under both scenarios. These trends of prolonged droughts and increasing heavy rainfall can go hand in hand and show that in EMT both extremes, i.e. very little and very large amounts of precipitation, become more frequent. In addition to water-related hazards, extreme temperatures pose a particular risk to the region. The report highlights a winter temperature increase of 1.0 to 3.2 °C by the end of the century and a summer temperature increase of 2.3 to 2.8 °C based on RCP4.5. In both scenarios, the number of days with temperatures above 35 °C increase across the region, particularly affecting lowland areas such as Evros. In addition, urban centres are especially exposed to days of discomfort based on the HUMIDEX index, hence presenting health risks for the cities Drama, Komotini and Xanthi. Additionally, forest fires pose a significant threat to the region. The number of days with extremely high risks of fire will rise to seven additional days under RCP4.5, and 18 to 26 additional days until the end of the century under RCP8.5. Based on this analysis, the report points out that the region, like many other Mediterranean regions, is particularly exposed to extreme water-related hazards as well as extreme heat and its consequences such as droughts or forest fires.

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Building on these findings, the RAAP provides a climate **vulnerability assessment**, examining the vulnerability of activities in different sectors according to climate parameters such as drought, temperature increase, wind, heat waves, cold spells/frost, heavy rainfall/snowfall, SLR and waves (storm surges). Activities considered include the primary sector with agriculture and livestock, industry, manufacturing, energy, waste, transport and categories such as health, biodiversity and cultural monuments. The assessment is based on an activity-specific quantitative and qualitative evaluation of literature on the sensitivity of each sector, international risk assessments reported in annual reports of boards of directors, and the assessment of project team members. In addition to the aspect of sensitivity, the probability of occurrence of the meteorological parameter, the geographical extent of climate change, the size of the population affected and the complexity and interactions of the phenomena are considered. The assessment also integrates the existing adaptive capacity of the sectors. The final rating follows a 5-point scale, ranging from no information on vulnerability (rating 0) and low vulnerability (rating 1) to extreme vulnerability (rating 4), with positive impacts included with a negative sign.

Both average temperature changes and extreme weather events make forests, agriculture and livestock, and thus the primary sector extremely vulnerable. Agriculture is highlighted as being extremely vulnerable to rising temperatures and also highly vulnerable to various climate risks such as increasing cold, droughts and heavy rainfall. The region's population, in particular vulnerable groups, are extremely sensitive to heat waves, heavy rain and snowfall, and highly exposed to cold spells and frost. The climate risk of heavy rain and snow also highly affects buildings, ski resorts and beaches. Beaches and harbours are furthermore highly vulnerable to waves and rising sea levels. The natural environment, wetlands and protected areas show extreme sensitivity to droughts and SLR. In general, wetlands and protected areas are extremely vulnerable to warming, reduced precipitation and longer seasons. Finally, road and rail transport infrastructure as well as the built environment, including cultural heritage sites, were found to be highly vulnerable to more frequent and more intense extreme weather events.

The assessment also considers the effects of **adaptive capacity**, reducing vulnerability despite changing climate parameters. Summer and urban tourism as well as education might become slightly less vulnerable despite rising temperatures as interventions in these areas facilitate adaptation to climate change and reduce its negative impacts. Additionally, the resilience of wind energy might increase in the future. However, in the energy sector hydropower plants remain highly vulnerable to increasing droughts.

In addition to the RAAP, the **8th National Communication (NC) to the UNFCCC** also includes a vulnerability assessment of the different regions (Ministry of Environment and Energy 2022). Here, the region's highest vulnerability is found in the general water supply sector, followed by the sectors of agriculture and forests. Since the preceding report in 2018, the vulnerability of health and fisheries has increased.

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The concluding impact assessment in the RAAP combines climate parameters and vulnerability to determine the overall risk of each activity field in the different sectors. Hereby risk is calculated as the sum of the individual risk of each climate parameter and is ranked on a 5-point scale from negligible (0), small (1) to extreme (4). The assessment covers two scenarios and two time periods, and the overall risk is differentiated by geographical area, time period and scenario. This analysis builds the foundation for identifying specific adaptation measures and **prioritizing according to immediate and long-term impacts**.

Concerning **topics of priority** up to mid-century, the report highlights primary sector activities such as agriculture and forest systems as well as protected areas, wetlands and biodiversity. In terms of economic sectors, winter tourism is seen as very important. In addition, public health is emphasized, especially regarding the impact of climate change on vulnerable groups. Overall, water resources such as irrigation or water supply for various sectors are highlighted as a priority until mid-century. When assessing the long-term priorities (2071-2100), climate risks increase for most of the identified sectors at risk. Here, the impacts on the region's forest systems, agriculture and livestock, protected areas, water resources and health are highlighted. Medium and high long-term risks are also expected for fisheries and aquaculture, road, rail and secondary port transport, building infrastructure, the tourism sector and the terrestrial and aquatic environment. Other sectors such as mining, manufacturing, aerospace and energy are considered to be at low to medium risk in both the short and long term. In line with the priorities identified, the region highlights the climate risk of the agricultural sector and the variability of groundwater used for irrigation. The region also highlighted farmers and citizens as well as regional authorities and municipalities as highly vulnerable in the interview. People living in the mountainous areas of EMT largely depending on farming are particularly vulnerable as all economic activity in these regions is linked to agriculture and dairy production.

3.3.2.2 Comparison with ESPON data

The RAAP identified increasing temperatures, drought and heat waves to have a high impact on the primary sector, especially on agriculture and forestry, with forest fires posing a major threat to natural and human systems alike. Both slow-onset trends as well as extreme events affect natural systems and biodiversity. The population is highly vulnerable to heat waves, especially in urban areas. More frequent and intense extreme weather such as drought and flooding impact the built environment, i.e. housing and (critical) infrastructure as well as the population.

The ESPON CLIMATE dataset confirms this picture. As in the RAAP, the analysis differentiates between the six regions Drama, Evros, Rhodope, Xanthi, Kavala and Thasos but considers the last two jointly. Of the five climate-change related risks assessed within the ESPON project, the impacts of droughts on the primary sector, wildfires on the environment and heat stress on the population are identified as major threats in the baseline scenario (1981-2010). This is uniform across all regions, with overall risk levels higher than in the LSD SW Finland as well as the Twinning Region

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Normandy. EMT does not show higher levels of exposure or vulnerability compared to SW Finland and Normandy, but the assessed climate hazards drought, wildfires and heat occur with higher frequency and intensity in the region thus increasing the overall risk.

This picture solidifies when looking at the long-term future under RCP8.5. Drought, wildfires and heat remain highly relevant hazards and thus do the associated risks. Additionally, coastal flooding becomes extremely important in all regions but Drama, which has no access to the sea. In the long-term future, EMT should hence also consider adaptation towards increased coastal flooding which poses a severe threat to infrastructure, industry and the service sector.

3.3.2.3 Potential improvements for climate risk information

The RAAP includes an **in-depth assessment** of hazards, vulnerabilities and climate risks for the region. The climate risk assessment (CRA) follows the approach of the IPCC AR5 and includes two scenarios (RCP4.5 and RCP8.5) and considers medium- and long-term changes (2021-2050 and 2071-2100). The report incorporates specific considerations such as sensitivity, exposure, and adaptive capacity, in addition to aggregated factors like risk and vulnerability. Besides the clear presentation of the aspects, the assessment describes these factors as static over time. Therefore, the report does not address the variability over time, such as changes in adaptive capacity. The CRA showcases various long-term changes and extreme weather events. Furthermore, the methodological approach of the report provides transparency regarding existing uncertainties, data, and methodologies. The analysis benefits from a unique component of the CRA, highlighting the areas in which particular risks are most concentrated amongst the six subregions.

Apart from the above-mentioned profoundness of the assessment, the RAAP does not outline the impact chains in a transparent manner. In addition, vulnerable groups are partly considered, but the important distinction between different vulnerable groups is missing. While the existence of such groups is mentioned at several points in the assessment, it is not elaborated who these vulnerable groups are and how they were determined. It is also not specified which population groups are vulnerable to certain climate impacts, such as heat or flooding. To design adaptation measures in a way that is sensitive to the needs of particularly vulnerable people it is important to differentiate between climate impacts and identify who is vulnerable to which impacts. According to the regional partners one potentially vulnerable group is a large Muslim minority living in EMT which to a large extent lives in more mountainous areas and is mostly reliant on agricultural activities for income. Since these activities are particularly sensitive to climate change impacts, this population group can be highly vulnerable. However, further analysis is needed regarding vulnerable population groups in this region.

The assessment also lacks explicit consideration of maladaptation and its impacts. The report presents a profound assessment with a differentiated presentation of climate risks and impacts, thus providing a solid foundation for the adaptation process. However, the specific consideration of

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different vulnerable groups is essential in order to later define adaptation measures in a socially just manner.

3.3.3 Adaptation measures

3.3.3.1 Existing plans and measures

Important policy documents at national level

Greece's National Adaptation Strategy to Climate Change (NAS) was endorsed in 2016. Law 4414/2016 includes the formal endorsement of this strategy and defines the Ministry of Energy and Environment as the competent national authority for national climate adaptation policy (Ministry of Environment and Energy 2022). The strategy states as its core objectives, amongst others, the systematization and improvement of short- and long-term decision making for climate change adaptation, the establishment of a monitoring mechanism for the evaluation and review of adaptation policies and measures, and the linking of climate change adaptation with sustainable development through regional and local actions plans. Regarding the last objective, the NAS requires each of the 13 regional authorities to develop, implement and monitor a RAAP within seven years after the adoption of the NAS. The strategy also mentions the establishment of a National Climate Change Adaptation Committee, a formal coordination and advisory body for adaptation policy at the national level. In 2022 the new National Climate Law, covering both the transition to climate neutrality and adaptation to climate change came into force. According to this legislation, the NAS covers a period of at least ten years and will be evaluated at least every five years by the Ministry of Climate Crisis and Civil Protection.

Overall, the NAS constitutes an **overarching policy** document, defining goals, principles and guidelines for adaptation. However, the responsibility for planning and implementing adaptation measures is delegated to the regional authorities. National adaptation policy therefore does not follow a top-down approach, instead giving a central role to the regions in downscaling the guidance and priorities that are outlined in the NAS. For certain priority sectors (including agriculture, water resources, natural ecosystems and biodiversity) the national strategy suggests potential adaptation options as guidance for the regional authorities but does not assess the effectiveness or feasibility of individual adaptation measures. The selection, prioritisation and design of adaptation actions falls within the responsibility of regional authorities.

The NAS also details some of the content that each RAAP shall include, providing **detailed guidance for the regional authorities** in developing these plans. This includes the requirement to conduct an analysis on the regional level of trends of the main climate parameters for the short, mid-, and long-term for more than one climate scenario, an assessment of the vulnerability of specific sectors and/or geographical areas and the identification of priority sectors and geographical areas for action. In addition, the RAAPs should contain an examination of the potential actions included in

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the NAS based on the regional situation. Adaptation measures should be prioritized based on a cost-effectiveness analysis (Ministry of Environment and Energy 2022).

Concerning the **management and climate adaptation of water resources**, the national objectives in Greece are mostly based on various EU water-related directives which are sometimes supplemented with additional provisions. Important policy documents in this context are River Basin Management Plans (RBMP). The Regional Water Directorates in each of Greece's regions are responsible for the formulation and implementation of each of these plans, which are revised and updated every six years.

Overview of relevant policy documents at regional level

At the regional level of EMT, the **Regional Adaptation Action Plan** constitutes the central policy document for adaptation to the impacts of climate change. As already elaborated in section 3.3.2.1, this action plan contains a detailed assessment of climate impacts, risks and vulnerabilities, including the identification of geographical hotspots and priority sectors. The second part of the RAAP focuses on regional actions for climate change adaptation and lists 65 adaptation measures. The overall policy objectives of the RAAP are to strengthen the administrative capacity of relevant institutions and developing a system for monitoring the implementation of adaptation measures; the dissemination of knowledge and skills; and to strengthen resilience in the sectors that were identified as a priority.

The adaptation actions included in the RAAP have a particular **focus on infrastructure projects that have an immediate and medium-term effect** on reducing risks from hazardous situations, on studies aimed at improving the knowledge and understanding of climate impacts in the priority sectors, and on the application of information and communication technologies. Each of the 65 adaptation measures in the RAAP is described in a detailed manner and their cost-effectiveness is assessed. The description of individual measures contains the objective, implementing bodies, cost and funding source, timetable for implementation and other information.

Water-related risks play a large role in this list of adaptation measures and are addressed by a number of them. One of the main priority measures is the establishment of a regional Climate Change Observatory. It is supposed to enable the exchange and collaboration of various stakeholders, particularly regional and municipal authorities, as well as managers of protected areas and researchers. Also, through CCA an infrastructure should be created that supports regional authorities in implementing and monitoring measures and facilitates public communication.

Another main priority is the implementation of **adaptive measures directly related to extreme weather** events, predominantly flood risks and drought. The description of the Flood Risk Prevention and Management Measures comprise the planning, designing, and constructing of infrastructure and sets the focus on flood protection in highly vulnerable urban and peri-urban areas. Specific measures

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described include restoration projects in mountainous areas, fill removal projects, rehabilitation of existing infrastructures, and the management coastal agricultural areas. Other flood-related measures mentioned address the development of early warning systems, the updating of flood protection-related strategic plans, and specifically interventions for the protection of Lake Vistonida and Lake Ismarida from flooding. Although NbS, namely ecosystem-based adaptation measures to reduce the risk of loss and damage due to flooding, such as afforestation, wetland restoration, or dry polders, are partially included within the Flood Risk Prevention and Management measures, their potential implementation and the effectiveness in Flood Risk Management and the multiple provided co-benefits have not been acknowledged in detail (Mirli et al. 2022; Kourtis et al. 2022).

Drought is addressed with the planned update of the Water Scarcity and Drought Response Plan, which describes the creation of an integrated drought management study and measures to reduce drought-related risks. Drought is also reflected in the program for sustainable rural development based on vulnerability levels that must integrate climate change adaptation actions and are closely linked with climate change impacts on agriculture. Measures addressing the agricultural sector include an assessment of climate change impacts to existing crops and their vulnerabilities and the development of irrigation management and control tools that involve the assessment of existing irrigation efficiency, study of monitoring systems, and implementation of closed irrigation networks. Apart from flood and drought hazards, the risk of forest fires is addressed in the planned establishment of an early warning system for forest fire detection via remote-controlled aircraft, drones, and early-detection sensors.

Overall, the RAAP provides a very detailed and solid foundation for implementing adaptation measures in the region. The measures listed in this plan are well thought-out and assessed based on their effectiveness.

Two other important policy documents are the region's **River Basin Management Plans** (first version from 2009-2015; 1st updated version from 2016-2021). In these plans, surface and groundwater bodies were identified and characterized, reporting conditions and classifications of the potential of surface water bodies were reviewed, significant pressures and impacts assessed, and the progress of environmental objectives evaluated. The first updated version considered the implemented actions, acknowledged new implementation methodologies, and incorporated the measures and sub-actions of the National Strategy for Adaptation to Climate Change. The RBMPs play a significant role in adaptation efforts due to the data collection activities conducted. The collected high-quality data on water flow in general and flooding, in particular, can be used to prepare models that inform the design of adaptation measures.

Summary

While data on climate risk components is available and the ex-ante assessment of the predicted effectiveness and costs of proposed measures in the RAAP is relatively detailed, the existing

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regional adaptation scheme can be enhanced in several realms. Although highly **vulnerable groups** are mentioned in the plans, they are not clearly defined, thus increasing the uncertainty on how to consider the needs of vulnerable groups and design and plan adaptation measures accordingly. Furthermore, it is unclear whether vulnerable groups and their perspective was included in the design process and establishment of the RAAP.

Secondly, the RAAP lacks to acknowledge the **risk of maladaptation**, that is, "*Adaptation with negative consequences that increase the climate vulnerability of a system, sector or group, that shift vulnerability or exposure, or that erode sustainable development, now or in the future*" (Reckien et al. 2023). By identifying and addressing maladaptation risks, the plans can be optimized to avoid actions that might inadvertently exacerbate vulnerabilities or create new problems in the long term (Institute for European Energy and Climate Policy (IEECP) et al. 2023).

Thirdly, the **potential of NbS** for climate adaptation is not yet acknowledged in full terms, especially the contribution of ecosystem-based approaches to reduce flood risks. A study conducted in the EMT region found that NbS can especially benefit the water quality, however, the lacking consideration in respective measures is due to missing stakeholders' knowledge, funding shortages, and lack of mitigation hierarchy strategies (Mirli et al. 2022)

Furthermore, the findings of the conducted interviews reveal that gaps in the RAAP exist regarding the specific **implementation roadmap of the proposed adaptation measures** and the inclusion of different stakeholders in the planning, implementation, and continuation process.

3.3.3.2 Planned adaptation measures within RESIST

The activities planned by within RESIST **focus on the water sector** and are very data-driven. One planned adaptation measure is the development of an application that contains flood warning systems as well as information on water quality. Existing flood warning systems will be enhanced through the integration of machine learning and artificial intelligence in automated data analysis. Another line of activities includes the collection of data on costs and benefits of NbS. With the help of this data, a thorough CBA for NbS is planned. In addition, stakeholders will be informed about the benefits of NbS and involved in the co-creation of activities (see 3.3.4). More strategic work is planned in developing a roadmap for using NbS in flood retention, improvement of water quality through pollution reduction, and mitigation of water scarcity in irrigation.

For the implementation of adaptation measures in RESIST, the region has selected **two pilot sites**: the river basins of the Kosynthos and Laspias rivers. Both of these are peri-urban rivers of the city of Xanthi facing different challenges.

The **Kosynthos river** basin comprises an area of 240 km² with an extensive hydrological network of 88.9 km and a large average land slope of 60%. The entirety of this network will be part of the

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pilot. The river basin comprises a variety of land-uses, including agricultural and residential areas as well as forests. Previous flood events in the area have caused extensive damages to buildings and infrastructure. Due to climate change, the region is likely to experience more frequent and more intense flooding in the future.

The **Laspias river** is located in the Nestos basin, which comprises an area of 221.8 km². The area is mostly flat and characterised by intensive agricultural activity which is mainly irrigated by groundwater as well as some natural areas with low vegetation. The river basin includes two modified water bodies and is characterised by habitat fragmentation. It is subject to nitrate pollution and receives organic loads from a sanitary landfill, bio-waste treatment plant and industry. The main point sources of pollution are the municipal waste water treatment plant of Xanthi, the landfill and the industrial area of Xanthi. Main non-point sources of pollution in the watershed are agricultural run-off and several livestock units that dump their waste in the torrent. Hence, the 30 km long Laspias torrent is characterised as a Heavily Modified Water Body.

The area covered by the water districts under study is of high environmental importance due to the diversity of ecosystems (from mountainous to coastal), rich biodiversity, habitat coverage and transboundary rivers. The area includes five national parks and more than 20 Natura 2000 sites. While the Kosynthos river has been affected by flooding in the past and therefore provides an appropriate test site for flood protection measures, the Laspias river is more affected by drought issues and water pollution. The regional project team has worked with both of these river basins before and therefore has a detailed knowledge of the topography, water quality and water flow.

Challenges

The technical information, data, and expertise needed for the implementation of the planned adaptation activities in RESIST appear to be mostly available and existing gaps can be filled with data from regional authorities. However, it is essential to integrate a **social equity and gender-perspective** into this technical dimension of adaptation. This concerns both the data that is being used, especially when socio-economic data is relevant, and the specific design-decisions that are made based on the data. For example, if data sets are incomplete and do not include the particular vulnerabilities of certain population groups, adaptation solutions can be designed in a way that exacerbates existing inequalities. One of the challenges in this region will therefore be ensuring that all relevant perspectives and sources of information are included. The stakeholder engagement process will play a central role in this.

In contrast to the RAAP, the activities within RESIST have a clear focus on **NbS** and can help promote this type of adaptation measure in the region and beyond. At the moment, the common misconception persists that NbS are less effective or more expensive than other adaptation solutions. Lack of knowledge and expertise regarding the monetary and non-monetary benefits of NbS exacerbates this problem. Addressing this knowledge gap is therefore an important challenge

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in the region, shared with several other project regions. Another element that impedes the implementation of NbS is the lack of financial evaluation of these solutions. The CBA which will be conducted as part of this project can hopefully act as a catalyst for increasing the use of this type of adaptation solution.

A further challenge lies in finding **synergies between the NbS for adaptation and the management of national parks** and Natura 2000 sites in the region. These areas are under the management of the Natural Environment and Climate Change Agency and a common approach will be necessary to ensure long term success in their climate resilient management.

3.3.3.3 Support needed

Several areas and activities exist where support would be helpful in the planning, design, and implementation of adaptation measures and beyond:

- **Prioritisation and integrative planning.** adelphi can assist in ensuring that adaptive measures are being assessed in terms of their effectiveness and benefits in depth and that respective projects are implemented in an integrated and encompassing manner. Linking individual measures can create synergies and result in additional benefits that do not only apply to the planned adaptation objectives, but reach further beyond in terms of social co-benefits. The long-term efficiency of measures is thus increased.
- **Leading the pathway to transformative and innovative adaptation, by using digital tools and promoting NbS.** Through knowledge sharing and capacity building on social and digital innovation, RESIST can facilitate and foster the implementation of innovative and long-term solutions that address the root causes of vulnerability and climate risks, in contrast to incremental actions. Here, NbS offer entry points for co-benefits and synergies between and beyond solutions, such as measures that contribute to both flood and drought reduction and additionally provide climate mitigation benefits.
- **Avoiding maladaptation.** adelphi can provide expertise and assistance in conducting maladaptation screening to ensure that the adaptation measures do not inadvertently lead to negative consequences or exacerbate vulnerabilities. Through a robust screening process and ex-ante assessment of planned measures, potential risks and unintended impacts can be identified and mitigated, leading to more sustainable and climate-resilient outcomes.

3.3.4 Stakeholders and capacities

The RAAP mentions as one of its priority axes the “promotion and dissemination of knowledge and skills”, establishing the education of stakeholders and information transfer as an overarching goal. However, according to the regional project partners, the RAAP lacks detail on how to engage stakeholders and include them in the further process. RESIST plays a central role in addressing this

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shortcoming by establishing different formats of stakeholder interaction and engagement. One way the knowledge generated in these discussions will be utilised beyond the activities within RESIST is through an exchange with regional authorities. The feedback collected from stakeholders will directly feed into the implementation and evaluation of the RAAP.

Within the RESIST project, a number of activities are planned to engage different stakeholders. One of the main focus areas is raising the awareness of landowners and farmers in order to promote more sustainable water management practices. To increase the uptake of NbS, several events are planned to educate stakeholders on the true costs and benefits of NbS and on how to best design NbS in a way to minimise costs and maximise benefits. In addition, the development of information, guidance and participatory co-creation methods to increase stakeholder interest and motivation to invest in NbS for water retention is planned. For stakeholder engagement and co-creation, EMT employs the new method “Unified Stakeholders Needs Co-creation Process (AENEA)” which combines the agile methodology for software development with co-creation and stakeholder engagement methods (Koutalieris et al. 2023). AENEA is specifically suited for stakeholder engagement in research and innovation development projects.

To reach as many stakeholders as possible, the regional consortium plans to implement workshops, interviews and citizen science approaches. These aim at informing people about the RAAP and collecting information on their specific needs and concerns regarding climate change adaptation and how their lives and economic situation will be impacted be climate change. The regional consortium already has a strong relationship with several stakeholder groups, particularly within the field of civil protection. These relationships can provide a helpful distribution channel in order to provide relevant information to people affected by the impacts of climate change.

The region is currently developing a stakeholder engagement roadmap, with initial activities already planned and a first local hub workshop will be conducted at the end of January 2024. Stakeholders involve in this workshop will include scientists from the technical and geotechnical chamber of Greece, farmer associations which control irrigation systems, associations of aquaculture systems, relevant regional and municipal authorities, and central government bodies in charge of managing protected natural areas in the region. Additionally, an open invitation will be extended later to any interested citizen. The aim of the workshop is to define and assess factors affecting the use of NbS, such as awareness and knowledge about NbS, perceived effectiveness, cultural and social values, economic factors, policy and institutional framework, local environmental conditions, stakeholder engagement and participation, and technological advancements. The region will use the inputs to create a structured survey about stakeholders’ engagement and factors influencing the intention to use NbS in EMT.

With regard to potential opposing interests to climate adaptation, these do not seem to play a significant role in the region. While people may have a general scepticism towards governmental dialogue processes, they are normally not opposed to climate adaptation in general and see the

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need for action due to recent flooding and other extreme weather events. The regional consortium can also profit from the existence of a large group that is active in disaster protection and that can act as a multiplier for information and awareness raising around climate change impacts. Instead of showcasing the necessity of climate change adaptation itself, it seems more relevant for the success of this project to ensure stakeholders that the purpose is to discuss solutions with them and tailor them to their needs, not to impose measures they do not agree with. It will be essential to convince stakeholders that their input has real weight and will influence the design of adaptation measures.

Concerning stakeholder engagement, potentials for support by adelphi mainly concern additional input on relevant entities to include, with a special focus on ensuring vulnerable population groups and all genders are represented in the workshops and other formats. This way, their particular challenges and needs can be integrated in the design of adaptation measures. Furthermore, RESIST can support showcasing the benefits of NbS through visualization and digital tools such as the GDT.

In terms of **financial capacities**, the main source of funding for the region in the area of climate change adaptation are various EU funds, including LIFE, INTERREG, ERDF, ESF and Cohesion Fund. For the most part, this funding is deemed sufficient for the adaptation measures that are planned in the near future. Up to now, private funding has not played any significant role in adaptation in Greece. The same is true of public-private partnerships in adaptation financing, although the potential synergies in this kind of partnership are slowly being explored. Providing examples of private funding for adaptation measures can be of interest for the region to support this process.

The **institutional capacity** in the region has improved over the past decades and is now at a suitable level. However, constraints remain an issue in implementing important activities for adaptation. The establishment of a Climate Change Observatory, as stated in the RAAP, is impeded by a lack of resources. The regional administration is tasked with monitoring and implementation of the RAAP, which means a large additional administrative burden.

3.3.5 Results

River flooding and drought are main climate impacts in EMT, along with pollution and increased agriculture-related water insecurity (Table 10). Most affected by flooding are peri-urban populations, while drought, pollution and altered water cycles also heavily affect farmers. Planned activities are therefore targeted to reduced flood impacts as well as increase water security for agricultural purposes and reduce pollution.

Planned measures within RESIST focus on the water sector and are very data-driven. Pilot sites concern the basin areas of the Kosynthos and the Laspias river which are both affected by climate change but feature important differences in terms of their characteristics, main hazards and relevant impacts. To enable successful implementation of NbS, EMT will acquire regionally relevant information for various stakeholders on the immediate and co-benefits of nature-based measures

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and the potential of savings they provide over time versus other investments. In this context, EMT can rely on knowledge transfer on CBA approaches from other regions. Making this empirical evidence available and visualizing the benefits of NbS i.a. through the GDT can increase acceptance and thus promote uptake and upscaling of NbS. Additionally, EMT is working on AI-based tools with the support of Earth Observation (EO). After gathering EO data and indices for basins and employing High-Performance Computing, a Data Lake will be designed to integrate, process, and exploit EO and hydrological data to provide flood warnings and information on water quality and thus increase the region's adaptive capacity. Relevant stakeholders in the EMT region include residents and landowning farmers as well as regional authorities and businesses.

Table 10: Climate impacts, planned adaptation measures and relevant stakeholders in EMT.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
River flooding	Peri-urban population Farmers	**Kosynthos** river basin: minimize flood events through NbS	Residents Farmers Municipalities Regional authority
Drought **Pollution from various sources**	Peri-urban population Xanthi's industrial commerce Farmers	**Laspias** river basin: minimize surface water pollution through NbS	Residents Farmers Industrial businesses Municipalities (Xanthi's municipal wastewater treatment plant) Regional authority
River flooding **Drought** **Irrigation water scarcity**	Farmers	Develop flood warning: integrating machine learning and AI in automatic data analysis to identify and categorize hydrological trends and facilitate accurate and timely predictions of potential flood events	Residents Farmers Local businesses Municipalities Regional authority

Challenges and support

There is a range of challenges in the EMT region that impede planning and implementation (Table 11). At the current planning status, the largest need is to integrate dimensions of vulnerability, such as gender and socio-economic status, in the layout of the measures at the demonstration sites, and to design stakeholder engagement processes in an inclusive and collaborative way. When plans

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have evolved further, the measures should be checked for possible negative side effects and the potential of maladaptation. Furthermore, prevailing misconceptions regarding NbS have to be tackled, and evaluation and monitoring frameworks and financing instruments are needed, such as for ex-ante assessment of measures to avoid maladaptation.

adelphi can support the region in facilitating stakeholder consultations; identifying and addressing the needs of highly vulnerable groups and incorporate a gender perspective into adaptation actions; effectively prioritizing measures and ensuring an integrative planning process; enabling the use and development of innovative and transformative solutions; contributing to the avoidance of maladaptive practices; and monitoring and evaluating implemented measures. Furthermore, the EMT region can benefit from the transfer of best practices examples and knowledge exchange with SW Finland, Central Denmark and Normandy. An implemented CBA for NbS in SW Finland can serve as a good practice example for this type of analysis.

Table 11: Challenges, needs and support opportunities in EMT.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Integrating a social equity and gender perspective into technical dimension (data and specific design decision) **Enhancing a comprehensive risk understanding**	Mapping of needs and interests of stakeholders Guidelines for inclusive stakeholder engagement; design of formats Best practice exchange on citizen engagement	
Prevailing misconceptions of NbS hindering transformative and innovative adaptation	Communication toolkit and product to showcase benefits of NbS for adaptation and beyond (together with REVOLVE) Support realising the full potential of the GDT (together with AugmentCity)	
Lack of financial evaluation of adaptation solutions	Compilation of best practice, tools and guidelines for CBA	Best practice CBA approaches from Central Denmark, SW Finland
Finding synergies between NbS for adaptation and the management of national parks and Natura 2000 Sites		Exchange with Normandy
Ex-ante evaluation of measures concerning avoidance of maladaptation	Assistance to use self-assessment REGILIENCE tool / Workshop on screening for maladaptation	

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Developing an evaluation and monitoring framework	Support in the development of a monitoring framework (together with KU Leuven)	

Potentials for transfer

There are several ways in which the EMT region can support other regions (Table 12). The regional partners are involved in another cross-European project (OneAquaHealth) and offered to transfer potentially relevant insights gained in this project to other RESIST regions. Furthermore, data and used algorithms and programme code, e.g. for statistical analysis, are transferrable through open source libraries and licenses. Algorithms will be tested for the EMT region and might subsequently be applied to other regions. This transferability will be targeted through the development of a universal approach, but its applicability remains context specific**.**

Table 12: Expertise and transfer potentials in EMT.

Strengths and expertise	Topics of interest	Transfer with other regions
Support in decision-making and monitoring freshwater ecosystems in urban environments	Investigate the interconnection of ecosystem health and human wellbeing Improve sustainability and integrity of ecosystems	Share results from OneAquaHealth project
Hydrological numerical modelling		Share modelling expertise with e.g. Normandy
Leveraging Python, Power BI, and advanced AI algorithms, for data visualization and predictive analytics/early warning		Give introduction to and exchange on AI methods
AENEA method for co-creation with stakeholders		Share experiences with this new method
	Designing suitable NbS to address water resilience in urban and rural areas, including drought in agricultural area	
	Planning water and climate resilience at the level of the catchment	
	Synergies with nature conservation/NATURA 2000 reserve areas	Exchange with SW Finland

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Going beyond RESIST

The greatest challenge to creating more systemic solutions is bridging the gap between existing individual measures and establishing a long-term cross-sectoral adaptation strategy. Impulses from the co-creation processes and the results of the CBA can provide a momentum for upscaling solutions but institutional and policy innovations are needed to allow for more profound transformations: With the RAAP, an in-depth roadmap to the implementation of various adaptation measures is already in place. Furthermore, the River Basin Management Plans can contribute to the design of actions by data provision. However, despite the solid and profound creation of regional adaptation measures and its assessment in the RAAP, the existing plans fall short in some aspects which are deemed critical for the establishment of a socially just and long-term adaptation scheme. This concerns the inadequate acknowledgement and inclusion of highly vulnerable groups, missing consideration of maladaptation risks, lacking priority to NbS, and an unclear implementation roadmap and time schedule. The findings and measures developed within RESIST and the knowledge exchange with other regions can create a substantial benefit in ensuring an integrated, socially just, and efficacious adaptation design, but would necessitate further integration into regional frameworks and policies to realise its full potential.

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3.4 Needs assessment Central Denmark

3.4.1 Introduction

As stated in the RESIST proposal, Denmark is a high-income country and is administratively divided into five regions of which Central Denmark Region (CDR) administers the central part of the Jutland peninsula with 1,300,000 inhabitants (23% of Denmark's population). The CDR encompasses a variety of landscapes, including coastal areas, forests, and agricultural lands. The region is home to Denmark's second-largest city, Aarhus, as well as numerous smaller towns and rural communities. This geographical diversity poses various climate risks, including flooding along the coastal areas and potential drought or heat-related issues in the more inland-oriented agricultural zones. The region's urban centres, such as Aarhus and Randers, might also face unique climate challenges related to heat islands and stormwater management.

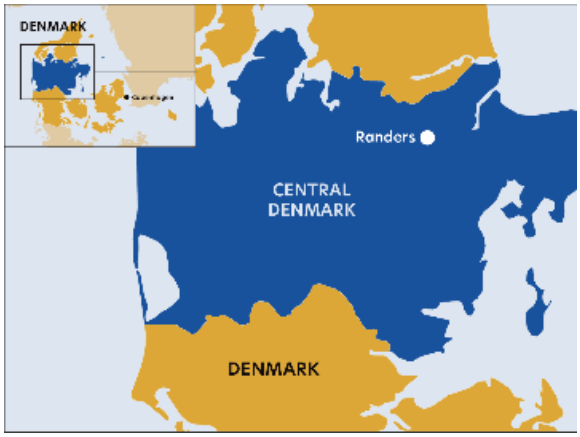

Figure 6: Location of Central Denmark.

As for climate, the CDR experiences a temperate oceanic climate, characterized by moderate temperatures, with cool summers and mild winters, and relatively high precipitation throughout the year. Given the region's proximity to the sea, it is particularly susceptible to SLR and coastal flooding, which are expected to be exacerbated by climate change. Changes in precipitation patterns could also impact agricultural productivity and water management in the region. Furthermore, the presence of culturally significant sites and infrastructure in areas at risk of flooding, such as Randers, adds another layer of complexity to the region's climate risks.

The Central Denmark demonstration activities focus on four main areas, implemented across four municipalities (Lemvig Municipality, Hedensted Municipality, Horsens Municipality, and Randers Municipality):

1. The first area involves the construction of a dense network of Internet of Things (IoT) data loggers for groundwater level measurement in coastal towns and urban areas, and the construction of demonstration buildings that can resist flooding. This includes the introduction of three multi-functional infrastructures for flood prevention.
2. The second focus is on decision-support systems, including the creation of local Extended Reality (XR) visualizations and a warning system app developed through machine learning and IoT data.

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3. In order to further develop the “BEST Adapt” tool, which supports prioritization of Climate Change Adaptation (CCA) investments, data from three additional flood sources will be added, along with a recreational value of these investments.
4. The final component includes the transfer of best practices. This will entail assessing the governance system, analysing the regulatory framework, and identifying mechanisms that accelerate CCA implementation. A handbook for CCA officials will be developed to accelerate local CCA in the EU, with plans to upscale results across the region.

3.4.2 Climate risks

Notably, no climate risk assessment (CRA) exists on the regional level for Central Denmark. Denmark’s national level strategies and policy papers related to climate adaptation, e.g. “Danish strategy for adaptation to a changing climate” 2008 (The Danish Government 2008) or the “Mapping climate change” – background report (Danish Nature Agency 2012) do identify climate risks, but also lack regional specifications on climate risks, making it hard to apply findings directly to the Central Denmark Region. Therefore, the focus of CRA and management falls on municipalities, which are required to develop their own plans.

3.4.2.1 Municipal climate risk assessments

In 2013, all municipalities in Denmark were mandated to produce municipal climate adaptation action plans. These plans were meant to specifically include risk mapping for flooding, as it presents a hazard of significant concern due to Denmark's geographical location, mostly flat topography and climate conditions. This municipal obligation has been supported in 2020 by a nationwide risk assessment in the form of the “Kystplanlægger“-webportal (Kystdirektoratet 2020), which was published by the Danish Coastal Authority. It presents mapping of risks from floods and coastal erosion along the entire coastline for the years 2020, 2070 and 2120 and provides recommendations for municipal planning authorities on risk reduction and coastal protection for every coastal unit (see Figure 7). In general, municipal risk assessments mainly – or even exclusively – focus on flood risk management, but not on assessing a broader range of climate risks. This strong focus on flooding and sea-level rise (SLR) is a common theme throughout Denmark’s climate adaptation related strategies and policy papers on different political levels (see chapter 3.4.3.1). There is less emphasis on other climate hazards such as heat and drought, leading to a potential information gap for some municipalities. Although expert interviews with regional partners revealed an increasing awareness of heat and drought as new and emerging challenges, the existing lack of data for such risks may limit risk assessments to simply mapping areas at risks from heat and drought.

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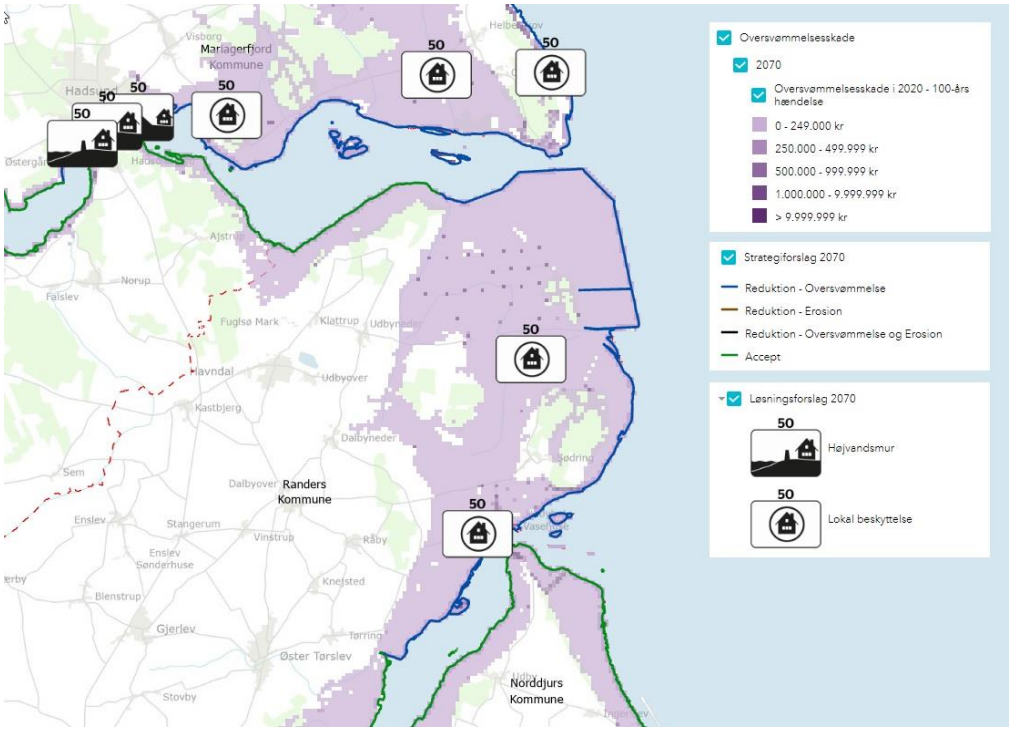

Figure 7: "Kystplanlægger" webportal mapping risk from flood and erosion and providing recommendations.

In the Central Denmark Region, municipal CRAs for three RESIST pilot areas are pertinent. Each of these assessments focuses on specific areas within the region, addressing local climate risks and providing strategies for mitigation and adaptation.

The RESIST pilot municipality "Randers City" developed a flood risk assessment for the period 2021-2027 (Oversvømmelsesdirektivet 2021) based on two different climate scenarios: a 100-year flood event in 2019, and a 100-year flood event projected for the year 2115. The assessment showed that the city centre of Randers City is most vulnerable to flooding, with an estimated 200 properties significantly impacted. Critical points include environmentally harmful companies and cultural heritage sites. Based on these findings, the municipality has developed plans to reduce flood impacts, avoid damage to properties, and prevent future floods.

The second RESIST pilot area "Juelsminde" published a "Reassessment and update of the flood risk assessment plan" (Oversvømmelsesdirektivet 2021b) for the same period 2021-2017, also referring to 100-year storm surge events in 2019, 2065 and 2115 as well as low, medium and high probability scenarios of flooding, as used in the initial plan. The reassessment showed that the pre-developed plan has met its goals of protecting the city against flood events, but recommends to implement measures that secure the city's safeguarding up to higher water levels than is currently the case: instead of protection up until water levels of 1.80 m (currently), future measures should ensure protection against water levels of up to 2.50 m, and on a more long-term perspective even

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be prepared for water levels up to 2.88 m/3.05 m. Accordingly, the Juelsminde reassessment plan clearly refers to the increasing threat of SLR in Central Denmark.

It becomes clear that none of these municipal risk assessments address climate risks on a broader scale and also do not recommend to do so in future reassessments, but continue to follow the dominant focus on flood risks. However, some municipalities have extended, at least, their climate adaptation plans to include other climate-related issues such as heat and drought, e.g. Hedensted Municipality's "Climate Plan 2050" from 2022 (Hedensted Kommune 2022). These climate adaptation plans are part of the Climate Adaptation Planning (CAP) Framework developed by the C40 Cities Leadership Group. Nevertheless, there is limited data available for heat and droughts (i.e. not enough high-quality data for a comprehensive cost-benefit analysis for heat risks). Therefore, municipal risk assessments continue to focus on mapping areas at risk from heat or drought.

3.4.2.2 Comparison with risks according to the ESPON-CLIMATE dataset

Since no CRA exists for Central Denmark Region, the ESPON-CLIMATE dataset is a valuable supplementary source of information on regional climate risks (see chapter 2.2.3). For the baseline scenario (1981-2010), ESPON identifies the effects of drought risks in the primary sector to be the most significant risk. These drought-related risks occur on a medium risk level and are expected to stay at that same level under the RCP8.5 scenario (2070-2100). This risk impact chain appears widely unconsidered among the existing CRAs in Denmark and thus may represent a considerable information gap that needs specific attention as an additional priority area in future risk assessments, especially on the municipal level.

Furthermore, the ESPON dataset reveals several flood-related risk impact chains for Central Denmark. The highest flood-risks in the baseline scenario (1981-2010) come from river floods affecting the population and from flash floods affecting the cultural sector, followed by risks from river floods affecting infrastructure, industry and the service sector. All these flood-related risks are expected to increase to a medium or slightly higher risk level under the RCP8.5 scenario. An outstanding role is played by coastal floods and their impacts on infrastructure, industry and service sectors. Coastal floods show the strongest increase in risk between the baseline scenario and the RCP8.5 scenario. Coastal floods are currently on a comparatively low risk level (baseline scenario), but are expected to escalate to an extent in the future (RCP8.5 scenario, 2070-2100) so that they exceed the medium risk level and even surpass all other impact chains. The currently dominant focus on flood-related risks throughout Denmark's national policy papers and municipal action plans and risk assessments well reflects the increasing climate risks that have also been identified in this area by ESPON. However, one should highlight again that risks related to drought (on the primary sector) and heat stress (on the population) will exceed medium risk levels as well and need to be considered accordingly in Denmark's landscape of risk assessments.

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While referring to ESPON data, one should note that the aggregated risk indicators used only partly contain projected data for the future, but mostly rely on historical data (see chapter 2.2.3) and thus might contain incorrect assumptions.

Summarizing the different perspectives on assessing climate risks in the Central Denmark Region, one can note that the municipal risk assessments (as described in chapter 3.4.2.1) are mostly in alignment with the ESPON dataset. ESPON expects increasing risks from all types of floods in the Central Denmark Region and Danish municipalities put great effort into getting prepared for these scenarios and assessing flood risks accordingly. But where ESPON data and the current way of undertaking municipal risk assessments diverge strongly, is the aspect of drought stress (on the primary sector) and heat stress (on the population). These climate risks are expected to become significant – or even the most pressing – regional risks in the future. However, current risk assessments approach in Denmark and its municipalities fall short of integrating these climate risks. Interviews revealed an increasing awareness about this information gap.

3.4.3 Adaptation measures

3.4.3.1 Existing plans and measures

Important policy documents at national level

Denmark does not have a National Climate Adaptation Plan currently, but various stakeholders expect such a guiding policy paper to be formulated by the Danish government in the near future. An outline was published in the last quarter of 2023 and includes the issue of shallow groundwater, which aligns with the CDM activities. Currently, the political dialogue seems to have started to push the process forward. A "**Danish Strategy for Adaptation to Changing Climate**" (The Danish Government 2008) has been formulated, which identifies various climate hazards under three different climate scenarios (A2, B2 and EU2C) nationwide until mid-century and end of century and respective vulnerabilities and possible measures in 11 significantly affected key sectors (coastal management, buildings and infrastructure, water supply, energy supply, agriculture and forestry, fisheries, nature management, land use planning, health, rescue preparedness and insurance aspects). The strategy sets three main objectives which represent rather soft measures: 1) an information campaign including a web portal (for climate change integration into planning and development), 2) a (climate) research strategy as well as 3) an organizational framework including horizontal coordination among public authorities.

The national assessment report "**Mapping Climate Change – Barriers and Opportunities for Action**" (Danish Nature Agency 2012) presents the most important positive and negative impacts of climate change in Denmark for 14 different areas (housing and infrastructure, coasts and ports, transport, water, agriculture, forestry, fisheries, energy, tourism, nature, human health, emergency preparedness, insurance, spatial planning). For all mentioned areas, it provides an overview of adaptation possibilities, bodies of responsibilities, ongoing and completed initiatives as well as

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barriers and opportunities for adaptation. It also puts emphasis on the importance of a socio-economic analysis on climate adaptation that reveals its cost-benefit-dynamics.

Based on these policy papers, the "**Action Plan for a climate proof Denmark**" (The Danish Government 2012) presents 64 concrete initiatives that should support implementation of Denmark's climate adaptation efforts. These initiatives are grounded in five general areas: 1) improving the climate adaptation framework; 2) expanding consultation and developing a new knowledge base; 3) strengthening collaboration and coordination; 4) advancing the green transition and 5) adapting to climate change at the international level. In this national action plan, Denmark's municipalities are mandated to prepare both municipal climate change adaptation plans (including municipal wastewater utilities' flood risk assessments under A1B climate scenario) and to carry out risk assessments, which must assess flood risks specifically (based on nationwide blue-spot maps (i.e. road infrastructure vulnerable to flooding) provided by the Ministry of Environment). So here it becomes clear again that Denmark's landscape of policy documents sets a clear focus on flood risks in the country's strategic climate adaptation efforts.

Overview of relevant policy documents at regional level

Regional level climate policies and strategies have been published under the project C2C CC ("**Coast to Coast Climate Challenge**"), which lasted for a duration of 6 years between 2017 and 2022 and has been managed by the Central Denmark Region. The "Common Strategy & After LIFE plan" (Coast to Coast Climate Challenge (C2CCC) 2022) is a publication on behalf of all 31 project partners, including 18 municipalities, 3 knowledge institutions and several private organisations, that collected regional experiences related to climate adaptation and formulates 1) main principles for guiding future efforts in climate adaptation, 2) a reflection of the future adaptation agenda with a collection of themes that are expected to characterize future adaptation, 3) next steps for 24 sub-projects (mainly in the Central Denmark Region) spanning the whole water cycle, as well as 4) an action plan called "After LIFE", which comprises a selection of projects stemming from the C2C CC project on an international, national, regional and local level and further details on e.g. time planning and the status of initiation. The C2C CC sub-projects are further detailed in the so-called "Layman's report" (Coast to Coast Climate Challenge (C2CCC) 2022), including tool development for municipalities, groundwater management, innovation rainwater usage, dialogue between local stakeholders, joint municipal risk assessment and management etc.

Additional projects which plan or implement adaptation measures in the Central Denmark Region – and are directly connected to the C2C CC project mostly – include the following: "BioScape" (improving Biodiversity in the landScape) is a project that aims improving the government's pilot programme for multifunctional land consolidation, which includes Horsens, Lemvig and Hedensted as municipal partners among others, and which includes adaptation measures e.g. delaying water in the hinterland, re-meandering streams and reducing flooding, combined with strengthening biodiversity. "Blue Transition" is another project in the region and in parts focuses on holistic water management, protection of groundwater resources, on salt water intrusion and the interaction

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between SLR and shallow groundwater. “ENCORE” (Environmental Conference of the Regions of Europe) is a project that focuses on the outstanding role of regions and focuses on creating a dialogue among EU regions and with relevant EU directorates on environmental and sustainability issues and climate action. Another very relevant project has not yet started and remains in the proposal phase until 2024: “LIFE SIP” aims at elevating and promoting the actual implementation of all Danish municipalities’ DK2020 Climate Plans on both mitigation and adaptation and to create a broad network for knowledge exchange.

Looking at this set of policy documents as well as existing projects and their respectively formulated adaptation measures, one can note a few important aspects that are worth being considered while conceptualizing climate adaptation efforts and measures, are actually missing. A gender-sensitive or vulnerable groups-sensitive approach to climate adaptation is currently not present in Denmark’s adaptation efforts. Social equity topics in general seem rather unaddressed in the identified documents. Also, projects and the integration and consideration of Nature-based Solutions (NbS) appears selective rather than across the board. Potential maladaptation cannot be excluded e.g. due to the rather narrow focus of Denmark’s adaptation efforts on flood-related risks, instead of a broader spectrum of climate risks.

3.4.3.2 Planned adaptation measures within RESIST

The measures within RESIST in Central Denmark are set to take part in several locations, including Lemvig Municipality, Hedensted Municipality, Horsens Municipality, and Randers Municipality. The final pilot locations and activities in each of these municipalities are currently in the process to be clarified. The project's main focus is on water-related risks such as SLR, saltwater intrusion, and interaction between shallow groundwater and rising sea levels.

A key part of the RESIST project is to build demonstration houses close to the water. The goal here is to explore different construction techniques that result in flood-resistant infrastructures and to advocate for such building techniques amongst the construction sector and individual owners. Two types of houses will be demonstrated: houses that are placed “on water” and houses that are close to water.

The project also plans to use Machine Learning (ML) in order to track shallow groundwater logging. This system could serve as an early warning mechanism against the impacts of rising sea levels on groundwater (i.e. rising groundwater levels as an additional flood source and saltwater intrusion). The Danish municipalities of Horsens and Lemvig have already implemented the IoT technology for logging groundwater levels. The primary focus in Horsens has been on monitoring the intrusion of saltwater into the freshwater supply, a significant concern with the rising sea levels due to climate change. In Lemvig, continuous logging of groundwater levels has also been carried out, with an existing project set to be continued and expanded. A phenomenon of particular interest is the response time between rising seawater levels and corresponding groundwater levels in unidentified inland areas. Detailed analysis of this data could help in predicting potential impacts of seawater

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level fluctuations and plan appropriate responses. In the coastal municipality Hedensted, there are plans to set up new loggers in an area protected by a dike. The primary goal here is to monitor how SLR affects the area behind the dike, providing invaluable data for future coastal management strategies and climate change adaptation measures.

Additionally, the RESIST project plans to have a test site for the “BEST Adapt” tool that was developed prior to the RESIST project and initially focused on pluvial flooding only. Recognizing the need for a more comprehensive tool, it was subsequently expanded to also account for other flood sources including rivers, the sea, and rising groundwater. The tool is capable of calculating damage costs and defining needed services - essentially determining the most economically beneficial level of protection against flooding. This earlier version of the tool was developed in accordance with Danish regulations and primarily used available data based on housing prices. However, it did not account for the recreational value of areas. With the RESIST project, plans are underway to integrate these additional factors into the tool, for instance, to account for the positive impacts of a park on local house prices. Additionally, RESIST aims at determining what data is crucial for the tool to function optimally. However, it is important to note that the tool is proprietary software and its transferability to other regions or countries might be challenging due to differences in economic factors such as housing prices. Furthermore, the effectiveness of the tool may be dependent on the availability of high-quality, freely accessible data in other regions.

Finally, the implementation of XR technology for educational purposes is planned, providing an immersive and interactive method for visually interpreting the threats of rising sea levels and other water-related hazards. The utilization of XR is to ensure that CCA plans and benefits are better understood by everyone, including politicians and citizens. This tool promises to be instrumental in persuading a variety of stakeholders to respond proactively to climate change consequences. It is still uncertain as to the specific areas where this XR simulation would be primarily used, whether in infrastructural development or in NbS. However, it is clear that the XR system will establish a nexus with other WP, for instance, the governance WP. The focus of planned visualisations will be defined in dialogue with municipalities in the upcoming month. Regional partners have also highlighted the importance for exploring synergies and linking the efforts with Augment City on the Digital Twin approach.

As stated earlier, NbS are not widely featured in adaptation plans. While they have potential to provide resilient and sustainable solutions, it is crucial to ensure that they respond to climate justice criteria, maintaining fairness and equity in adaptation efforts. Showcasing NbS in RESIST’s XR activities without this validation could propagate a misleading narrative, potentially leading to misplaced resources and efforts, increasing the risk of maladaptation. It therefore might be important to consider these aspects when choosing specific NbS for XR demonstrations in RESIST and ensure that adaptation efforts consider a comprehensive range of climate risks, that data gaps are addressed, and that the fairness of solutions such as NbS is proven before they are widely promoted or implemented.

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Some municipalities have begun to address vulnerable groups in their CCA plans, particularly in relation to heat. Due to the comprehensive data in Denmark, it has been quite successful in mitigating risks and reducing the relevance of the demographic composition of specific areas. Nevertheless, the question of how to effectively communicate and inform different populations, such as elderly people or non-Danish speakers, remains a significant consideration and a topic of ongoing discussion.

As part of the demonstrator, the RESIST partners plan to conduct interviews to understand what it is like to live in a vulnerable area. Specifically, they want to know how different groups respond when they experience threats from climate change. They anticipate diverse responses based on various factors like age, language proficiency, socio-economic status, etc.

3.4.4 Stakeholders and community engagement

A needs assessment has been conducted for the RESIST project, identifying both the primary partners involved and the potential stakeholders who could contribute in various capacities. The main partners of the project are municipalities, which participate to varying degrees at different levels. However, their specific involvement in each of the four main activity areas of the project needs further clarification. So does the potential for their involvement in workshops and other co-creation and capacity-building activities if they are not directly part of the project.

Five distinct stakeholder groups have been identified, each contributing in different capacities:

- **Media, Cultural NGOs, and Civil Society**, including Klimatorium (directly involved in demonstration houses), CONCITO, DNNK: National Network for Climate Adaptation, and the network of stakeholders from the EU-LIFE project C2CCC. These stakeholders play a crucial role in data collection, as well as in increasing the visibility of the project. Therefore, the stakeholders that are not directly involved in the project are the ones that the project partners have established contacts to through previous collaborations.
- **Governance and Policy-Makers**, like the CDEU (Central Denmark EU Office), KL (Local Government Denmark), and the Danish Regions. These stakeholders are not directly involved into the project and according to regional partners might need to be convinced to participate in some activities. Therefore, one of the project activities directly addresses governance aspects.
- **Research and Academic institutions**, featuring Aarhus University, VIA University College, and the Danish Technological Institute.
- **Municipal Stakeholders** include Lemving Municipality, Norddjurs Municipality, Randers Municipality, Hedensted Municipality, and Horsens Municipality.
- **The Private Sector** primarily includes water tech and utility service companies. The project is also considering involving small tech companies in the demo houses. These stakeholders will become more concrete in the upcoming month of the project.

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Currently, the strategy to engage these stakeholders and to ensure their commitment is still in the ideation phase. However, it should be noted that a positive dialogue with many of these stakeholders has already been established. This is primarily due to existing relationships forged through prior projects and contact, leading to a foundation of mutual trust which could be leveraged in the current project.

No stakeholders with conflicting interests have been identified during the needs assessment. While the project has a varied assortment of partners, regional stakeholders have highlighted the necessity for national and regional decision-making bodies to be involved in strategic alignment and planning for CCA. At present, this doesn't represent an urgent requirement but is projected to gain significance with time.

A potential challenge lies in securing buy-in from decision-makers, a critical factor for successful governance dialogue. It is essential not only to ensure their participation in specific project activities but also to ensure broad outreach at the national and regional level. Encouragingly, groundwork has been laid at the national level, and a critical mass of stakeholders with aligned interests is currently applying pressure on the governmental structures. Despite these positive steps, ambiguity persists regarding the timeline for the development of a national CCA plan, as political negotiations have not started yet.

Furthermore, a notable gap exists in the current project structure: vulnerable and gender groups have not been factored in, a shortcoming attributed to the absence of a suitable mechanism for this in Denmark. As the project proceeds, developing a strategy for considering and involving these stakeholders will be important.

Among stakeholder groups, many are not directly involved in the project but share common interests and objectives. Their motivation is apparent, yet it is imperative to confirm their commitment to specific activities and pilots. This foundational trust will be instrumental in the successful implementation of the current project.

3.4.5 Capacity and capacity constraints

Regional partners emphasized that funding of adaptation measures is among the biggest constraints at the moment. Channelling funds into projects is therefore considered a challenge. For the moment, the following resources and programmes have been identified as accessible:

Table 13: Accessible financing options for Central Denmark.

	Resources / programmes	Financed projects include
EU level	LIFE LIFE (S)IP Horizon Europe Interreg	https://www.c2ccc.eu/ http://www.life-bioscape.eu/ https://www.interregnorthsea.eu/blue-transition https://northsearegion.eu/c5a/about/

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		https://northsearegion.eu/topsoil/ https://resist-project.eu
	Danish Board of Business Development European Regional Development Fund European Social Fund	https://lighthousewatertech.dk/
	European Investment Bank	Currently, there is a dialogue on loans for municipalities to implement large-scale solutions
National	Innovation Fund Denmark	https://redoco2.net/
	Aage V Jensens Charity Foundation	Cascading funds for http://www.life-bioscape.eu/ on nature and recreational actions

There is a need for increased public financing to address climate change adaptation, alongside incentivizing investment from the private sector. The CBA tool “BEST adapt” should form the basis for overcoming general reservations about adaptation measures by also including their recreational value and promoting the wider uptake of these solutions. However, more incentives for innovative methods of finance should be explored.

The matters of organisational and institutional capacities will in part be addressed by the regional partners in the forthcoming municipal surveys and RESIST workshops. It must be noted that some of the planned activities, like getting stakeholders involved, further developing the costs-benefit analysis, and using visualisation tools to spread the word about NbS can help improve the ability to adapt by raising awareness and expanding knowledge.

Regional partners perceive coordination as a challenge. The absence of a regional CCA plan makes it harder to align strategies, creating a disconnect between the regional and national level. However, this situation also provides municipalities with a certain degree of autonomy, which they may perceive as a positive aspect. At the same time, in regions with large catchment areas, municipalities are taking the initiative to collaborate and coordinate. They are, for instance, setting up shared secretariats to manage the water catchment area, where CCA is part of a wider complex approach.

3.4.6 Results

Coastal, river and pluvial flooding are main climate impacts in CDM, along with sea-level rise and salt-water intrusion (Table 14). Most affected by flooding are flood plains populations, while sea-level rise and salt-water intrusion also heavily affect coastal populations. Planned activities are therefore targeted to reduced flood impacts by building flood-resistant demonstration houses and developing tools for groundwater level monitoring, as well as calculating damage costs and benefits of adaptation services.

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Planned measures within RESIST focus on the construction and water sectors and are data-driven. Pilot sites for demonstration of flood-resistant houses close to water will be located in either Lemvig, Hedensted, Horsens or Randers municipality. To enable uptake the rest of the municipalities will also be reached out to, including a variety of stakeholders, such as construction sector, decision-makers, and residents as well as house/land owners. Machine learning (ML) that already exists in Lemvig and Horsens and focuses on tracking shallow groundwater logging will also be applied in Hedensted municipality. Finally, a CBA tool "BEST Adapt" for calculating damage costs and defining needed services will be implemented by year 2026. Additionally, CDM is working on XR tools to visualize flood impacts in artificial reality and use it to convince relevant stakeholders mentioned above.

Table 14: Climate impacts, planned adaptation measures and relevant stakeholders in Central Denmark.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Sea-level rise **Salt-water intrusion**	Coastal population	Build flood-resistant demonstration houses close to the water; in either Lemvig, Hedensted, Horsens or Randers Municipality Machine learning (ML) in order to track shallow groundwater logging; already existing in Lemvig and Horsens, further plans in **Hedensted**	Residents (Owners) Municipalities Construction sector
Coastal flooding **River Flooding** **Pluvial Flooding**	Population in flood plains	Build flood-resistant demonstration houses close to the water; in either Lemvig, Hedensted, Horsens or Randers Municipality Implement "BEST Adapt" tool for calculating damage costs and defining needed services	Residents (Owners) Municipalities Construction sector

Further relevant climate impacts in the region that are not addressed within RESIST include heatwaves, especially in urban centres like Aarhus and Randers, and drought, with high risks in the agricultural sector.

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Challenges and support

Major challenges evolve around coordination and alignment of adaptation efforts in the region, ensuring inclusive and collaborative stakeholder engagement for comprehensive climate-risk communication, integrating NbS approach into adaptation planning and identifying further funding opportunities (Table 15). Considerations include how to organize and manage stakeholder engagement for an inclusive, collaborative process, especially on different levels of governance and communicate the results of the CBA beyond the pilot projects. By integrating these questions into the current planning stage, several constraints such as the need to convince decision-makers at various levels of governance, limited knowledge, and reluctance towards financing can be addressed. Furthermore, CRM can benefit from integration of social equity and gender perspective into technical dimension.

Table 15: Challenges, needs and support opportunities in Central Denmark.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Absence of regional CRA plan hampers coordination and alignment of adaptation efforts in the region; disconnect to national level	Support for the development of a regional CRA (best practice exchange with other regions)	
Integrating a social equity and gender perspective into technical dimension (data and specific design decision) **Enhancing a comprehensive risk understanding (beyond flood-focus)**	Provide information on the approach to take vulnerable groups into account Stakeholder engagement plan on vulnerable groups Vulnerability assessment	
Integrate NbS-approach into adaptation planning	Provide information on NbS good practice	Best practice exchange within LSDT2, followed by an exchange with other regions
Funding constraints for adaptation measures	Support identification of financing options, incl. private sector actors (together with FASTTRACK)	
Enhance climate risk communication to relevant target groups (e.g. stakeholders from different sectors)	Provide guidelines for inclusive stakeholder engagement (together with ESF) Support design and implementation of formats Mapping of needs and interests of stakeholders Share and develop Connective Negotiation as approach to	Best practice exchange on citizen engagement

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	stakeholder involvement on interests and added value	

Potentials for transfer

Cross-regional transfer of approaches, experiences and best practices presents a key lever for tackling common challenges and learning from each other and is therefore an important element of the transfer framework. In this regard, CDM can contribute expertise in several fields to the twinning regions in LSDT2 and beyond this regional cluster, such as Network of Loggers for tracking shallow groundwater, CBA tool “BEST Adapt”, demo houses to invite water in, as well as other expertise in data collection, analysis and data-driven decision-making processes. In addition, experience with implementation of NbS and stakeholder engagement approaches can be shared with other regions (Table 16).

Table 16: Expertise and transfer potentials in Central Denmark.

Strengths and expertise	Topics of interest	Transfer to other regions
Network of Loggers (Machine learning (ML) in order to track shallow groundwater logging, already existing in Lemvig and Horsens)		Blekinge, Zemgale, Other Interested Regions
Expertise in data collection, analysis, and data-driven decision-making processes		Blekinge Potentially Zemgale
Cost-benefit analysis and data collection		Blekinge, SW Finland, Other Interested Regions
Connective negotiation as approach to stakeholder involvement on interests and added value **NbS cases**		First exchange on stakeholder engagement within LSDT2, followed with exchange with all interested regions
Demo houses (how to invite water in)		Blekinge

Going beyond RESIST

Although still at an early phase of the project, this needs assessment is exploring initial needs and opportunities to effectively broaden and systematically incorporate the solutions intended for LSD2. A successful, well-documented demonstration of these innovative solutions would be crucial for scaling up.

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One of the biggest hurdles in developing more systemic solutions is bridging the gap between existing individual measures in municipalities and formulating a National Climate Change Adaptation Plan. The formulation of such a national plan could strengthen regional actors' ability to formulate, implement, and monitor adaptation action. The visualisation of NbS, consultations and co-creation with project stakeholders and results from the CBA ("BEST Adapt Tool") can provide the momentum that is needed to scale up solutions. However, institutional and policy coordination and innovation are needed to enable deeper transformations. This could include taking advantage of the growing regional coordination and collaboration within RESIST in order to a) institutionalize vertical exchange and local stakeholder engagement, b) utilize the results of the CBA to persuade key actors to establish improved financial conditions for public and private investment, and c) advocate for a more comprehensive integration of climate change adaptation into national and regional climate policy and planning.

To ensure effective climate change adaptation beyond RESIST, the following points should be considered:

- **Regional CRA:** Risk assessments should not be limited to municipal levels but should also be conducted at a regional scale. This ensures a broader understanding of climate risks across inter-connected ecosystems and communities, and could help design regional adaptation strategies that are more holistic and effective.
- **Broader Scope of CRA**: Risk assessments should include a broader spectrum of climate hazards, such as droughts and heatwaves, and should not be solely water-related. Climate risks are multifaceted and interconnected; focusing primarily on water-related risks could neglect other equally significant vulnerabilities and hazards. Such a broadened scope should not only be applied on the national and regional level, but also in risk assessments on the municipal level, so that a better understanding of resulting climate risks can guide targeted, context-specific adaptation strategies in each municipality.
- **Inclusive Framework in Climate Adaptation:** An approach that considers both gender differences and the needs of vulnerable groups should be employed. Climate change impacts are not uniform; they vary based on gender, socio-economic status, age, disability, and other factors. Consequently, adaptation strategies should consider these differentiated impacts. Perspectives based on gender and vulnerability should be integrated into CRAs, adaptation planning, and the design and implementation of NbS. This ensures that the needs, vulnerabilities, and capacities of all demographic groups, including men, women, and vulnerable populations, are considered and addressed effectively.

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3.5 Needs assessment Blekinge

3.5.1 Introduction

Figure 8: Location of Blekinge.

Blekinge Region, located in Sweden (population: 160,000), is situated along the Baltic Sea and boasts an expansive archipelago consisting of over 1,000 islands, encompassing five municipalities (Figure 8). As a well-developed region, its experience in Climate Change Adaptation (CCA) remains relatively incipient. Sweden has outlined 16 national environmental quality objectives targeted for 2030. The County Administrative Board spearheads the regional initiatives focused on energy transition, mitigating climate impact, and monitoring progress towards these environmental goals. Regrettably, a 2021 assessment indicated that the region is unlikely to achieve any of the 16 objectives by the 2030 deadline. Characterized by its rural landscape and sparse population, Blekinge grapples with significant demographic shifts and urbanization challenges. The evident changes along its extensive coastline and archipelago underscore the pressing threat of the climate crisis to its inhabitants. Yet, Blekinge's smaller population and favourable political climate position it uniquely to pilot transformative innovations swiftly and cost-effectively. A recent emphasis, aligned with the local smart specialization strategy, aims to cultivate Blekinge as a mission-driven region. Particular attention is drawn to urgent climate-related concerns: i) The deterioration of marine ecosystems, especially near coastlines and in inland waters, which impacts coastal communities – a situation exacerbated by insufficient data and monitoring; ii) The decline in groundwater reserves, anticipated to worsen due to climate change; and iii) A heightened susceptibility to flooding.

3.5.2 Climate risks

3.5.2.1 Regional climate risk assessments and identified risks

While the regional climate risk and vulnerability assessment for Blekinge ("**Översiktlig klimat- och sårbarhetsanalys - naturolyckor**") published in 2012 (Blekinge County Board) does not present the most up-to-date information after more than 10 years since publishing, it still gives a systematic overview over the identified changes of climate conditions and resulting climate risks for the region under two different time periods (currently in 2012 and up to year 2100). Flood risks occur due to heavy rainfalls or rising water levels both in the sea as well as in-land waters. Risks from coastal (beach) erosion appear due to rising sea levels as well. An increase in precipitation especially during the vegetation-free period is expected to intensify landslide risks, mainly in coastal areas or along waterways. The assessment report also investigates how the different hazards pose risks to society

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and infrastructure (Blekinge County Board 2012). Apart from the mentioned assessment report, regional representatives highlighted during interviews that risks from flooding (rather long-term) and drought as well as heatwaves (rather short-term) present the most pressing climate risks in the region of Blekinge.

The main dataset on climate risks is available through the Swedish Meteorological and Hydrological Institute (SMHI), which is a leading authority on weather, water, and climate. SMHI gathers and processes vast data, offering timely decision support for both short-term and long-term planning. SMHI's team produces forecasts, climate scenarios, and studies. They also share knowledge through their website, media, and training programs. Their services cater to various sectors, providing weather forecasts, warnings, and specialized industry insights. SMHI operates through government funding, assignments from other agencies, and commercial activities, with offices in Norrköping, Gothenburg, and Uppsala.

SMHI considers a wide range of climate indicators, three emissions scenarios (RCP2.6, RCP4.5, RCP8.5), four seasons and periods until 2100 and provide basic risk maps in open access. They also provide data on Hydrology and Oceanography. SMHI's data collection includes temperature, precipitation, and wind, supplemented by satellites and radars. This data supports their diverse weather services. They also offer integrated services to the private sector and authorities, grounded in their expertise. Their research spans meteorology, hydrology, and climate, with historical observations aiding in understanding Sweden's climate shifts.

Regarding the data generated by SMHI and its integration into specific risks and adaptation plans, the interviewee believes that the data will be referenced and linked to the adaptation plan in some manner. However, there is uncertainty about the full extent of its integration. It is evident that the data is instrumental for action plans, helping municipalities gauge their current position and future direction. The data has been employed in places like Karlskrona and Karlshamn, serving as a foundational resource for risk assessments. In addition, municipal climate action plans are available. However, they do not follow the same directive. There is a recognition that while there is an abundance of data, it is not well-organized, an aspect the project aims to improve.

3.5.2.2 Comparison with ESPON data

The ESPON CLIMATE dataset provides valuable insights into climate hazards, exposure, and vulnerability in Blekinge region. For the analysis, the region is not divided into further sub-units. Considered hazards in the analysis comprise of heat stress, droughts, wildfires and different types of flooding (river, coastal and flash floods).

When looking at the hazard component specifically within the baseline scenario (1981-2010), droughts play the most prominent role, affecting the primary sector of Blekinge region more than

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moderately. All other hazards are assessed to play a smaller role according to ESPON data, with flash floods still occurring slightly more than wildfires and river floods as well as heat stress.

Comparing this to the RCP8.5 high-emission scenario (2070-2100), drought impacts still appear similarly severe, while the coastal floods increase drastically, highly affecting the infrastructure, industry and service sectors. Heat stress affecting the population, river floods affecting the infrastructure and flash floods affecting the cultural sector are rising to become comparatively prominent (more than moderate) hazards. Exposure analysis shows that Blekinge is rather strongly exposed to river floods, droughts and heat stress. The analysis shows that the population is moderately sensitive and rather strongly exposed to river floods, coastal floods and flash floods, but as the hazard levels are relatively low in the baseline scenario, the population's overall risk from river floods remains moderate in Blekinge. However, this changes with a high-emission scenario, exacerbating the mentioned risks.

3.5.2.3 Potential improvements for climate risk information

For Blekinge at the current stage, available information on regional climate risk does appear to be comprehensive enough to provide an initial foundation for the region's adaptation process. However, despite the wealth of the available data, it is recommended to organize the wealth of information for various purposes and stakeholders. The region would benefit from an in-depth climate risk assessment report for various sectors, especially considering that the data is already available. Ideally, such a risk assessment would also formulate clear impact chains that outline the exposure, sensitivity and adaptive capacity of the system considered. In addition, different vulnerable groups within the region should be explored. This would serve as a more solid foundation for strategically building Blekinge's climate resilience.

This could also benefit municipal level adaptation plans and make sure that the common structure and approach is followed throughout. This would allow for a more comprehensive and well-founded approach in improving climate resilience in Blekinge's municipalities.

3.5.3 Adaptation measures

3.5.3.1 Existing plans and measures

Important policy documents at national level

The Swedish government has introduced the **National Strategy for Climate Adaptation** to address the challenges of climate change (Swedish Government 2018). This strategy aligns with international commitments, including the Paris Agreement and the European Union's climate adaptation strategy. The main goal is to strengthen Sweden's resilience against climate-related adversities and to identify and act on opportunities. This aligns with global objectives, especially those in Agenda 2030.

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Recognizing the changing nature of climate challenges, the strategy will be reviewed every five years, ensuring its continued relevance and effectiveness.

The document highlights the increasing frequency and intensity of extreme weather events, such as more intense rainfall leading to increased risks of flooding and heatwaves, which can have adverse effects on health. The energy sector, particularly hydropower, is vulnerable to changes in precipitation and temperature, affecting production. There is an anticipated rise in the risk of landslides and avalanches in certain areas due to more intense and frequent rainfall, posing threats to infrastructure, buildings, and roads. Erosion, especially in coastal areas, is a significant concern, with rising sea levels and frequent storm surges leading to increased coastal erosion, threatening infrastructure and settlements.

To address these challenges, the strategy proposes several measures:

- **Preventive Measures.** Studies indicate that the costs of addressing damages to the built environment due to landslides, erosion, and flooding are significantly higher than the costs of preventive measures. The proposal suggests that municipalities assess the risk of damages and present a strategy to reduce or eliminate these risks, thereby enhancing preventive actions.
- **Risk Management.** In situations with high risk, where the likelihood and severity of an event's consequences are significant, preventive measures should be taken, warning systems designed, and responsibilities clarified. Adaptation measures should consider events with very low probabilities but high consequences. Robust measures that work across a range of future scenarios should be prioritized.
- **Flexibility and Integration.** Adaptation measures should be designed to be flexible and robust, favouring various future action alternatives. Where possible, adaptation strategies should be integrated into existing strategies and plans.
- **Support for Municipalities.** Several agencies have developed freely available planning materials to support municipal analyses. This provides a strong foundation for municipal work.
- **Identification of Special Risk Areas.** There is a need to identify specific risk areas in Sweden concerning landslides, erosion, flooding, and other related risks that threaten communities, infrastructure, and businesses.

Overview of relevant policy documents at regional level

The **Klimat- och energistrategi för Blekinge** (Länsstyrelsen Blekinge 2019) presents the climate and energy strategy for the Blekinge region, aligning with the regional development strategy for Blekinge 2050 and focusing specifically on mitigation and does not address adaptation. The goal is to make Blekinge a fossil-free region by 2045. Sweden aims to have zero net greenhouse gas emissions by 2045, with emissions from activities within its borders being 85% lower than the 1990 levels. The remaining emissions will be offset by complementary measures. The vision for Blekinge

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is to create a region resilient to climate change, supported by a sustainable energy infrastructure that enhances residents' quality of life.

To achieve this vision, the strategy sets several goals, including reducing greenhouse gas emissions, expanding renewable energy, and enhancing energy efficiency. Key sectors like transportation, industry, agriculture, and housing are identified, each with specific measures to drive progress.

The **Åtgärdsprogram för vatten 2022-2027 Södra Östersjöns vattendistrikt** is the action program for water in the Southern Baltic Sea water district for 2022-2027 (Vattenmyndigheterna i Sveriges fem vattendistrikt 2022). The primary objective is to achieve and maintain a good water status in the region, emphasizing the significance of water quality and the challenges in attaining it. This program is driven by the need to prevent the deterioration of water status and to enhance the aquatic environment. It provides an overview of the current water status, pinpointing areas that meet the desired standards and those that require attention. Factors such as pollution and human activities are identified as primary influencers of water quality.

The strategy stresses the importance of collaboration between authorities, organizations, and the public. It outlines steps for effective implementation of the proposed measures and emphasizes continuous monitoring to gauge their success. The program also highlights the challenges in implementation, emphasizing the need for adequate resources and funding.

3.5.3.2 Planned adaptation measures within RESIST

Blekinge's approach to addressing climate risks and adaptation focuses on several key areas:

- **Awareness and Engagement.** A primary focus for Blekinge is to enhance awareness among its citizens and decision-makers. Mobile Pop-up´s to be deployed at various festivals exemplifies this, aiming to engage the public and stakeholders through various demonstrations. An informed populace is crucial for effectively addressing and adapting to climate challenges.
- **Data Collection and Decision-making Tools.** Monitoring and data collection are pivotal for informed decision-making. Blekinge is keen on implementing decision-making tools backed by accurate and comprehensive data. The region plans to test these tools in at least two of its municipalities in relation to their Risk Management Plans.
- **Increased Policy Coherence.** Blekinge recognizes the importance of aligning all strategies and actions with the region's overarching goals. Ensuring policy coherence means that different initiatives and strategies complement rather than contradict each other, leading to more effective and efficient outcomes.
- **Addressing Conflicts in Development and Adaptation.** There is a notable interest in understanding the conflicts between the demand for increased building development and the imperative need for climate adaptation and risk management. This will involve stakeholder rounds to facilitate knowledge exchange and gather diverse perspectives.

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- **Specific Climate Risks.** The region is especially concerned about the marine ecosystem, decreasing groundwater levels, and increased risks of flooding. Despite ongoing efforts, groundwater levels and flooding continue to be primary issues. The region aims to adopt a mission-oriented approach, bringing all stakeholders on board to address these challenges cohesively. The precise mission statement, outlining the region's approach and objectives for 2030/2050, is still in development but is expected to be finalized soon. This mission will also involve insurance companies and industries as well as citizens.
- **Future Plans and Collaborations.** The mission adaptation forum has been a significant focus, with discussions initiated with the County Administrative Board (CAB), which collaborates with the municipalities. The goal is to gather more data on the coastal line, including insights from a cultural perspective, especially concerning UNESCO heritage sites. The challenge is ensuring that adaptations do not compromise these cultural landmarks. Several areas will be selected for this project, symbolizing a joint effort to address this unique challenge. The upcoming months are crucial, with stakeholder meetings planned to outline the region's scope and objectives until 2027.

Challenges include:

- **Regulations and Legislation.** One of the primary challenges faced in the implementation of activities is navigating the complexities of regulations and legislation. Determining responsibility at both local and regional levels can be ambiguous. This ambiguity extends to property owners who are responsible for their own properties but must ensure they do not adversely affect others. However, there is no clear entity responsible for overseeing the collective well-being of the region.
- **Property Ownership and Responsibility**. The principle that property owners are responsible for their own properties, coupled with the stipulation that municipalities cannot favour individual property owners, creates a challenging dynamic. This can lead to potential conflicts and hinder coordinated efforts for regional development and adaptation.
- **Financing Models.** The absence of clear financing models poses a significant challenge. Without established models, it becomes difficult to secure consistent funding for projects and initiatives, potentially stalling or delaying their implementation.
- **Drinking Water Regulation.** While municipalities are responsible for drinking water, the presence of numerous individual wells complicates the situation. There is a pressing need for regulations to ensure the safety and availability of drinking water for all residents.
- **Coastal Built Environment.** A significant portion of the built environment is situated along the coast. This location makes it vulnerable to rising sea levels, coastal erosion, and other climate-related challenges, necessitating careful planning and adaptation strategies.

Opportunities include:

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- **Vinnova KA-Project.** Partners are exploring the possibility of a KA-Project with funding from Vinnova. If successful, this project could bring additional resources and expertise to the region, aiding in its climate adaptation efforts.
- **Funding from MSB.** The Swedish Civil Contingencies Agency (MSB) offers funding related to natural disasters. This presents an opportunity for Blekinge to secure financial support for projects aimed at mitigating the effects of natural disasters and enhancing the region's resilience.

3.5.3.3 Support needed

The following areas of support were identified:

- **Improve understanding of climate risks.** While current data for CRAs is well-founded, there is room for enhancement to ensure a more robust adaptation framework. This includes updating the risk model with the latest knowledge standards (like IPCC AR5), recognizing interconnected and escalating risks, adjusting to the present-day climate change scenario, and analyzing vulnerabilities, especially those affecting the most at-risk populations.
- **Improve understanding of well-functioning adaptation plans.** A valuable insight would be to discern patterns in effective adaptation action plans, as such feedback could be instrumental in enhancing future strategies. This could be provided as support from project partners or transferred from other regions.
- **Stakeholder engagement for increased policy coherence.** The current coordination structure faces several challenges. Determining clear responsibilities is complex due to the involvement of numerous stakeholders, each with their distinct agendas. Consolidating these varied agendas into a unified action plan is a significant challenge. Successfully implementing a holistic adaptation plan in Blekinge requires the active participation of relevant stakeholders. Engaging these actors not only improves the update and execution of strategies but also enhances the CBA. This can lead to long-term support and even attract private sector investments.

3.5.4 Stakeholders and capacities

Figure 9 shows an overview of stakeholders in the region relevant in the project context. Central actors include national agencies, regional administrative units, municipalities and authorities involved in adaptation planning as well as water infrastructure construction and maintenance. Additionally, networks and the private sector were identified as relevant stakeholders.

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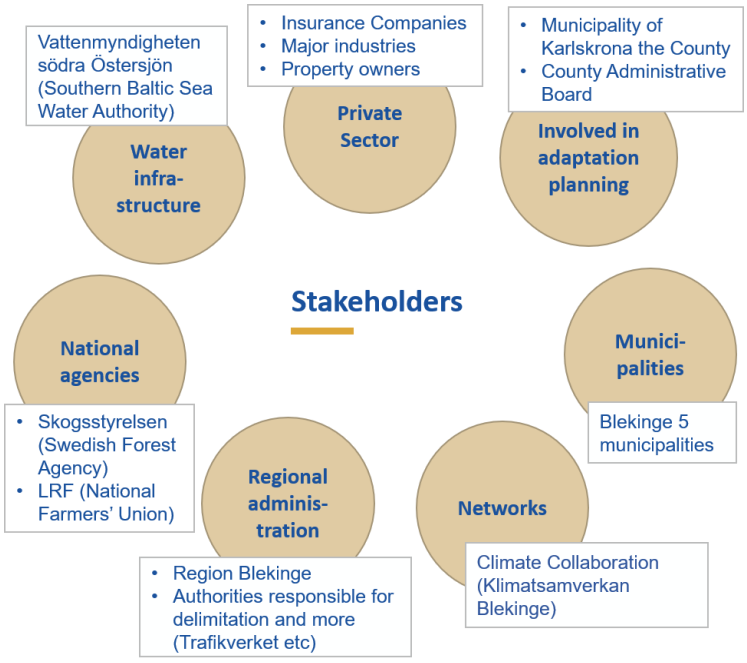

Figure 9: Relevant stakeholders in Blekinge.

The following capacity constraints were highlighted during the interview:

- **Funding Constraint.** One of the primary challenges faced in the region is the significant funding constraint. Securing adequate financial resources is a persistent issue, which has led the region to adopt a strategic approach to address this limitation. The prevalent method has been to amalgamate various projects, ensuring that they align with and support the region's long-term goals. The CAB, a key institutional player, unfortunately, lacks the necessary funds to drive these initiatives independently. However, there is a glimmer of hope as there are indications that some financial support could be channelled from the national level. Additionally, the region anticipates receiving some funds from the HORIZON program, which could alleviate some of the financial pressures.
- **Institutional Constraint.** The CAB faces its own set of challenges, primarily stemming from its limited resources. This scarcity of resources poses a significant hurdle in enhancing policy cohesiveness, a critical aspect of ensuring that various initiatives and strategies align seamlessly. The constraint also means that the CAB needs to collaborate with a diverse range of stakeholders to achieve its objectives. This necessity for collaboration, while beneficial in many ways, can also introduce complexities given the varied interests and priorities of different stakeholders.
- **Stakeholders Constraint.** Navigating the diverse political interests of stakeholders presents a significant challenge, especially when it comes to CCA at a strategic level. These varying interests can introduce risks, potentially obstructing the smooth execution of CCA strategies. To address this, there is an imperative need to establish clear goals and communicate transparently with all stakeholders. It is essential to elucidate the reasons for their involvement and the value they bring

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to the table. For instance, a landowner with considerable influence and power in the region must be made aware of their role and the broader vision, ensuring alignment of interests and fostering collaboration for the collective good of the region.

3.5.5 Potentials for transfer

- **Evaluating social risks and vulnerabilities,** with an intensified focus on vulnerable populations and gender dynamics, is essential. It is crucial to probe into the susceptibilities faced by diverse community groups and discern the underlying social threats. Incorporating these identified risks into Blekinge's regional adaptation blueprint will ensure that the concerns of the most vulnerable and gender-specific nuances are adequately addressed in the adaptation interventions and actions.
- **Begin comprehensive and focused planning.** With adelphi's expertise, adaptation efforts can be optimized for maximum positive outcomes. Interconnecting various strategies can amplify their benefits, both in terms of adaptation goals and societal advantages. Holistic planning enhances the consistency and effectiveness of adaptation policies across different areas and industries.
- **Best practices on strategic adaptation action.** A valuable insight would be to discern patterns in effective adaptation action plans, as such feedback could be instrumental in enhancing future strategies. This could be provided as support from project partners or transferred from other regions.

3.5.6 Results

Coastal and river flooding are main climate impacts in Blekinge, along with degradation of marine ecosystems and coastal erosion, specifically near the coastline and in lakes (Table 17). Most affected by flooding are populations, living close to the coastline and rivers. Planned activities are therefore targeted to reduce flood impacts through data-driven approaches, increasing policy coherence and stakeholder engagement.

Planned measures within RESIST focus on improving data collection and monitoring to establish cause and effect increasing policy coherence as well as awareness among citizens and decision-makers. Blekinge plans to learn from CDM and the CBA tool "BEST ADAPT". To enable a successful implementation of activities along with knowledge transfer to decision-makers, Blekinge closely works with the County Administrative Board. Additionally, Blekinge is working on XR tools on virtual reality to visualise climate impacts in an interactive gaming approach and use it for support in convincing decision-makers and general public. The results can be transferred to other regions.

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Table 17: Climate impacts, planned adaptation measures and relevant stakeholders in Blekinge.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Degradation of marine ecosystem (specifically near the coastline and in lakes/waters), Coastal erosion	Coastal Communities	Improve data collection and monitoring to establish cause and effect Increase awareness among citizens and decision-makers Increase policy coherence	County Administrative Board Municipalities Insurance companies Citizens Industries

Heatwaves, erosion or landslides as well as wildfires are further climate change impacts in the region which are beyond the scope of measures within RESIST.

Challenges and support

The current coordination structure faces several challenges (Table 18). Determining clear responsibilities is complex due to the involvement of numerous stakeholders, each with their distinct agendas. Consolidating these varied agendas into a unified action plan is a significant challenge. Additionally, systematization and re-organization of the wealth of available data would benefit the region.

Despite the acknowledged importance of climate change issues, they often lack adequate funding. While climate change topics are recognized as crucial, they often do not receive the priority they deserve. As a starting point here, understanding main criteria for effective adaptation action plans could be instrumental in enhancing future strategies. Blekinge can benefit from an updated in-depth regional risk assessment and adaptation action plan that includes gender aspects and vulnerable groups.

The coordination structure for climate change adaptation is primarily overseen by the CAB. However, the presence of regional responsibilities poses challenges, especially since municipalities hold the legal authority to act independently. The CAB, while tasked with numerous responsibilities, often faces capacity constraints. They aim to spearhead discussions and devise an exit plan, ensuring a smooth transition of responsibilities post-project.

Finally, the region is interested in exchanging on the NbS practices and stakeholder engagement approaches both within LSDT2 and beyond it with other regions that are a part of RESIST.

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Table 18: Challenges, needs and support opportunities in Blekinge.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Updated in-depth regional risk assessment and adaptation action plan, incl. gender aspects and vulnerable groups	Developing a proposal for adaptation planning (also integrate social dimensions and to find innovative ways forward)	Exchange and consultation on sea level rise adaptation measures with Vesterålen, Normandy and South-West Finland, CDR NIRAS BEST ADAPT tool from CDR Needs to be carried out in close collaboration with Partnership for Regional Innovation (PRI)
Navigating complexities of regulations and legislation: challenges around property ownership; independence of municipalities		
Re-structuring and re-organization wealth of available and usable data	Developing proposal for re-organizing existing information and structures	Needs to be carried out in close collaboration with Partnership for Regional Innovation (PRI) Twinning partnership with Denmark to adopt their expertise in data collection, analysis and data-driven decision-making processes
Funding constraints & absence of clear financing models	Overview of and support for identifying further climate adaptation financing options	Needs to be carried out in close collaboration with Partnership for Regional Innovation (PRI)
Stakeholder engagement and awareness raising amongst citizens, decision-makers (for policy coherence) and other stakeholders	Communication toolkit and products to showcase benefits of NbS for adaptation and beyond Provide guidelines for inclusive stakeholder engagement (together with ESF), incl. Mapping of needs and interests Support design and implementation of formats Support stakeholder exchange, helping to increase political relevance of adaptation and policy coherence	Best practice exchange on citizen engagement Needs to be carried out in close collaboration with Partnership for Regional Innovation (PRI)

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NbS solution cases	Structure and coordination of the exchange process and the final materials	Best practice exchange: a) within LSDT2 and b) within RESIST

Potentials for transfer

There are several ways in which Blekinge can support other regions (Table 19). Blekinge has experience with the use of XR technologies, specifically virtual reality, to raise awareness about the sustainability-related decisions. They can also offer tools and practices for the development, monitoring and use of Digital Twins. Finally, there is an interest to contribute to an exchange on stakeholder engagement with their experience in development of collaborative decision-making arenas.

Table 19: Expertise and transfer potentials in Blekinge.

Strengths and expertise	Topics of interest	Transfer to other regions
Tools and practices for the development, monitoring and use of Digital Twins, mostly in the manufacturing sector	PAPER1, PAPER2, PAPER3	Exchange with all interested regions
Experience with the development of serious games to drive innovation and design decision-making including sustainability aspects	PAPER	First exchange on stakeholder engagement within LSDT2, followed with exchange with all interested regions.
Experience with need finding methods and tools to support collaborative decision making with stakeholders with different backgrounds	LINK	Exchange with all interested regions
Experience with the use of XR technologies to raise awareness about the sustainability-related consequences of innovation and design decisions	PAPER1	Exchange with all interested regions
Experience with the development of collaborative decision-making arenas ('decision theatre') where a number of stakeholders can be gathered and supported in their discussion.	DECISION ARENA and VIRTUAL PRODUCTION STUDIO	First exchange on stakeholder engagement within LSDT2, followed with exchange with all interested regions.

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3.6 Needs assessment Zemgale

3.6.1 Introduction

Figure 10: Location of Zemgale.

Located in the southern part of Latvia (Figure 10), the region Zemgale covers an area of approximately 10,733 km² with a population nearing 500,000 people. This region, also historically known as Semigallia, is notably a flat territory rich in agriculture due to the fertile plains of the Zemgale upland. In terms of economic activity, Zemgale is recognized as a prominent European Regional Development Fund (ERDF) transition region, where the primary business sectors include agriculture, dairy farming, forestry, light industry, and tourism. The region boasts a unique blend of Latvian history and culture, with ancient Semigallian fortresses and an assortment of medieval landmarks that contribute to its identity.

Zemgale experiences a temperate oceanic climate, transitioning to a humid continental climate. This means the winters can be cold, while summers tend to be moderately warm. Data from the Latvian Environment, Geology and Meteorology Centre (LEGMC) for 2020 suggests that the region's average temperature has risen by 1.5 °C between 1970 and 2020. Like other parts of Latvia, Zemgale has experienced a significant decrease in cold days and an increase in hotter summer days, indicative of global warming trends. As the region is landlocked, it does not face the same challenges as coastal regions; however, the increasing temperatures may impact its agricultural yield, which is a primary economic activity in the area. On the matter of precipitation, Zemgale receives around 650 mm annually. Although there has been no significant trend in annual precipitation, there is a noted decrease in snowfall events and a slight increase in intense rainfalls, which may pose challenges to the region's farming and infrastructure.

3.6.2 Climate risks

3.6.2.1 Regional climate risk assessments and identified risks

Zemgale does not have any regional climate risk assessment (CRA) and has no concrete intend yet to prepare such a document in the near future. However, the regional representatives expressed general interest in developing such plans. CRA and relevant plans and strategies are existing on a national level, but show no systematic evidence of climate risks specifically at the regional level. Nevertheless, interviews with Zemgale representatives highlight the importance of existing national level documents in guiding adaptation efforts within the region. On national level, in the years 2016

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and 2017, climate risk and vulnerability assessments in six different areas of action have been published alongside adaptation indicators and measures (VARAM 2020), but these assessments consider the regional level only marginally. Also, the 2017 report on “Climate change scenarios for Latvia” (Avotniece et al. 2017) makes some reference to projected climate trends for some of Latvia’s regions, but not for Zemgale. Finally, scientific literature was also not found to provide relevant insights and findings regarding Zemgale’s regional climate risks.

However, the Zemgale Planning Region (ZPR) published an environmental report “ZPR AP Vides pārskats” (SIA Estonian, Latvian & Lithuanian Environment 2021) alongside its regional ZPR Development Program (“ZPR Attīstības programma 2021-2027”) which formulates a moderate trend for both rising air temperatures as well as increasing average precipitation amounts in the region. Further clarifications on the impacts of these climatic trends in Zemgale were not formulated though. However, selective references are made primarily to existing flood risks and marginally to erosion risks. Interviews with Zemgale representatives showed that flood risks are perceived as the most pressing climate risk in the region, followed by impacts from extreme weather events like heatwaves, heavy precipitation (in both urban areas and rural sites) and hailstorms and its damages on roofs, solar panels and agricultural land. It was also mentioned that the current network of meteorological observation stations in Zemgale cannot precisely forecast such extreme weather events.

On the municipal level, there is no common framework and process of developing local CRA. However, the LEGMC performed detailed analysis on long-term historical climate data for 22 selected Latvian municipalities (only three of them in Zemgale: Jelgava, Dobele, Bauska) and presents its findings accessible online in the Climate Change Analysis Tool for local governments to use and integrate it into municipal adaptation plans and strategies. It shows four different climate index risks (heat waves, cold waves, snow blanket thickness, severe rainfall) under the scenarios RCP4.5 and RCP8.5 for the three time periods 2011-2040, 2041-2070 and 2071-2100. Additionally, the LEGMC provides flood risk information and data for all river basin districts in the flood risk information system (Figure 11).

The information system presents various risk areas mapped per city (e.g. flood risk areas, population at risk, buildings at risk, roads in flooded areas, agricultural land at risk. These findings “allow flood risk to be integrated in a timely and qualitative manner into planning documents of various levels of territories, as well as providing high-quality information for the institutions responsible for the coordination of actions in case of floods” (Interview with ZPR, 05 Sep 2023).

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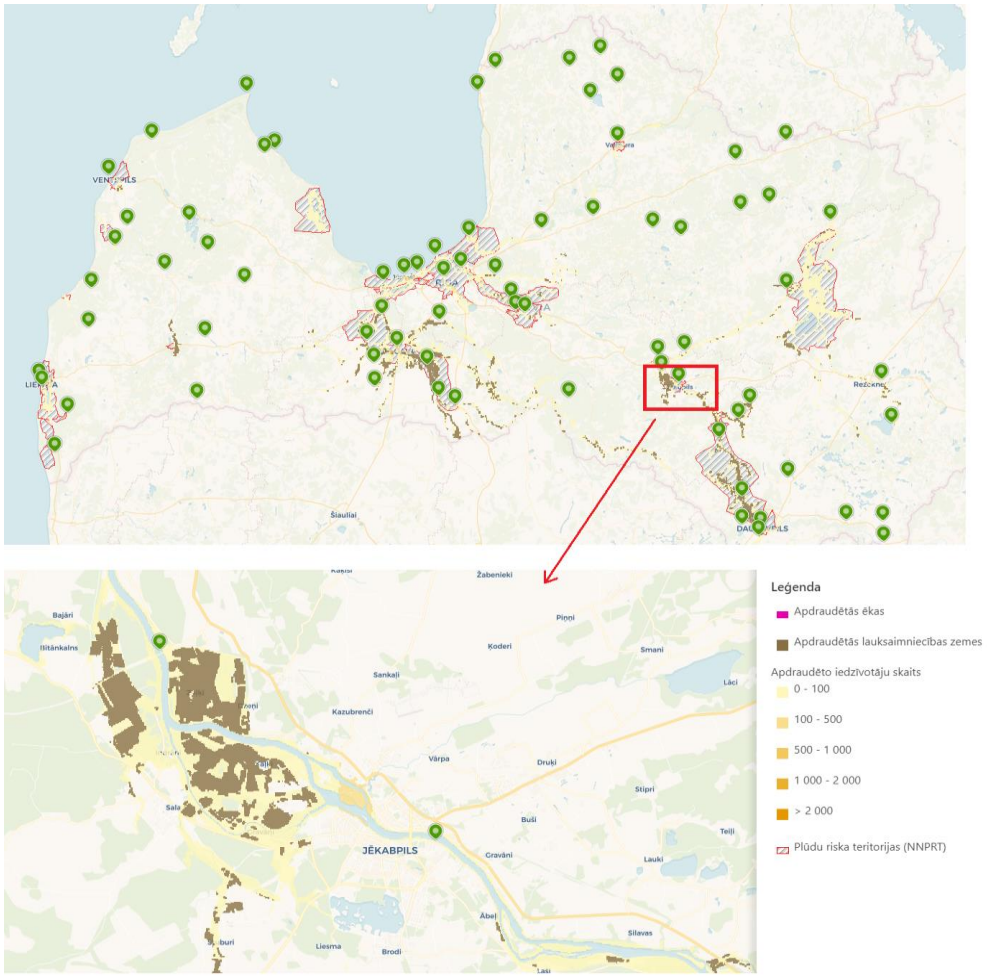

Figure 11: Latvian Flood Risk Information System – exemplary municipality Jēkabpils in Zemgale region showing layers on flood risk areas, buildings at risk, agricultural land at risk and population at risk (own illustration; after LEGMC 24.08.2023).

Next to these online portals, several Latvian municipalities have developed Sustainable Energy and Climate Action Plans (SECAPs) which are performed on a voluntary basis. While some municipalities do integrate CRA and climate adaptation strategies into their SECAP, other municipalities do not cover these topics at all.

For example, Saldus municipality (Kurzeme region, not within Zemgale) published a SECAP in the frame of the C4S project, which performs a detailed climate risk and vulnerability assessment (partly grounded in the online data portals mentioned above) for various hazards like extreme heat, extreme cold, extreme precipitation, floods, drought, storms and forest fires (low, moderate, high intensity) under three different climate scenarios RCP2.6, RCP4.5 und RCP8.5 and its impacts on various areas of action (low, moderate, high influence). It also gives some consideration to vulnerable groups

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at risk, like elderly and unemployed persons (Ekodoma 2020). Instead, other Latvian municipalities like Jelgava municipality (Zemgale region) do not cover these topics within their SECAPs at all and focus solely on climate mitigation aspects (ZREA 2010). According to interviews with Zemgale representatives, there is no central online platform existing that provides complete overview of all published municipal SECAPs in order to analyse the state of Zemgale's municipal SECAPs.

3.6.2.2 Comparison with ESPON data

The ESPON CLIMATE dataset provides valuable insights into climate hazards, exposure, and vulnerability in Zemgale. This is especially the case since regional CRA have not been conducted for the region yet. For the analysis, Zemgale region is not divided into further sub-units. Considered Hazards in the analysis comprise heat stress, droughts, wildfires and different types of flooding (river, coastal and flash floods).

When looking at the hazard component specifically within the baseline scenario (1981-2010), droughts play the most prominent role, affecting the primary sector of Zemgale region more than moderately. This is especially relevant "considering the importance of the region in agriculture at the national level" and the fact "that in the Zemgale plain, where large areas of agricultural land are concentrated, periods of continuous drought are longer than in other parts of the country" (SIA Estonian, Latvian & Lithuanian Environment 2021). All other hazards are assessed to play a smaller role according to ESPON data, with wildfires still occurring slightly more than river and flash floods as well as heat stress (Navarro et al. 2022). Coastal floods play no role in Zemgale due to its geography.

Comparing this to the RCP8.5 high-emission scenario (2070-2100), drought impacts on the primary sector still appear similarly severe, while heat stress affecting the population and flash floods affecting the cultural sector are rising to become comparatively prominent (more than moderate) hazards in Zemgale. Exposure analysis shows that Zemgale is rather strongly exposed to river floods and wildfires, but since the hazard levels for these phenomena remain rather low, the overall risk occurring from river floods and wildfires also continues to play a rather small role in the high-emission scenario, according to ESPON data. The analysis shows that the population is moderately sensitive and rather strongly exposed to river floods, but as the hazard levels are relatively low, the overall populations' overall risk from river floods remains rather less than moderate in Zemgale.

The identified risks in the ESPON dataset do not align with the insights gained through desk research and interviews with Zemgale representatives, which showed a strong focus on flood-related hazards and climate risks. These findings indicate that the region's current emphasis on flood risks might be too narrow, when considering future climate scenarios, and suggests considering appropriate measures to also enhance Zemgale's resilience towards heat stress and drought-related risks.

3.6.2.3 Potential improvements for climate risk information

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For Zemgale at the current stage, available information on regional climate risk does not appear comprehensive enough to provide a solid foundation for the region's adaptation process. The current lack of a regional CRA and the focus on flood risk may overlook very relevant additional hazards and vulnerabilities (as assessed with ESPON datasets). Therefore, it is recommended to perform a regional in-depth assessment of (various) hazards, vulnerabilities and climate risks, that considers at least two different climate scenarios (e.g. RCP4.5 and RCP8.5) and both medium- as well as long-term changes (e.g. 2021-2050 and 2071-2100). Ideally, such a risk assessment would also formulate clear impact chains that outline the exposure, sensitivity and adaptive capacity of the system considered. In addition, different vulnerable groups within the region should be explored. This would serve as a more solid foundation for strategically building Zemgale's climate resilience than currently exists.

Such a regional CRA could serve as a baseline for municipal level adaptation plans and strategies to also perform municipal CRA, or if not possible, to let municipal adaptation efforts be guided by the findings obtained from regional level assessment. The current inconsistency regarding identification of municipal climate risks could thereby be compensated to some extend or even be improved. This would allow for a more comprehensive and well-founded approach in improving climate resilience in Zemgale's municipalities.

3.6.3 Adaptation measures

3.6.3.1 Existing plans and measures

Important policy documents at national level

According to interviews with Zemgale representatives, national level plans and strategies play an important role in guiding the regions' adaptation efforts due to a lack of climate adaptation strategitization in Zemgale. In the years 2016 and 2017, Risk and Vulnerability Assessments in six different areas of action (health and well-being, landscape planning and tourism, biodiversity and ecosystem services, agriculture and forestry, civil protection and emergency assistance, construction and infrastructure planning) were published along-side proposals for adaptation indicators and recommendations for prioritized adaptation. In 2019, Latvia published its National Adaptation Plan 2030 ("Latvia's Climate Change Adaptation Plan for the period up to 2030) which formulated 5 strategic objectives (briefly summarized as: health and well-being; economy; infrastructure and construction; nature, cultural and historical values; and information and scientific reasoning) split into 14 dimensions of action and substantiated with more than 80 priority adaptation measures (VARAM 2019). Latvia's 8th NC and Fifth Biennial Report under the UNFCCC takes up the content of the National Adaptation Plan and highlights in relation to its first strategic objective that "(i)n the area of health and welfare, additional assistance should be provided to vulnerable groups of society (elderly people, children, people needing social care etc.) and to reduce the load on the health care system" (Lupkina et al. 2013).

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Overview of relevant policy documents at regional level

On the regional level in Zemgale, there are two main guiding policy documents according to interviews with Zemgale representatives: the medium-term ZPR Development Program 2021-2027 and the long-term ZPR Sustainable Development Strategy 2015-2030. Both regional plans pay only very limited attention to climate adaptation as a strategic objective for the region

The ZPR Development Program 2021-2027 ("ZPR Attīstības programma 2021-2027") formulates "climate change, environmental and circular economy" as one priority field amongst several with a sub-goal formulated "climate change adaptation and mitigation". While there is a strong dominance of mitigation-related recommendations and measures, adaptation comes in the form of the following exemplary measures: management of water resources, green and blue infrastructure, restoration of natural habitats and ecosystems to prevent flood risks municipal climate adaptation strategies, and educational activities related to climate change (ZPR 2021). However, the more long-term oriented ZPR Sustainable Development Strategy 2015 – 2030 ("Zemgales plānošanas reģiona ilgtspējīgas attīstības stratēģija 2015-2030") shows no references to the topic of climate change at all (ZPR 2015), indicating a blind spot in the regions' strategic long-term sustainable development planning. Both regional policy documents do not refer to vulnerable groups specifically.

In the context of Zemgale's climate resilience, the HORIZON IMPETUS project takes place. Predicated on enhancing regional early warning and monitoring apparatuses, the project aims to craft a robust, evidence-based climate adaptation strategy specific to the Zemgale context. One of the focal areas within IMPETUS is evaluation of mid-term socio-economic variables, which is instrumental in delineating comprehensive strategies for climate change adaptation. A roadmap for IMPETUS aims to finalize a regional adaptation plan by 2024. Notably, an integral synergy exists between the IMPETUS and RESIST projects, requiring operational and strategic alignments. While the emphasis of IMPETUS predominantly lies in the area of early warning mechanisms, the project has made demonstrable advancements. To elucidate, optimal location for new equipment installation have been identified, and there is an effort to assimilate national data repositories with the intent of transitioning a city-level flooding alert mechanism to a more encompassing regional paradigm. Concurrently, a structured plan has been delineated for the conceptualization and assimilation of a regional digital twin. It is projected that the tools and methodologies created by IMPETUS can also have a contribution in the RESIST project, thereby ensuring empirical and contextually relevant interventions.

3.6.3.2 Planned adaptation measures within RESIST

Zemgale continues to align with its original objectives. Groundwater level monitoring aims to establish a network of data loggers in coastal towns and urban areas to measure groundwater levels.

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Additionally, the project envisions citizen engagement to provide supplementary groundwater and precipitation data. This aligns with Zemgale's plans to procure groundwater level monitoring sensors.

Plans to implement NbS in urban areas are in place. Zemgale exhibits strong interest in NbS, especially "blue-green solutions in rivers" that can aid in flood risk management. This component focuses on establishing a dialogue with citizens about possible NbS implementations and the associated impacts, like risk mitigation and biodiversity enhancement. While initial plans considered the construction of flood-resistant buildings and early warning systems, Zemgale has streamlined its focus. The region now plans to solely prioritize groundwater level monitoring and has shifted early warning systems to the IMPETUS project.

In the interview it was indicated that capacity-building exercises remain ongoing and that coordination groups to embed climate change considerations into local strategies are underway.

Although the precise priorities might be hard to pin down at this stage of the project, the Zemgale region aims to:

- Procure equipment for data collection and analysis.
- Engage in a twinning partnership with Denmark to adopt their expertise in data collection, analysis, and data-driven decision-making processes.
- Engage stakeholders, especially municipalities, to ensure the effective realization of project goals. All six municipalities in Zemgale are involved in RESIST, and Zemgale's Planning Region (ZPR) is open to participation from other municipalities, emphasizing them as pivotal stakeholders.
- There is a drive to integrate climate change considerations into municipal planning documents. This will be supported through workshops on knowledge transfer, capacity building related to CCA plans, governance processes, and the organization of virtual interactive exhibitions.

Three main challenges were highlighted by the project team:

- **Capacity limitations of partners**. Partners have varying scope of their commitments. The discrepancy between their commitments and their capacities poses a tangible threat to the realization of advanced solutions. Such over-commitments may result from optimistic projections and might hinder the successful implementation of solutions, such as the flood warning system, which at the moment appears to be a unique initiative in the region.
- **Complexity of the project**. The RESIST project, while offering an avenue for progress, is inherently intricate. Many complex actions are predominantly tailored for large research institutions. Zemgale, being neither a technical nor a research institution, finds itself in the middle ground. Navigating the delicate balance between technical implementation and research-oriented objectives emerges as a formidable challenge. This institutional mismatch might intensify the difficulties of harnessing the full potential of the project.

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- **Human resource constraints**. While financial resources appear to be sufficient, thanks to project budgets, the real impediment lies in human resource constraints. There is a noticeable deficiency of specialists from research and academia, especially within state institutions. As Zemgale depends on such actors as third-party entities, especially for the implementation of sophisticated technical solutions, the scarcity of expert human resources becomes a significant bottleneck. The essence of the challenge is not about availability of funds, but the ability to leverage and manage expertise efficiently and effectively.

3.6.3.3 Support needed

In addressing Zemgale's adaptation challenges within the RESIST framework, several supportive activities have emerged as essential. It is crucial for Zemgale to address the existing knowledge gaps, diversify its risk assessment criteria, institutionalize climate risk and vulnerability assessments at the grassroots level, and adopt a forward-thinking regional climate risk strategy.

- Firstly, a fundamental challenge for Zemgale is its current lack of expertise in **conducting CRAs**. Addressing this requires a dual approach. On one hand, securing external funding can enable the region to onboard experts or consultancy firms with a proven track record in these assessments. Concurrently, by organizing workshops and knowledge transfer sessions, Zemgale can ensure that the expertise of these external entities filters down to the local stakeholders, cultivating a sustainable local skill set.
- Next, it is imperative for Zemgale to **re-evaluate its climate risk priorities**. While the region's current risk assessments predominantly focus on flood risks, preliminary findings imply that this might not be a holistic approach considering potential future climate scenarios. Zemgale's significant contribution to national agriculture makes it especially vulnerable to threats like heat stress and drought. Therefore, it would be important for the region to expand its risk assessment parameters to account for these threats. Engaging with experts or regions that have successfully integrated such risks into their adaptation strategies can provide Zemgale with valuable insights and best practices.
- Another area of focus should be the **integration of CRA at the municipal level**. Currently, there is a conspicuous absence of a cohesive approach in this respect. By establishing a standardized framework or guidelines, Zemgale can ensure a harmonized integration of CRA into SECAPs. To further this, training sessions and workshops for municipal stakeholders can be pivotal, ensuring that individual municipal SECAPs resonate with the overarching regional climate adaptation objectives.
- Lastly, Zemgale's current stance on regional CRA — where there is neither a comprehensive assessment nor immediate plans to commission one — warrants a strategic shift. The region would benefit immensely from a **well-structured strategy** that clearly delineates its approach to climate risks. This strategy should be flexible, allowing for adjustments based on emerging

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challenges or opportunities. Engaging with national and international stakeholders can offer Zemgale a starting point, allowing them to adapt best practices rather than starting from scratch.

3.6.4 Stakeholders and capacities

In the Zemgale region, the primary stakeholder is ZPR, responsible for coordinating and overseeing climate adaptation efforts. The comprehensive knowledge ZPR possesses regarding other stakeholders in the region makes the idea of a detailed stakeholder involvement mapping redundant for them. They are well-acquainted with the roles and functions of all regional players.

However, a challenge emerges with civil society's involvement. Civil society often becomes active at the latter stages of planning processes, and public participation levels remain disappointingly low, especially when compared to the contributions of ministries. This late-stage involvement can result in unforeseen resistance after plans have been approved. ZPR, thus, must exercise caution when involving civil society, ensuring that their concerns and perspectives are addressed proactively.

From a financial standpoint, funding mechanisms in Zemgale are still nascent. While ministries operate activities of national importance using the state budget, municipalities finance their initiatives through their own budgets. Meanwhile, ZPR actively engages in EU programs, funding their activities through successful project bids.

ZPR has identified human capacity constraints as a significant concern. Despite having ambitious goals, especially concerning the unique flood warning system they aim to implement, there is concern about the feasibility of these aspirations. Partner institutions, while optimistic, sometimes fall short on delivering due to their limited capacities. This challenge is further compounded by the regional representatives' impression that the technical intricacies of programs like HORIZON are designed primarily for research institutions. ZPR finds itself at a crossroads, balancing between technical deliverables and research expectations, given that they do not strictly align with either category. The key constraint, however, is not financial, as there are ample project budgets available. Instead, the primary challenge lies in the limited human resource capacities of partner institutions. The lack of science-based specialists in state institutions leaves ZPR dependent on these third-party entities.

3.6.5 Potentials for transfer

Incorporating the following aspects into Zemgale's climate adaptation measures can provide a more holistic, inclusive, and systematic approach to addressing the region's unique challenges.

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- **Diversification of Climate Risk Assessment**. Zemgale's emphasis on flood risks might benefit from expansion to consider other potential climate scenarios, such as heat stress and drought-related risks, especially given the region's significant contribution to national agriculture.
- **Mainstreaming Climate Risk Assessments**. Instituting a common approach for CRA at the municipal level can ensure a cohesive and standardized adaptation strategy across Zemgale. This would facilitate more uniform planning and execution of adaptation measures.
- **Early engagement with civil society**. Given the challenge of civil society engaging late in the planning process, proactive outreach might be effective. By involving civil society at earlier stages, Zemgale can reduce potential resistance and ensure a more inclusive planning process. The engagement should ensure that the concerns of the most vulnerable and gender-specific nuances are adequately addressed.
- **Technical and research partnerships**. Since Zemgale is caught between the intricacies of technical implementations and research requirements, forging alliances with dedicated technical institutions or research bodies might offer specialized guidance and ease the project's execution.
- **Capacity-building initiatives**. Recognizing the limited human resource capacities of partners, Zemgale could prioritize capacity-building sessions. This could encompass training sessions, workshops, and exchange programs to enhance the skill sets of the involved entities.
- **Stakeholder involvement mapping**. While Zemgale feels well-acquainted with its stakeholders, establishing a more comprehensive stakeholder involvement map could help in understanding potential synergies, risks, and the broader interests of each party. This not only ensures a systematic approach but also aids in foreseeing potential challenges.
- **Budget allocation and funding schemes**. While monetary resources seem available, a structured funding scheme might be beneficial. This could outline the allocation of funds for specific tasks, ensuring efficient utilization and transparent financial governance.
- Zemgale stands to gain significantly from **transferring NbS from other regions, especially in the context of urban spaces**. With a pronounced inclination towards "blue-green solutions in rivers" to manage flood risks, the region should prioritize fostering community discussions on potential NbS implementations. By doing so, Zemgale can heighten awareness of the dual benefits of these solutions: reducing risks and augmenting biodiversity. Drawing insights and best practices from other regions can provide Zemgale with a comprehensive roadmap to harness NbS optimally.

3.6.6 Results

Flooding and groundwater deficit are the main climate impacts in Zemgale (Table 20). Most affected by flooding are farmers and populations, living close to water. Planned activities are therefore targeted to reduce flood impacts, primarily through establishing a data collection, analysis and monitoring system. This is planned to be achieved by installing flood monitoring stations and establishing a network of data loggers in coastal towns and urban areas. Furthermore, other activities include building capacities of municipalities to work with data, integrating climate change perspective

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into planning documents of municipalities, and stakeholder engagement. Zemgale is also interested in exchange with other regions within RESIST on blue-green NbS in rivers for flood risk management.

Table 20: Climate impacts, planned adaptation measures and relevant stakeholders in Zemgale.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Flooding	Farmers Other Groups	Blue-green NbS in rivers for flood risk management Citizen engagement to provide supplementary groundwater and precipitation data Establishment of data collection, analysis and monitoring systems and how to apply these in planning practices regional and locally for installation of flood monitoring stations Capacity building related to municipal operational information centres Integrating climate change in the planning documents of all municipalities in their region	Municipalities Citizens
Groundwater deficit	Farmers Other groups	Groundwater level monitoring: establishing a network of data loggers in coastal towns and urban areas	Municipalities

Beyond these climate change hazards addressed within RESIST, Zemgale is also impacted by erosion, heatwaves, heavy precipitation, and hailstorms. The region's primary focus has been on flood risks. However, given Zemgale's importance in national agriculture, there is a pressing need to diversify and consider other climatic threats.

Challenges and support

Zemgale's unique set of challenges and needs in climate adaptation, stakeholder engagement, and capacity constraints necessitates tailored solutions both through regional exchange and horizontal partner support (Table 21):

- **Need for regional CRA** and adaptation action plan as a baseline for municipal adaptation plans**.** As this is not the focus of the CDM region, Zemgale could either learn from the activities of other regions in this regard or be supported by horizontal partners, i.e. adelphi in this activity.

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- **Capacity constraints**: Capacity limitations, particularly in human resources, among partner institutions present significant challenges. Ambitious aspirations, such as the flood warning system, may be jeopardized by these constraints. There is a need for connection to ad-hoc external experts on adaptation planning (technical and research partnerships) and support in development of capacity building formats for local experts on adaptation planning (municipal).
- **Structured and cohesive planning**. A standardized and unified approach to CRA across municipalities can streamline the planning and execution of adaptation measures.
- **Nature-based Solutions**. While there is a keen interest in "blue-green solutions" for flood risk management, an exploration into broader NbS, influenced by insights from other regions, can offer substantial benefits.
- **Stakeholder coordination**. While the Zemgale Planning Region is a central organization in the region's climate adaptation efforts, there could potentially be a gap in the engagement of the broader civil society.
- **Data collection and monitoring**. As the topic is quite complex, understanding a baseline scenario and formulating a specific need is essential for defining where to start. Potential support could come from KU Leuven, followed up by support from CDM if there is a need-offer match.

Table 21: Challenges, needs and support opportunities in Zemgale.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Need for regional CRA and adaptation action plan as a baseline for municipal adaptation plans	Support development of Climate Risk Assessment and a Climate Adaptation Strategy (regional)	Potentially exchange with Centro Portugal
Expert human resource constraints within state institutions (third party dependence), esp. for advanced technical solutions (consultancy firms)	Connection to ad-hoc external experts on adaptation planning (technical and research partnerships)	
Need for investment into education of local experts	Support development of capacity building formats for local experts on adaptation planning (municipal)	
Challenges with civil society engagement in adaptation (only come in during late stage in planning processes)	Support early engagement and communication with civil society (e.g. Do's and Don'ts for civil society participation)	Potentially exchange with Catalonia
Strong interest in NbS, especially "blue-green solutions in rivers"	Provide information on NbS good practice (blue-green solutions in rivers)	Blue-green NbS solutions from other regions, especially in the context of urban spaces. First exchange within LSDT2 and then with the rest of the regions

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Data collection and monitoring	There is a need to define where to start. Support could come from KU Leuven to help Zemgale identify their particular needs in data collection and monitoring	Central Denmark

There are no activities that Zemgale aims to transfer or offer their expertise in.

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3.7 Needs assessment Catalonia

3.7.1 Introduction

Figure 12: Location of Catalonia.

Catalonia is located in north-eastern Spain (Figure 12) and encompasses an approximate area of 32,000 km^2. Situated in a predominantly subtropical Mediterranean climatic zone, it is known for its prevalent hot and arid summers. The region is further characterized by mild and relatively rainy winters. However, due to the diverse geographical and orographic features, the climate within the region exhibits variations associated with local continental, oceanic, and alpine influences (Servei Meteorològic de Catalunya 2022).

The region is home to approximately 7.6 million people (roughly 236 inhabitants per km^2), with the majority living in Barcelona and its surrounding satellite towns. Barcelona is Catalonia's economic and political centre, encompassing a population of 5 million inhabitants in the metropolitan area. Due to a shortage in economic opportunities, Catalonia's hinterland and rural regions are experiencing depopulation and outward migration to urban centres and coastal areas (OECD **[Jahr ermittelt fehlt!];** Generalitat de Catalunya 2022b).

Catalonia is Spain's wealthiest and most industrialized region. It functions as Spain's economic powerhouse, with a thriving tourism sector. However, the manufacturing industry takes precedence, with a substantial transition from traditional textile production to sectors such as chemicals, pharmaceuticals, food processing, and metalworks. The automobile industry also holds a key position within Catalonia's industrial landscape. Overall, agricultural activities in Catalonia now constitute only a small fraction of the GDP (Generalitat de Catalunya 2022a).

Climate change has resulted in a rise in climate-induced emergencies, causing casualties, infrastructure damage, and impacting natural systems and socio-economic sectors. Measures within RESIST focus on the civil protection sector with the aim to improve and extend Early Warning Systems (EWS) and raise awareness for climate-related risks. The measures address the heightened risks of extreme events such as flash floods, wildfires, heat waves, and strong winds.

The adaptation measures include four key areas. As a first area, IT developments will focus on facilitating regional-local coordination in emergency management, as well as on improving and expanding EWS. The second key area focuses on raising awareness and effectively communicating risks to communities, including the design of EWS messages and giving special attention to the needs of most disadvantaged or marginalized groups. The third area of adaptation measures focuses on local-regional demonstration. The goals include identifying vulnerable areas and communities susceptible to specific or multiple hazards and implementing better EWS, starting with the municipalities of Terrassa and Blanes. The last area of adaptation measures focuses on

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transferring best practices (and potentially developed EWS solutions) to the twinning regions Puglia and Baixo Alentejo and making use of the digital twin developed in WP 1.2 of the RESIST project.

3.7.2 Climate risks

3.7.2.1 Regional climate risk assessment, focussing on the civil protection sector

The central document analysing climate change risks for the Catalonia region is the Strategic Reference Framework for Adaptation to Climate Change for the Horizon 2030 (Generalitat de Catalunya 2021) (in Catalan: Marc estratègic de referència d'adaptació al canvi climàtic per a l'horitzó 2030), hereafter abbreviated as ESCACC30. The ESCACC30 investigates climate change risks in natural systems, socio-economic sectors and different territories (hereafter referred to as investigated "systems") and covers many relevant aspects of a comprehensive climate risk assessment (CRA). A full list is provided in Table 22.

Table 22: Natural systems, sectors and territories as defined in ESCACC30, for which risks from climate change were assessed.

Natural systems	Sectors	Territories
	Agriculture and livestock	
	Insurance and financial sector	
	Energy	
Biodiversity	Industry	
Water	Services and trade	Inland
Forests and forestry	Mobility infrastructure	Coastal
Marine ecosystems	Natural risks and civil protection	Mountain areas
Fisheries	Research and training	
	Health	
	Tourism	
	Urban planning and housing	

Each system is analysed in detail (ESCACC Annex 2), mostly based on a literature review of existing studies. Based on the findings, key climate risks are identified and tabularised for each system, differentiating between hazards, potential impacts, vulnerability, and exposure. Due to the somewhat overlapping systems, certain risks are mentioned several times with a slightly different framing (e.g. "risk of forest fires" in the territory "mountain", and "risk of forest fires" in the natural system "forest"). Two summary tables are shown as examples below.

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Table 23: Summary table for identified climate risks in the sector "Insurance and financial sector" (Generalitat de Catalunya 2021).

Scope / sector	Climatic hazard	Impacts	Exposure	Vulnerability	Risk
Insurance and financial sector	Extreme climatic events	Personal damage Property damage Damage in the agricultural sector (crop losses)	High exposure of population, goods and services in coastal region; high exposure of nearly one-third of the region's agricultural land	High vulnerability of the agricultural sector and the coastline	Increase in the cost of coverage and risk premiums for insurance

Table 24: Summary table for identified climate risks in the sector "Natural risks and public protection" (Generalitat de Catalunya 2021).

Scope / sector	Climatic hazard	Impacts	Exposure	Vulnerability	Risk
Natural risks and civil protection	• Floods • Droughts • Forest fires • Land slides	Damage to people, goods, services and ecosystems	Elevated in densely populated areas and in areas of high economic activity	Dependant on the magnitude of the climate hazard Catalonia has numerous civil protection plans in place to deal with natural and climate risks	• Loss of lives and money • Increased costs of repairing major infrastructure • Increase in energy prices

The detailed analysis for the sector "Natural risks and civil protection" – which is also the focus of LSD 3 in RESIST – differs from the other analyses included in ESCACC30. For this sector, the analysis is divided into three risk categories:

1. Meteorological risks (such as heat waves, cold, snow, frost, extreme rainfall)
2. Socio-natural risks (floods, droughts and forest fires)
3. Geological risks (landslides and snow avalanches)

Risks from heat are not included in the sector "Natural risks and civil protection" but are covered in the sector "health".

Meteorological risks

Annex 1 of the ESCACC30 investigates past and future changes in temperature and precipitation for Catalonia, which form the base for the meteorological risks assessed for the sector. Observed changes in climate are thoroughly assessed, looking at temperature, precipitation (and various

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related climate indices) for the period 1950-2020, as well as at sea-water temperature and sea level (for Estartit, since 1974). It further includes analyses of the snow thickness in the Pyrenees and state of the glaciers, phenological observations in the Serra D'Almos (i.e. relationships between climatic factors and the seasonal or periodic manifestations of species such as the flowering of plants, migration of birds, etc.), and episodes of strong wind and storms.

The future climate is analysed based on the results of the study "Regionalized climate scenarios in Catalonia: regionalized statistical projections at 1 km spatial resolution (1971-2050)" (Servei Meteorològic de Catalunya 2020), performed by the Meteorological Service of Catalonia and abbreviated as ESCAT20. This study assesses future climate (for 2030 and 2050) in Catalonia at a 1km spatial resolution, using regionalised climate scenarios. Both a moderate emission scenario (RCP4.5) and a high emission scenario (RCP8.5) are considered. Average, maximum and minimum temperature, accumulated precipitation (both on an annual and seasonal scale), and temperature- and precipitation-related climate indices are derived. The main conclusion of ESCAT2020 is that in 2050, the region of Catalonia will be, on average, warmer and drier (compared to the period 1971-2000). The average annual temperature will continue to increase across the region across all scenarios. For a high emission scenario, the average temperature may increase by up to 3ºC by 2050. Maximum temperature is projected to increase by up to 4 ºC, minimum temperature by up to 3 ºC. Geographically, the largest increases are projected for the Pyrenees. Projected precipitation presents a large interannual variability. Despite the uncertainty, the trend seems to point towards a general decrease in average annual precipitation, particularly during summer.

Socio-natural risks

For each municipality in Catalonia, a level of risk for fluvial (riverine) flooding has been established in the Special Flood Emergencies Plan of Catalonia (INUNCAT) (Comissió de Protecció Civil 2017). This was done based on existing flood hazard zones (under current climate conditions) and using monetary damages, number of people located in the flood zone and total length of circulation routes within the flood zones as indicators to assess vulnerability. Table 25 shows the number of municipalities falling into different pluvial flood risk categories. Pluvial (precipitation-driven) flood risks are not explicitly discussed.

Table 25: Number of municipalities in Catalonia falling into different fluvial flood risk categories (Generalitat de Catalunya 2021).[4]

Very high risk	High risk	Medium risk	Moderate risk	Low risk

[4] Catalonia consists of 947 municipalities. The riverine flood risk is only reported for 946 municipalities in the ESCACC30 – the riverine flood risk for one municipality is therefore missing.

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200	180	108	260	198

Future risks from fluvial flooding in Catalonia are assessed by the Catalan Water Agency within the risk management plan for river basin district of Catalonia for the period 2022-2027 (Agència Catalana de l'Aigua 2022). This assessment is again discussed in the ESCACC30. Fluvial flood risk is assessed for two emission scenarios (RCP4.5 and RCP8.5) for different flood return periods (10, 100 and 500 years). Results indicate that areas with significant increases in fluvial flood risk correspond to the large river basins of the region, affecting important urban centers such as Barcelona, Girona, Tarragona or Manresa.

Droughts are discussed and analysed in the ESCACC30 based on the ESCAT20 projections. According to the results, precipitation anomalies (annual and seasonal), both positive and negative, are projected to increase, leading to years with very significant increases but also years with significant reductions in precipitation. The dry streak length index is generally increasing throughout the territory.

Forest fire risk in Catalonia is analysed in a special emergency plan for forest fires (INFOCAT) (Generalitat de Catalunya 2014). It assesses vulnerability of areas based on five indicators: population, particularly dangerous elements, infrastructure, protected natural spaces and potential for fuel. A map of municipal vulnerability to forest fires is available.

Geological risks

Risks from landslide are only assessed based on the results of a study which investigates the damages produced by the storm Glòria in 2020 (ICGC 2020). Future risks from landslides are not assessed.

Risks from avalanches are discussed based on the study investigating the effects of climate change in the Pyrenees (OPCC and CTP 2018). It considers three emission scenarios (RCP8.5, RCP6.0 and RCP4.5) and medium-term as well as long-term changes (until 2100). Results of the study suggest that the frequency of avalanches and their impact will probably decrease in the future due to an increase in winter temperature. However, the impact of climate change on avalanche risk remains fairly uncertain.

3.7.2.2 Comparison with risks according to the ESPON-CLIMATE dataset

The ESPON project has identified several prevalent risks for the region of Catalonia under current climate conditions. These include flash floods posing a risk to the cultural sector, droughts affecting the primary sector, and wildfires impacting the environment. Additionally, risks from heat stress on the population are projected to become increasingly prevalent during the time period 2070-2100 (under a high emission scenario – RCP8.5), while the previously mentioned risks remain high.

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It is important to note that the ESCACC30 does not assess risks from flash floods, which represents a significant gap in the analysis. However, expert interviews conducted with regional partners indicate a high level of awareness regarding flash flood risks among local authorities and research institutes. Furthermore, risks from droughts in the primary sector are not adequately addressed in the main risk summaries for the sectors of "agriculture and livestock" or "water" of the ESCACC30. Instead, they are only mentioned in the risk summaries for the sectors "energy," "industry, trade, and services," and "natural risks and civil protection". Nevertheless, droughts play a crucial role in the adaptation measures outlined for the agricultural sector in the second part of the ESCACC30. It is essential to rectify this discrepancy in future adaptation strategies and plans to ensure comprehensive coverage of risks from droughts in the primary sector. While the ESCACC30 discusses risks from wildfire, it only considers current climate conditions and fails to account for future developments. Additionally, since risks are not prioritized in the ESCACC30, it remains unclear whether certain risks have been identified as particularly relevant.

3.7.2.3 Qualitative assessment of the regional CRA

Methodologically, no unified approach is applied to analyse the risks from climate changes across the various systems, and the analyses performed vary in depth. Many shortcomings thus stem from the lack of a clear climate risk analysis framework. The time horizons considered differ substantially, future climate scenarios are only sometimes explicitly taken into account. For certain systems, only past changes are assessed, such as for the “forest and forestry”: here, only the development of ecosystem services over time is analysed, given changes in forest extent, quality and management practices between 1990 and 2014. The risk analysis for marine ecosystems and fisheries, on the other hand, considers different climate scenarios (RCP4.5 and RCP8.5) as well as medium- and long-term changes (2050 and 2100). Furthermore, the structure of ESCACC30 results in a very high number of risks identified for Catalonia, without prioritizing some of them. The results of the analysis are therefore not easily transferrable to concrete adaptation action.

The ESCACC30 explicitly uses the terminology based on the definition of risk from the IPCC Fifth Assessment report, which defines risk as emerging from the interaction of hazards, exposure and vulnerability (IPCC 2014). These terms, however, are not always used consistently. For the vulnerability assessment of certain systems, potential impacts are discussed rather than vulnerability. When investigating vulnerability, a distinction is sometimes made between adaptive capacity and sensitivity, but this is not done consistently. Furthermore, a clear differentiation between risk, impact, hazard and exposure is not uphold across all components of the analyses.

Nevertheless, the report fulfils several requirements of a sound CRA. The ESCACC30 touches on a wide range of climate-related hazards. Both slow onset trends in temperature and rainfall as well as extreme events are considered. Data sources, uncertainties and knowledge gaps are clearly communicated. Furthermore, for most risks, the ESCACC30 outlines where in Catalonia these risks are most prevalent, thereby providing important spatially differentiated information.

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3.7.3 Adaptation measures

3.7.3.1 Existing regional plans and measures, focusing on the civil protection sector

ESCACC30

The ESCACC30 (Generalitat de Catalunya 2021) contains the region's adaptation framework and is also the most important and extensive document with regard to the region's adaptation strategy. It is regulated by Law 16/2017 of 1 August on climate change[5], which establishes climate change mitigation and adaptation objectives and prescribes the production of a Strategic Reference Framework for Adaptation. Furthermore, the law specifies that the objectives and measures presented in the framework shall be integrated into the sectoral strategies and the planning of the responsible ministries of the Generalitat (region) of Catalonia. The ESCACC30 was officially approved by the Catalan government in January 2023 (Generalitat de Catalunya 2023).

The ESCACC30 contains operational objectives for each natural system, sector and territory as defined in Table 22. Several adaptation measures are defined for each operational objective, resulting in a total of total of 312 measures for the period 2021-2030. The ESCACC30 includes an inexhaustive list of sectoral plans and programmes which have to integrate these objectives and measures. The operational objectives and measures for the sector "Natural risks and civil protection" focus on the following key areas:

- Promotion of the assessment of natural risks under consideration of climate change (using climate scenarios)
- Consideration of how natural risks will develop under climate change in planning documents
- Expansion and strengthening of existing systems for climate observation, early warning, communication and education
- Revision of regulations related to natural risks (e.g. urban planning regulations, establishment of fire prevention strip, etc.) in accordance with climate change scenarios

This shows that the region is aware of certain gaps in assessing climate risks (as identified in section 3.7.2.3) and is already taking action to remedy some of these gaps. Overall, although the ESCACC30 is a very comprehensive adaptation framework targeting various sectors, the majority of measures included are of rather general nature, not providing detailed and concrete activities for implementation. This, however, can partly be explained by the process of implementation for the ESCACC30 measures, which have to be taken up by and implemented through the plans and programmes of the various sectors. Nevertheless, the general nature of the measures leaves room for interpretation and might render the monitoring and evaluation of the implementation more difficult.

[5] Available at: https://portaljuridic.gencat.cat/eli/es-ct/l/2017/08/01/16

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Furthermore, the objectives and measures in the ESCACC30 are rather strictly divided between different natural systems, sectors and territories. This has the potential to create adaptation actions designed in “sectoral silos” instead of using synergies with other sectors (or natural systems / territories). Droughts and heat waves, for example, are not targeted in the sector “natural risks and civil protection”, although these climate hazards can have severe impacts on the population and targeting these hazards could benefit from solutions developed within the civil protection sector.

Civil Protection Map

The Civil Protection Map is an online interactive mapping tool which allows the user to choose from various layers, which are consequently mapped for Catalonia (Generalitat de Catalunya n.d.). These include layers showing the level of risk of an area, available for various climatic and non-climatic risks. Layers for climate-related risks are available for the following hazards:

- Forest fire
- Impediments through snow events
- Flooding
- Avalanche

The risk maps only exist for current climate conditions, risks under future climate conditions are not considered. As previously mentioned, however, the measures of the ESCACC30 aim at further promoting the inclusion of climate change scenarios.

Additionally, the mapping tool also includes layers showing the municipalities for which a territorial civil protection plan (Catalan Territorial Civil Protection Plan, PROCICAT) and/or a municipal emergency plan for a certain risk is recommended or obligatory. These plans aim at establishing organizational structures and procedures for intervening in emergencies, providing coordination mechanisms with the State Protection Plan, and establishing a coordination system with organisations in each territory. Furthermore, they include the creation of a Municipal Action Plan and require the establishment of basic risk maps for the communities. PROCICAT is mandatory for municipalities of a certain size and covers (in a more general manner) risks not included in special emergency plans. Climate-related risks covered by the PROCICAT include the following hazards:

- Heat waves
- Droughts
- Frost with serious impact on the supply of basic services
- Storm surges

Special emergency plans exist for various risks, referring to the following hazards:

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- Forest fire
- Impediments through snow events
- Flooding
- Avalanches
- Strong wind and storms

Whether it is recommended or required (or none of the former) for a municipality to implement a special emergency plan is determined by a set of risk-specific indicators. These, however, are based on current climate conditions. The consideration of risk development under climate change scenarios is missing so far and would represent a very valuable addition.

Global indicator of climate change adaptation in Catalonia

A global indicator of adaptation was first introduced in 2014 and reviewed in 2018, with the aim to measure Catalonia's progress in adapting to climate change over time (Oficina Catalana del Canvi Climàtic (OCCC) 2019). The global indicator is currently composed of 42 sectorial sub-indicators.[6] Assessments of how the indicator's value has changed show that it has increased by 8.74% between 2005 and 2014, suggesting successes in Catalonia's overall climate adaptation strategy (Oficina Catalana del Canvi Climàtic (OCCC) 2019).[7]

3.7.3.2 Planned adaptation measures

Adaptation measures planned within RESIST focus on the civil protection sector, aiming at improving and expanding Early Warning Systems (EWS) as well as at raising awareness for climate-related risks. The measures address the heightened risks of extreme events such as flash floods, wildfires, heat waves, and droughts. The adaptation measures include four key areas, shortly described in this section and summarized in Figure 13**Fehler! Verweisquelle konnte nicht gefunden werden.**.

[6] The sectors include: agriculture and livestock; biodiversity; water management; forest management; industry, services and trade; mobility and transport infrastructure; health; energy sector; tourism; urban planning and housing.

[7] The increase is measured against the indicator baseline value of 100 in 2005. In 2014, the indicator value had increased to 108.74.

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Figure 13: Overview of key activities planned for LSD3, adapted from the LSD3 kick-off meeting.

The focus of the first key area lies on facilitating regional-local coordination in emergency management, as well as on improving and expanding EWSs. The development of tools for the systematic application of Multi-Hazard Early Warning Systems (MH-EWS) at the local (municipal) level will be supported to monitor complex emergencies. To this purpose, the web-based early warning system “Argos” will be further developed and implemented in municipalities. To date, a first version of the city-level, real-time MH-EWS Argos is implemented in the municipalities Terrassa and Blanes. Furthermore, IT developments will include expanding the scope of site-specific warnings (SSWs) to trigger self-protection protocols tailored to different hazards and areas. These SSWs target high priority locations from a civil protection perspective (for example a school or a roundabout that is known to always flood). In Terrassa, the implementation of real-time SSWs for floods has already started. In the future, SSWs should be available in an easy-to-use app, which directly issues site-specific warnings to affected users and potentially include recommendations for action. For certain locations, SSWs could be connected to automated reactions, for example the lowering of a barrier that closes off a flooded road. This is, however, currently still in the pilot phase. Additionally, systems will be implemented to collect local data to enhance emergency management processes. This may involve utilizing crowd-sourced data, potentially involving the network of social workers,

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crowd-sourced date for slow-response hazards such as heatwaves or drought, and impact data. The development of digital tools further aims at facilitating regional-municipal-community coordination of emergency management. Lastly, trainings and e-learning materials will be prepared based on historical cases.

The second key area focuses on raising awareness and effectively communicating risks to communities. It involves designing targeted warning messages for SSWs and developing an inclusive framework for prevention and emergency management at the local level to incorporate the needs, knowledge, and capacities of the most disadvantaged or marginalized groups, ensuring their voices are heard and accounted for in decision-making processes. Further, surveys will be conducted to evaluate IT developments and assess community awareness. Other participatory activities will also be conducted, such as dedicated end-user community workshops and sessions. The overarching goal is to engage the vulnerable communities, understand their risk response, and prioritize their needs. Establishing an ecosystem of urban stakeholders will support effective communication and collaboration.

The third area of adaptation measures focuses on local-regional demonstration. The goals include identifying vulnerable areas and communities susceptible to specific or multiple hazards, and evaluating the performance of the MH-EWS tools during significant weather events. Additionally, the improved communication and risk awareness within the community is to be evaluated with the use of surveys. Additional activities include the organisation of regional workshops, as well as stakeholder engagement formats for local and regional stakeholders, including municipal CPs and first responders. All activities will first be implemented in Terrassa and Blanes. In a second cycle (starting October 2025), these activities will also be implemented in other municipalities within Catalonia as well as in the twinning regions to build a community of practice.

The last area of adaptation measures includes transferring best practices (and potentially developed EWS solutions) to the twinning regions Puglia and Baixo Alentejo, and making use of the digital twin developed and implemented in Task 1.2 of the RESIST project. This will be done through visits, working groups, and dissemination materials. However, there are ongoing discussions on how to also transfer the experiences and knowledge gained in Catalonia to other regions.

The adaptation measures planned within RESIST focus on the civil protection sector, mainly addressing emergency response. In the planned measures, the main focus so far lies on flood risks and risks from forest fires. The inclusion of risks from heat waves and further hazards are being considered for the MH-EWS tool Argos, potentially on a needs basis for participating municipalities. The suggested EWS solutions have the potential to increase the outreach of early warnings and make them more readily available for different target groups (directly affected population as main target group of the SSW solutions, civil protection staff as main target group of the MH-EWS Argos). Special attention is given to identify and reach vulnerable and marginalised groups, thereby helping civil protection services to prioritize action and redirect efforts where they are most needed. Targeted early warning messages can further help trigger appropriate action by the affected people themselves.

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Currently planned measures prominently include activities to identify and consider the needs and capacities of vulnerable and marginalised groups and how to better reach them in the context of EWS. The progressive approach of addressing the topic of social vulnerability holistically – integrating aspects of socio-economic capacities, gender, demography as well as mental and physical health – while aiming at developing evidence-based solutions needs to be emphasised and can be used as positive example for other regions.

The measures planned for RESIST are partly of incremental and partly of more transformative nature. LSD3 aims to achieve actionable change going beyond existing practices, aiming at increasing risk awareness and sharpening risk perception by citizens as well as improving civil protection coordination between the local and regional level. Many activities in LSD3, however, are deeply integrated into the existing Catalan civil protection project landscape. This ensures that synergies with other projects are used and solutions are developed in a way compatible with established processes. Further consideration should be paid to how the developed solutions could be further extended (or results used) to contribute to long term risk mitigation, i.e., decrease exposure or increase adaptive capacity.

3.7.3.3 Support needed

A key challenge for successful project implementation identified by the regional partners is to establish a good connection between the civil protection sector and the region's citizens. This should ideally be supported by the early warning tools used within the project. The challenge consists in making sure that people most at risk are reached, but also to ensure a high credibility of the warnings and targeted, useful warning messages.

The region therefore expressed interest in support activities related to stakeholder engagement formats. These are crucial to ensure that the developed solutions not only suit the civil protection sector, but also enhance the usefulness of EWS for citizens, and can also support activities aiming to identify and address vulnerable groups. Although the region has already envisaged multiple ways to engage with stakeholders, they would be interested in support with innovative stakeholder engagement concepts and the proofing of existing formats.

Additionally, the region expressed interest in support activities aiming at identifying project components with the potential to be scaled up (also beyond EWS tools), and interested recipient regions.

3.7.4 Stakeholders and community engagement

Stakeholders explicitly identified as important by the regional partners in LSD3 include stakeholders to be engaged in local-regional demonstration activities, regional stakeholders, and municipal stakeholders. The most important ones are listed below:

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Stakeholders to be engaged in local-regional demonstration

- ACCIÓ (Agència per la Competitivitat de l'Empresa) – Agency for Business Competitiveness
- OCCC (l'Oficina Catalana del Canvi Climàtic) - Catalan Office for Climate Change
- Project EDERA (Early warning Demonstration of pan-European rainfall-induced impact fore-casts)
- Project CLIMAAX (CLIMAte risk and vulnerability Assessment framework and toolbox)

These stakeholders will be engaged in the local-regional demonstration activities planned in Terrassa and Blanes, and potentially additional municipalities in Catalonia. The EDERA project is a European Commission Civil Protection Preparedness project focusing on an improved strategy for compound flood impact forecasts (combining convective hazards, flash floods and river floods). The CLIMAAX project is another Horizon Europe project aiming at supporting European regions in improving their regional climate and emergency risk management plans, including comprehensive multi-hazard CRA. Catalonia is involved in both projects. More specifically, both CRAHI-UPC and INT are involved in the CLIMAAX project, CRAHI-UPC is additionally involved in the EDERA project; good contacts as well as good project overviews, including possible synergies with the RESIST project, are therefore already established.

Regional stakeholders

- Departament de Drets socials (Social Rights Department)
- Red Cross Catalonia

Both the Social Rights Department and the Red Cross Catalonia have been identified as important regional stakeholders, especially for identifying vulnerable and marginalized groups, assessing their needs and capacities and discussing EWS options to reach those groups.

Municipal stakeholders

So far, municipalities strongly involved in the local-regional demonstration activities are Terrassa and Blanes. Further municipal stakeholders will need to be identified and contacted when the EWSs will be expanded to other municipalities in Catalonia. Potential stakeholders could include the Federation of Municipalities of Catalonia (Federació de Municipis de Catalunya) as well as regional councils (consells comarcals).

Community engagement

As previously mentioned, a key challenge identified by the regional project partners is establishing effective communication between the civil protection sector and the region's residents, which should ideally be supported by the EWS tools deployed through the project. The challenge lies in ensuring

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that the individuals who are most vulnerable receive the necessary information while also maintaining the credibility of the warnings and delivering targeted, useful warning messages. Community engagement will therefore be key. The evaluation of improved communication and awareness will be assessed with the use of surveys. Additionally, workshops are envisaged to further engage regional and local stakeholders.

3.7.5 Capacity and capacity constraints

3.7.5.1 Funding and financing

Catalonia's climate adaptation financing can be divided into three main pillars: European funding, state financing (Spain) and regional financing. European funding plays an important role for Catalonia's overall climate adaptation finance. According to the ESCACC30, the following EU funding mechanisms / EU funded projects are especially relevant for Catalonia (Generalitat de Catalunya 2021):

- Next Generation EU: Recovery and Resilience Mechanism and REACT-EU
- European Green Deal: EU Horizon projects
- European Social Fund Plus (ESF+)
- European Regional Development Fund (ERDF): For the period 2021-2027, Catalonia will receive around 840.5 million EUR from the EU (40%), the contribution of the Generalitat's budget in investments will be 1,260 million EUR (60%).
- European territorial cooperation (Interreg) 2021-2027, financed by the European Regional Development Fund (ERDF)
- European Agricultural Fund for Rural Development (EAFRD)
- European Maritime, Fisheries and Aquaculture Fund (FEMPA)
- RIS3CAT 2030, Research and innovation strategy for the intelligent specialization of Catalonia 2030: financing of actions will come from the cohesion funds (from FEDER and from the from the REACT-EU mechanism of the Next Generation funds)

Additionally, the EU LIFE program and the European Investment Bank (EIB) (especially its increased support for climate adaptation based on its Adaptation plan) are mentioned as potential future funding sources.

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With regard to Spanish financing, the ESCACC30 highlights the Spanish Law 7/2021 of 20 May on climate change and energy transition.[8] This law establishes financing mechanisms for several climate change adaptation policies, including:

- Financing plan for climate change adaptation related to the water sector and hydrology
- Financing mechanisms for fair transition agreements for vulnerable workers

Furthermore, the PIMA Adapta Plan, launched in 2015, provides a dedicated financing line for adaptation projects across various sectors within the framework of the Spanish National Climate Change Adaptation Plan (Plan Nacional de Adaptación al Cambio Climático - PNACC). Additionally, through the Biodiversity Foundation (Fundación Biodiversidad), public calls for financing climate change adaptation projects are carried out (Generalitat de Catalunya 2021).

With regard to funding from the region itself, the Catalan Climate Fund plays an important role. It was established through the Law 16/2017. The fund is financed by taxes on economic activities that generate GHG emissions as well as from a tax on port emissions from large ships. Additionally, part of the revenue from income taxes flows into the Climate Fund. Available funds are estimated at 50 million EUR per year (Generalitat de Catalunya 2021).

An evaluation of the financing opportunities for climate adaptation in Catalonia – and the civil protection sector more specifically – as well as the identification of funding gaps is still outstanding and needs to be provided by the regional partners. Results will be included in the final report.

3.7.5.2 Institutional capacity (personnel, governance)

The regional partners highlighted the current “emergency focused” approach of the civil protection sector. Long-term adaptation processes to increase climate resilience are not integrated in the civil protection sector yet. To initiate this shift, a need for trainings and improved skills was mentioned by the partners.

This also touches upon another institutional constraint, namely the attribution of different natural and climatic risks to different sectors and institutional entities. Increased cooperation across sectors could therefore be highly beneficial, such as between the civil protection sector, the Catalan water agency (Agència Catalana de l'Aigua – ACA) which is responsible for drought management, and the health sector, which is responsible for measures to reduce impacts from heat waves.

[8] Available at: https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-8447

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3.7.6 Results

In the ESCACC30, the analysis of climate risks lacks a unified approach and varies in depth across different systems. Furthermore, there is a need for more comprehensive consideration of risk developments under future climate scenarios. However, the adaptation strategy demonstrates awareness of this issue and includes measures to incorporate climate projections into future plans and products in the civil protection sector.

The region's approach focuses on the development, implementation and evaluation of EWS, prominently including activities that aim to identify and address the needs and capacities of vulnerable and marginalized groups. This serves as a positive example for EWS design, which can be applied to other projects or regions. The project's key activities are summarized in Table 26. The measures focussing on EWS and digital solutions are deeply integrated into the existing Catalan civil protection project landscape. It is crucial to invest further efforts in identifying project components with the potential to be scaled up not only within the twinning regions but also beyond, while considering the necessary pre-conditions. Additionally, it is important to give due consideration to how the developed solutions can extend beyond supporting emergency response and contribute to long-term risk mitigation.

One of the key challenges identified by the project partners is to ensure that the developed solutions not only suit the civil protection sector but also enhance the usefulness and credibility of EWS for citizens. Therefore, community engagement becomes crucial. However, community engagement activities are still in the planning stage and require further refinement.

As previously emphasized, the Catalan adaptation strategy assigns different natural and climatic risks to specific sectors and institutional entities. Enhanced cooperation across sectors, such as between the civil protection sector, the Catalan Water Agency (Agència Catalana de l'Aigua - ACA), responsible for drought management, and the health sector, responsible for measures to mitigate the impacts of heatwaves, would be highly beneficial. For future projects that extend beyond RESIST, it would be worth considering the potential for expanding the MH-EWS tool to other climate-sensitive sectors, including health and agriculture. This expansion would enable the project to go beyond the scope of RESIST.

Table 26: Climate impacts, planned adaptation measures and relevant stakeholders in Catalonia.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Flooding **Wildfires** **Heatwaves** **Drought**	Citizens Esp. vulnerable population Civil Protection and relevant first responders	Multi-hazard EWS at the municipal level "Argos" to be further developed and implemented in additional municipalities	Citizens Regional and municipal civil protection staff

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Flooding **Wildfires** **Heatwaves**	Citizens Esp. vulnerable population Civil Protection and relevant first responders	Identifying vulnerable areas and communities susceptible to specific or multiple climate hazards, starting with the municipalities of Terrassa and Blanes	Citizens Esp. vulnerable population Civil protection staff
Flooding **Wildfires** **Heatwaves**	Citizens Esp. vulnerable population Civil Protection and relevant first responders	Evaluating the performance of implemented MH-EWS tools (Argos) during significant weather events	Civil protection staff
Flooding **Wildfires (TBD)** **Heatwaves (TBD)**	Citizens Esp. vulnerable population Civil protection staff	Install and expand site-specific warnings (SSWs) in different high-risk locations, able to trigger automatic protection protocols, starting in Terrassa	Citizens Civil protection staff
Flooding **Wildfires** **Heatwaves**	Citizens Esp. vulnerable population	Raising awareness and effectively communicating risks to communities, including designing targeted warning messages for SSWs	Citizens Esp. vulnerable population Civil protection staff
Flooding **Wildfires** **Heatwaves**	Citizens Esp. vulnerable population	Developing an inclusive framework for prevention and emergency management at the local level to incorporate the needs, knowledge, and capacities of the most disadvantaged or marginalized groups	Citizens Esp. vulnerable population Civil protection staff
Flooding **Wildfires** **Heatwaves**	Citizens Esp. vulnerable population Civil Protection and relevant first responders	Transferring best practices (and potentially developed EWS solutions) to the twinning region Baixo Alentejo and potentially other regions	Citizens Esp. vulnerable population Civil protection staff

Challenges and support

A key challenge identified by regional partners for successful project implementation is establishing a robust connection between the civil protection sector and the region's citizens. This challenge hinges on effectively utilizing early warning tools to reach individuals most at risk while maintaining the credibility of warnings and delivering targeted, useful messages. To address this, the region is

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keen on support activities related to stakeholder engagement formats, crucial for ensuring that developed solutions not only align with the civil protection sector but also enhance the utility of EWS for citizens. Furthermore, the region seeks support in identifying project components with scaling potential, extending beyond EWS tools and involving interested recipient regions. Challenges and needs are summarized in Table 27.

Table 27: Challenges, needs and support opportunities in Catalonia.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Ensure that the developed solutions not only suit the civil protection sector but also enhance the usefulness of EWS for citizens.	Support stakeholder engagement formats: support with innovative stakeholder engagement concepts, proofing of existing formats and provision of workshop examples to engage community and vulnerable groups	Exchange with Southwest Finland, Blekinge and Centro Portugal on stakeholder engagement practices
Identify and address vulnerable groups		
Good formats for raising awareness and effectively communicating risks to communities		
Efforts needed to identify project components with the potential to be scaled up, as well as identification of interested regions	Support transfer of solutions to other regions (also beyond EWSs). Identify other regions with potential synergies.	

Potentials for transfer

Catalonia has expertise in piloting and implementing multi-hazard Early Warning System (EWS) solutions, specifically utilizing the Argos software. They can also support in piloting solutions for site-specific warnings (SSWs) and in designing targeted warning messages for specific groups within warning systems. Additionally, Catalonia can support activities related to incorporating the needs and perspectives of vulnerable groups in EWS and civil protection, showcasing a comprehensive understanding of how to identify and reach vulnerable and marginalized groups within the context of civil protection initiatives. Expertise and transfer potentials are summarized inTable 28.

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Table 28: Expertise and transfer potentials in Catalonia.

Strengths and expertise	Topics of interest	Transfer to other regions
Piloting and implementing multi-hazard EWS solution (Argos software)	Potentially exchange with EMT, as they have experience in AI methods in EWS	Transfer to Baixo Alentejo and other regions interested in EWS, if necessary technical skills and data available
Piloting solutions for site-specific warnings (SSWs)	Especially for flooding, potentially also for wildfire	Transfer to Baixo Alentejo and other regions interested in EWS
Design of targeted warning messages (to specific groups) in warning systems		Transfer to Baixo Alentejo and other regions interested in EWS
How to include the needs and perspectives of vulnerable groups in EWS / civil protection		Some aspects might also be transferable beyond civil protection sector
How to identify and reach vulnerable and marginalised groups (in the context of civil protection)		Exchange with Baixo Alentejo and other interested regions

Going beyond RESIST

RESIST aims at developing innovative solutions with the potential for transformative change, scaling up piloted project measures beyond participating lead regions. The LSD3 measures planned for RESIST are deeply integrated into the existing Catalan civil protection project landscape. Further efforts should therefore be invested in investigating which project parts have the potential to be scaled up for and beyond the twinning regions – and under which pre-conditions. Additionally, further consideration should be paid to how the developed solutions could go beyond supporting emergency response and contribute to or be integrated into long term risk mitigation. Furthermore, cooperation with other sectors – especially the health sector – should be further strengthened to identify and use synergies with regard to the tools being developed and implemented within the RESIST project. Where useful, the expansion of the MH-EWS tool could be considered for other climate-sensitive sectors beyond civil protection, such as the health or agricultural sector. This is well beyond the scope of the current project, but could be taken up by other projects in the future.

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3.8 Needs assessment Baixo Alentejo

3.8.1 Introduction

Figure 14: Location of Baixo Alentejo (in dark green) (Guias Essenciais 2013).

Baixo Alentejo, a sub-region in south-eastern Portugal, comprises 13 municipalities within the larger Alentejo region. The sub-region comprises an area of 8,542 km² and thus constitutes approximately 10% of the country's total land area (Sociedade Portuguesa de Inovação et al. 2018). Bordered by Spain to the east and the Algarve to the south (Figure 14), this sub-region is characterized by a unique geographical and socio-economic landscape. The region is rich in cultural heritage, including archaeological sites, castles, churches, old mines, and traditional villages as well as natural heritage with the presence of protected areas like Guadiana and Moura (LCA4Regions Interreg Europe 2022).

According to the Koeppen Climate Classification, most of Baixo Alentejo is characterized by temperate climate with dry and/or hot summers. An exception is the Beja district, where the climate is characterized as dry and semi-arid. The average minimum temperature in Baixo Alentejo during the coldest months of December to February registers at around 6°C, whereas the average maximum temperature during the peak summer months of June to August reaches 33 °C, with maximum air temperatures of up to 45 °C. Precipitation levels exhibit their peak during October to December, averaging at 70 mm. During the summer months, precipitation reaches its lowest average level which remains below 20 mm from June to August. The prevailing climate aligns with the climate averages of southern Portugal and Spain's Extremadura region (Sociedade Portuguesa de Inovação et al. 2018).

Geographically, the territory is characterized by a lowland plain, with altitudes generally below 250 m (Sociedade Portuguesa de Inovação et al. 2018). The landscape also encompasses small, gently sloping mountains and is nourished by small water courses. Crossing the eastern expanse of Baixo Alentejo, the Guadiana river valley extends from north to south, influencing the region's hydrological dynamics and is one of the most valuable natural resources of the region, connecting Portugal and Spain (LCA4Regions Interreg Europe 2022). Despite its vast expanse, Baixo Alentejo is home to a relatively sparse population of approximately 115,000 inhabitants, amounting to roughly 14 inhabitants per km², which is in stark contrast to the national average of 112 inhabitants per km² (United Nations, Department of Economic and Social Affairs 2022). In recent decades there has

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been a demographic trend of population decline, attributed to an ageing population and migratory balances (Sociedade Portuguesa de Inovação et al. 2018).

Baixo Alentejo's economic system is characterised by a diverse range of sectors. Mining, forestry, livestock farming, and agri-products like cork, olive oil, cheeses, sausages, hams, and wines form the cornerstone of the region's economic activities (LCA4Regions Interreg Europe 2022). Additionally, the sub-region strategically leverages its proximity to tourism hubs, particularly the Algarve, to foster regional development. However, challenges related to accessibility and in mobility persist, especially due to the low density of transport infrastructure in some areas of the territory (Sociedade Portuguesa de Inovação et al. 2018).

Baixo Alentejo faces an array of climate risks and has already been experiencing negative impacts from different extreme weather events over the last decade (Sociedade Portuguesa de Inovação et al. 2018; World Bank Group 2021). These include excessive precipitation, which led to repercussions such as road cuts, damage to property, and disruptions of (mainly agricultural) production chains. Moreover, heat waves and high temperatures, two of the main concerns, have already caused detrimental effects on human health, triggered wildfires, induced ecosystem changes (such as alterations in tree varieties), and damage to production chains (mainly agriculture). Another concern stems from droughts, leading to constraints and interruptions of water supply, impacting agricultural and livestock production, degradation of ecosystems and an increased incidence of fires. Further, strong winds have led to culminating property damage (Sociedade Portuguesa de Inovação et al. 2018; Portuguese Institute of the Sea and Atmosphere (IPMA) 2022). In addition, changing seasonality of frost events have resulted in considerable harm to the agricultural sector. While frost overall is becoming less frequent in the region due to increasing temperatures, out-of-season frost in the month of April and May have led to devastating effects on vineyards and horticultural crops (Agencia Portuguesa Do Ambiente 2015; Sociedade Portuguesa de Inovação 2022).

3.8.2 Climate risks

3.8.2.1 Regional climate risk assessments and identified risks

Climate risks for the region are analysed in the regional adaptation strategy: the **Intermunicipal Plan for Adaptation to Climate Change in Baixo Alentejo** (PIAAC BA) (Sociedade Portuguesa de Inovação et al. 2018). The plan first provides a detailed analysis of past weather events and their impacts in Baixo Alentejo from 2007 to 2017. The following events are considered: excessive precipitation, heat waves, strong wind, drought, frost, as well as high particles concentration and dust. For each event type, past impacts are analysed differentiating between types of impacts (such as property damage, damage to production chains, changes in ecosystems, etc.). Additionally, the key impacts are summarized for several priority sectors, namely: agriculture and forest, biodiversity, economy, energy, health, safety of people and goods, and transport and communications. The

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sectors considered are based on those identified in the National Strategy for Adaptation to Climate Change (Agencia Portuguesa Do Ambiente 2015).

In a second step, the plan includes an analysis of historical climate data and climate projections. Regional climate models are used for the simulations, using 1979-1999 as reference time period and modelling three future time periods: 2006-2035, 2036-2065, and 2066-2095. The simulations are conducted for two emission scenarios, namely RCP4.5 and RCP8.5. The main climatic variables considered in the simulations are precipitation (daily and monthly temporal resolution), minimum temperature (daily and monthly temporal resolution), average temperature (monthly temporal resolution) and maximum temperature (daily and monthly temporal resolution). Based on these variables, annual and seasonal climate indexes are computed.

The simulation results suggest that both minimum and maximum temperature will rise significantly in the region until the end of the century: simulations suggest an increase by +1.7 °C (RCP4.5) to +3.2 °C (RCP8.5) for minimum temperatures, and by +1.8 °C (RCP4.5) to +3.5 °C (RCP8.5) for maximum temperatures. An increase in in the number of hot days is further expected. Total annual precipitation is expected to decrease by the end of the century by 9% (RCP4.5) to 10% (RCP8.5) over the entire region. The projected number of consecutive days with precipitation less than 1 mm, however, does not deviate substantially from the reference time periods. For the end of the century, an average increase of +2 days in autumn/winter and +4 days in spring/summer is expected according for the RCP8.5 simulations. These results therefore do not suggest a sharp increase in the duration of dry spells in the future. However, given projected rising annual temperatures and decreasing annual total precipitation, more arid climatic conditions might nevertheless be expected in the region for the end of the century. Based on the simulation results, the following five climatic trends are identified as having the highest potential for negative impacts on the region under future climatic conditions: 1) increase in average temperature, 2) more frequent heat waves, 3) more frequent heavy precipitation events, 4) decrease in annual average precipitation, 5) overall more arid conditions. Potential impacts of these climatic changes are then discussed in detail for the different priority sectors.

Based on the previous results of the assessment and on expert opinions, the frequency and severity of selected weather events is then qualitatively evaluated for the current time period as well as for the middle of the century. A number between one and three is attributed to the frequency and severity of each event type, representing the categorisation into low (1), medium (2), or high (3) frequency / severity. This is done for the following event types: excessive precipitation, heat waves, strong wind, drought, frost, high particles concentration and dust. The risk by such events is then determined by the product of frequency and severity. On this basis, the following four climatic trends are prioritized as bearing most risks for the region:

- Increase in average annual temperature
- Increase in the frequency and intensity of heat waves

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- Increased frequency and intensity of drought
- Increased frequency and intensity of heavy precipitation events

3.8.2.2 Comparison with ESPON data

The ESPON CLIMATE dataset is a valuable resource for RESIST's analysis as it offers consistent data that can be compared across different European regions. Considered climate hazards are heat stress (on the population), negative impacts from droughts (on the primary sector), different types of flooding (river, coastal and flash floods) and wildfires. In the baseline scenario (1981-2010), Baixo Alentejo is most strongly affected by droughts and wildfires. Impacts from flash floods on the cultural sector and heat stress are also discernible as important hazards. River flooding does not display a high relevance. Under the high emission scenario RCP8.5 and looking at the end of century (2070-2100), hazards from droughts, heat stress and wildfire amplify to reach a very high level, while flash flood occurrence decreases slightly. Hazards from river flooding remains of low importance.

The findings from the EPSON dataset support the results of the Plan for Adaptation to Climate Change of Baixo Alentejo with regard to the increasing importance of heat stress and droughts in the future. They additionally highlight damages from wildfires as key hazard, which is already very relevant today and will become even more prominent in the future.

3.8.2.3 Potential improvements for climate risk information

The Plan for Adaptation to Climate Change in Baixo Alentejo provides an important knowledge base for the region's climate adaptation efforts. While the plan may not cover all aspects of a standard CRA, it offers vital information and insights concerning key hazards and a thorough analysis of impacted sectors. For further analysis, the region should consider applying a risk concept which clearly differentiates between vulnerability, exposure and hazard. Especially the explicit consideration of vulnerability (and factors contributing to it) is so far lacking. Additionally, the region should integrate the explicit consideration (and if feasible, also the modelling) of further secondary hazards, such as from wildfires, landslides, river flooding and flash floods, and soil erosion in future assessments. These should also include an investigation of how these hazards might change over time.

3.8.3 Adaptation measures

3.8.3.1 Existing plans and measures

Important policy documents at national level

Through the **National Strategy for Adaptation to Climate Change 2020 (ENAAC)**, extended until the end of 2025, Portugal put in place both objectives and a robust implementation pathway for

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sectoral climate adaptation (Agencia Portuguesa Do Ambiente 2015). ENAAC covers various sectors, such as agriculture, biodiversity, economy, energy and energy security, forests, human health, safety of people and goods, transport, communication, and coastal areas. ENAAC serves a dual purpose: enhancing awareness about climate change and integrating adaptive measures into sectoral and territorial planning. It is a relevant resource for national, regional, and local administrations. Thus, the strategy holds practical value at the regional level, offering a comprehensive national overview and guidelines for climate adaptation. Furthermore, the **Action Program for Adaptation to Climate Change** complements and systematizes the work of ENACC 2020 by offering concrete lines of action for direct interventions (Diario de Republica 2019).

The **National Roadmap for Adaptation 2100** is currently being developed. It is expected to provide important guidance for both national and regional policy, addressing climate adaptation in both territorial and sectoral planning, as well as estimating the costs of climate adaptation for different sectors (Agencia Portuguesa Do Ambiente 2023).

Lastly, the **National Climate Framework Law (Law n.°98/2021)** consolidates objectives, principles, and obligations for the different levels of climate action through public policies. It establishes obligations concerning the necessity to develop new climate policy instruments, such as the Regional Climate Action Plans and Municipal Climate Action (Diario de Republica 2021).

Relevant plans, strategies and measures at the regional level

The **Baixo Alentejo Intermunicipal Climate Change Adaptation Plan** represents a robust regional-level strategy to address climate change adaptation effectively. This plan comprehensively analyses historical extreme weather events and regional climate scenarios (see section 3.8.2.1). It identifies action areas for adaptation in response to the identified four climatic trends bearing most risks for the region (increase in average annual temperature, increase in the frequency and intensity of heat waves, increased frequency and intensity of drought, increased frequency and intensity of heavy precipitation events). It then categorises the action areas according to “sector priorities”, differentiating whether actions have the largest positive effect on society, the economy or on ecosystems. Additionally, three transversal action areas are identified. Overall, 26 action areas are included in the Adaptation Plan. An overview is provided in Table 29.

A series of measures have been implemented to operationalize the regional adaptation strategy. One example is the “Living the Climate in Alentejo” (Viver o clima no Baixo Alentejo) project (2022), which centres on restoring ecological balance within agro-ecosystems. Another measure is the “CityZen” project (2019-2023), which fosters scalable innovation and new business models based on urban farming through the establishment of urban gardens, which not only serve to promote traditional agricultural practices but also aims at catalysing social and economic transformation.

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Table 29: Adaptation actions proposed for Baixo Alentejo (adapted from (Sociedade Portuguesa de Inovação et al. 2018).

	Society	Economy	Ecosystem	Transverse Measures
Increase in average annual temperature and increase in frequency and intensity of heatwaves	**AA1**. Urban renaturalization and introduction of Nature-based Solutions **AA2.** Elaboration of the Seasonal Health Contingency Plan – Summer Module **AA3.** Promotion of bioclimatic design measures for buildings	**AA5.** Promotion of new agricultural practices, agricultural species, and varieties adapted to new climate patterns **AA6.** Monitoring new agricultural pests and diseases and anticipating ways to combat them	**AA7.** Adoption of forest management measures and fire prevention mechanisms **AA8.** Operationalisation of Municipal Forest Defence Plans against Fires (PMDFCI) **AA9.** Control and monitoring of invasive species **AA10.** Monitoring impacts on ecosystems	**AA24.** Establishment of Early Warning Systems **AA25.** Conducting awareness and education campaigns **AA26.** Adoption of measures to combat depopulation
Increased duration of dry spells	**AA11.** Rationalization and management of the water supply systems **AA12.** Promotion of water-saving measures and efficient water use **AA13**. Elaboration of Intermunicipal Contingency Plans for prolonged periods of drought **AA14.** Use of rainwater and wastewater	**AA15.** Adoption of new practices in livestock systems adapted to new climate patterns **AA16.** Operationalization of Alqueva Dam Hydraulic Use Projects **AA17.** Use of efficient irrigation systems **AA18.** Creation of retention basins and water infiltration	**AA10.** Monitoring impacts on ecosystems	
Increased frequency and intensity of heavy precipitation	**AA19.** Adoption of Sustainable Drainage Measures **AA20.** Identification and intervention for containment and stabilization of slopes in critical areas of slope movements	**AA18.** Creation of retention basins and water infiltration	**AA10.** Monitoring impacts on ecosystems **AA22.** Cleaning of water lines **AA23.** Renaturalization of water lines	

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	AA21. Elaboration of an Intermunicipal Plan for Flood Risk Management

The **Baixo Alentejo Supramunicipal Housing Strategy** is a regional strategy targeting action in the field of housing (Sociedade Portuguesa de Inovação 2022). This strategy can be considered a relevant addition to the region's overall adaptation approach, as housing is a crucial factor playing into vulnerability of different population groups to climate impacts. Although the strategy does not explicitly consider adaptation aspects, it promotes a housing strategy which addresses the needs of vulnerable groups, promoting innovative approaches and affordable housing in the region.

Other important plans exist for the region. Significantly, all municipalities have developed **Municipal Civil Protection Emergency Plans** to ensure preparedness to various risks and swift response in the case of emergency at the local level (Ministerio da Administracao Interna 2016; Sociedade Portuguesa de Inovação 2022).These plans are currently undergoing updates with the overarching goal of creating a cohesive inter-municipal civil protection plan.

Moreover, a comprehensive effort is in place to counter risks posed by forest fires through **Municipal Fire Defense Plans**. All thirteen municipalities that are part the Baixo Alentejo region have approved Municipal Fire Defense Plans. These follow the structure of the National Forest Fire Defense Plan and are organized along the same strategic axes, ensuring comparability and alignment.

Overall, the region stands out as displaying strong and well-integrated municipal planning in the areas of civil protection and wildfire management. The Baixo Alentejo Intermunicipal Climate Change Adaptation Plan remains the cornerstone of the region's overall adaptation strategy. Although it identifies comprehensive action areas to address current and future climate impacts, it does not provide concrete adaptation measures. How the action areas are translated into actions could be more detailed. Additionally, gender and vulnerable groups are not specifically considered in the adaptation measures. Vulnerable groups do play an important role in the Baixo Alentejo Supramunicipal Housing Strategy, which, however, does not explicitly consider climate adaptation issues in the field of housing. A stronger interconnection of both strategies could therefore be envisaged in the future.

3.8.3.2 Planned adaptation measures within RESIST

Within the framework of the RESIST project, a diverse set of measures is envisaged, although many are still in the early planning phase. As one of the key measures within the RESIST project, the region aims to enhance and strengthen stakeholder and community engagement capabilities. Therefore, meetings with relevant stakeholders, such as civil protection and forest managing authorities, have been set up to better understand their needs, gain access to relevant information and collect data from these actors, as well as identify relevant data gaps. Additionally, the region

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envisages to set up measures to enhance the competencies within the regional workforce, exemplified by enhanced coordination mechanisms within Civil Protection. The exact scope and format, however, are not yet fully defined.

A key interest of the region involves supporting adaptation efforts in small, rural, and dispersed villages. This includes identifying transformative solutions tailored to the specific contexts of these communities, including water management (to address the risk of water scarcity), forest management (to mitigate the threat of forest fires), and energy (to counter the potential reduction in hydroelectric power production). In this context, measures to address this topic are still being defined as part of the RESIST project.

Another interest of the region lies with strengthening and improving early warning systems and the localisation of vulnerable groups. Particularly vulnerable individuals, such as the elderly, may necessitate supplementary assistance during extreme weather events, especially in sparsely populated regions with long distances to health facilities and sparse infrastructure. As a result, accurate information regarding their locations becomes pivotal for amplifying efforts of civil protection in rural areas. This information, however, is not yet available. Addressing this issue is therefore another key interest of the region within the RESIST project.

A central challenge for successful implementation of adaptation measures within the region revolves around the availability of information and data at the municipal levels. While high quality data at the regional and national level is predominantly accessible, a significant deficiency emerges for issues specific to the municipal level. This gap in municipal-level data is pivotal for advancing early warning systems and facilitating proactive response by regional and local authorities in instances of emergency. Additionally, municipal authorities do not always have the necessary technical skills to process and utilise available data resources by themselves. The regional level, however, is confronted with limited monetary and personnel resources.

3.8.3.3 Support needed

The required support for the RESIST initiative in the Baixo Alentejo region is multifaceted. Key aspects revolve around utilizing technology, identifying good practices, and ensuring their effective application, for instance for supporting adaptation action in small, rural villages and localising vulnerable groups. Here, support in improving early warning systems and utilising digital solutions would be highly beneficial. Another area where support is required is innovative financing models, potentially involving the private sector, to increase the region's financial resources for adaptation. Moreover, pursuing more innovative and efficient ways to engage stakeholders is of interest to the region. Lastly, support would be welcomed to identify and integrate social risks into the regional adaptation strategy.

3.8.4 Stakeholders and capacities

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In the Baixo Alentejo region, municipalities, local networks and civil protection are considered the most important stakeholders, as they act at the local level. CIMBAL, the Intermunicipal Community of the region (in Portuguese: Comunidade Intermunicipal do Baixo Alentejo), is the local authority coordinating climate adaptation efforts and is responsible for the regional adaptation strategy. Important local authorities from the civil protection sector include the National Emergency and Civil Protection Authority, the National Republican Guard, and the fire brigades. Further, the Parish Councils are considered crucial stakeholders due to their proximity to the population and importance in identifying vulnerable groups.

Regional administrative entities, including the Institute for the Conservation of Nature and Forests in Alentejo (ICNF Alentejo), along with the central administration of Alentejo (CCDR Alentejo), represent additional crucial stakeholders. They play a pivotal role in accessing information pertaining to climate change and adaptation. An overview of important stakeholders as identified by CIMBAL is provided in Figure 15.

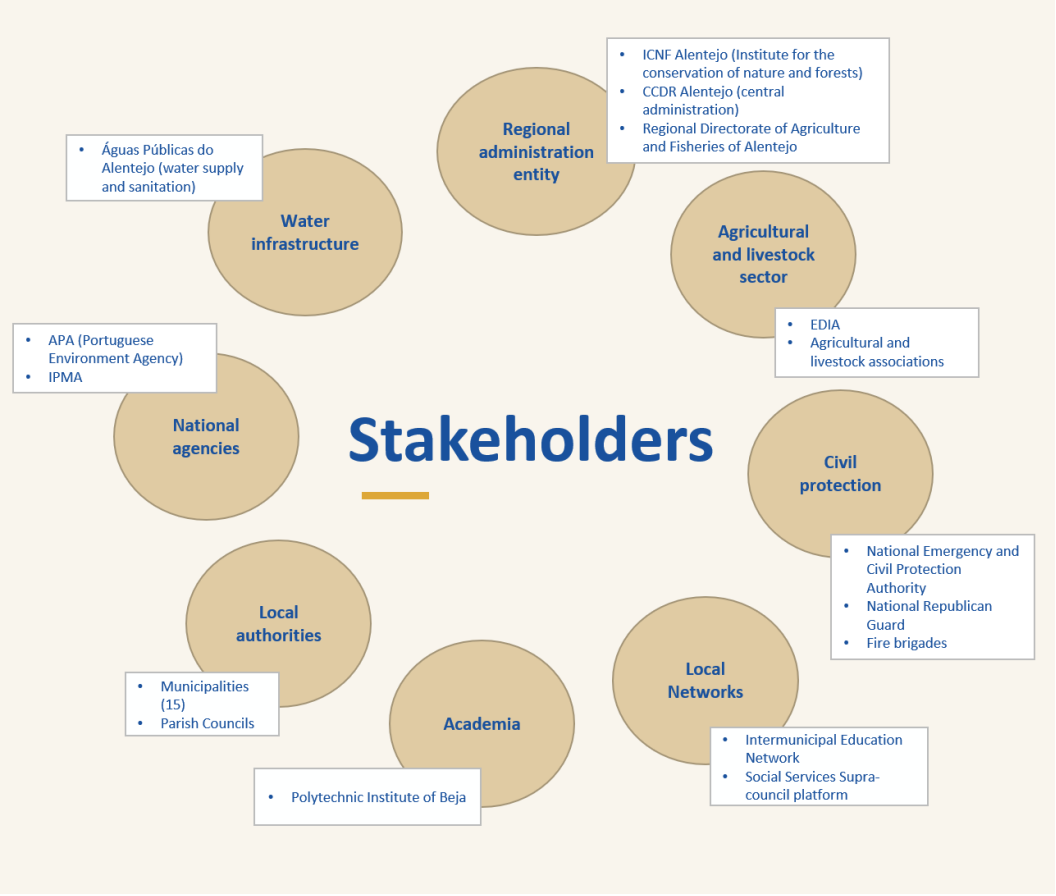

Figure 15: Relevant stakeholders in Baixo Alentejo.

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Baixo Alentejo encounters two primary capacity constraints constraining the implementation of adaptation measures. Foremost is the challenge of funding. CIMBAL, as the executing public entity of the RESIST project, relies on financial support from national resources, EU projects, and has also used funding from European Environment Ageancy (EEA) Grants for a recently completed project. Consequently, it is crucial to actively navigate these avenues to ensure sufficient funding for future adaptation efforts. The second constraint pertains to data availability at municipal level. The situation is further compounded by issues relating to technical and human resources within municipalities, particularly concerning their capacity to effectively utilize data.

3.8.5 Potentials for transfer

Based on this assessment's results, various entry points for transfer activities with other regions were identified, based on the region's explicit interests and the identified needs. The following topics could be further explored for transfer activities:

- **Digital solutions and early warning systems.** Investigating how LSDTs' activities and good practices have contributed to improving early warning systems and the localization of vulnerable populations (potentially addressing civil protection issues in rural areas), and whether these approaches can be transferred.
- **Innovative financing models.** Assessing the potential of innovative financing models, such as private sector financing, to access additional funding for future adaptation efforts. If other twinning regions or LSDTs already have experience with innovative financing models, learnings and best practice cases could be shared.
- **Considerations of social risks and vulnerabilities, stronger consideration of vulnerable groups and gender aspects.** Investigating the vulnerability of various population groups, and identifying social risks. Integrating these risks into the regional adaptation strategy, considering the needs of vulnerable groups and gender aspects in adaptation strategies and measures.
- **Data and information availability.** Identifying data gaps and improving municipal-level data availability to enhance the effectiveness of early warning systems and proactive responses in case of emergencies.
- **Engagement of stakeholder and communities.** Baixo Alentejo expressed a strong interest in developing innovative ways to engage stakeholder and the communities which are part of the region. This interest extends to seeking support from other twinning regions or LSDTs in exploring innovative means and potential approaches.
- **Upskilling the regional workforce.** Baixo Alentejo intends to implement measures to enhance the competencies of the regional workforce, including improved coordination mechanisms within Civil Protection. However, as the scope and format are not fully defined yet, solutions and activities from other twinning regions or LSDTs that align with the specific needs of Baixo Alentejo could be considered as entry point.

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- **Adaptation actions in small, rural and dispersed villages.** Identification and implementation of transformative solutions in rural areas with small, dispersed villages, particularly in the sectors of water management (addressing the risk of water scarcity), forest management (addressing the risk of forest fires), and energy (addressing the risk of reduced hydroelectric power production). Experiences from other twinning regions or LSDTs may provide valuable insights.

3.8.6 Results

The Plan for Adaptation to Climate Change in Baixo Alentejo serves as a valuable foundation for the region's climate adaptation endeavours. While it may not yet encompass all aspects of a standard CRA, it provides essential insights into key hazards and an in-depth analysis of affected sectors. To enhance future risk assessments, the region should consider a risk framework that distinguishes between vulnerability, exposure, and hazard, with particular attention to vulnerability factors. Moreover, secondary hazards like wildfires, landslides, river flooding, flash floods, and soil erosion should be explicitly considered, along with their potential changes over time.

Baixo Alentejo demonstrates robust municipal planning in civil protection and wildfire management, with the Intermunicipal Climate Change Adaptation Plan as the cornerstone of the regional adaptation strategy. The plan does not explicitly address vulnerable groups, an aspect which could be further explored in future revisions. Furthermore, there is potential for synergies between the adaptation plan and the Baixo Alentejo Supramunicipal Housing Strategy, which does address vulnerable groups but not climate adaptation in housing.

Within the RESIST project, a diverse set of measures is envisaged, although many are still in the early planning phase. A summary of key planned activities within RESIST can be found in Table 30. As one of the key measures, the region aims to enhance and strengthen stakeholder and community engagement capabilities. A special interest lies in supporting adaptation in small, rural villages, addressing water management, fires prevention and energy issues, although specific measures for this are yet to be defined. Strengthening early warning systems and localizing vulnerable groups, particularly the elderly, is another priority, given the challenges of extreme weather events in sparsely populated regions. A central challenge lies in the availability of municipal-level information and data. While regional and national data is accessible, municipal data is lacking, hindering early warning systems and proactive response. Municipal authorities also face technical limitations, and the regional level has constrained resources.

adelphi can offer valuable support to the municipality of Baixo Alentejo within the RESIST framework in several key areas. Overall, adelphi can support with identifying synergies and common interests across RESIST regions, as well as support the process of identifying concrete transfer activities. Additionally, adelphi can assist in the development of innovative and efficient methods for engaging stakeholders, fostering collaboration, and ensuring a more inclusive and efficient decision-making

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process. Further, adelphi can help identify entry points to integrate social risks into the regional adaptation strategy, ensuring a comprehensive approach to build resilience in the region. adelphi could also support identifying innovative financing models which suit the region's interests and planned measures.

Table 30: Climate impacts, planned adaptation measures and relevant stakeholders in Baixo Alentejo.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Heatwaves **Forest fires**		Training of regional workforce, esp. targeting better coordination in the civil protection sector	Civil protection sector
Heatwaves **Forest fires**		Training and educational workshops in its 13 municipalities (led by CIMBAL), surveys, interactive exhibition	13 municipalities of the region Parish councils Fire brigades
Drought **Heat waves** **Forest fires** **Flooding**		Transfer and deploy EWS tools from Catalonia to the Baixo Alentejo region	Civil protection sector Civil society
Drought **Heatwaves** **Forest fires**		Community and stakeholder engagement	13 municipalities of the region Parish councils Civil society Fire brigades National Emergency and Civil Protection Authority

Challenges and support

The region identified various challenges and needs, both related to and beyond planned project activities. These include supporting rural villages with climate change adaptation measures, improving civil protection coordination, raising climate risk awareness, and implementing effective Early Warning Systems. Other needs include improving the monitoring and evaluation of activities, integrating vulnerable groups into civil protection/EWS, enhancing community involvement, securing adaptation finance, conducting strategic planning, and refining Climate Risk and Vulnerability

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Assessment processes. Table 31 summarizes key challenges and needs, as well as possible support activities by adelphi and transfer activities from other regions.

Table 31: Challenges, needs and support opportunities in Baixo Alentejo.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Support adaptation actions in small, rural and dispersed villages, focussing on: water management (risk of water shortages), forest management (risk of forest fires), energy (risk of reduced production of hydro power)	Support conceptualisation of adaptation strategy for rural areas	Learn from experiences and existing adaptation strategies for rural areas of other regions
Upskill regional workforce, esp. improve coordination in civil protection sector		Exchange of structures and processes which enable effective collaboration in the civil protection sector
Increase climate risk awareness, and appropriate EWS		Transfer and deployment of EWS tools, esp. together with Catalonia
Monitoring and evaluation of activities / initiatives	Support with the creation of processes for monitoring success of activities / initiatives, introduction to monitoring concepts	
Identify vulnerable groups / vulnerable areas and integrate in civil protection / EWS		Learn from and potentially transfer processes and frameworks developed by other regions, esp. Catalonia, on how to identify and address vulnerable groups
Improved community and stakeholder involvement	Co-develop innovative ways to engage stakeholder and the communities, develop overall stakeholder engagement concept	Learn from stakeholder engagement processes in other regions, e.g. Catalonia, SW Finland, Blekinge, and Centro Portugal
Adaptation finance	Introduction to innovative financing models, support set up of finance strategy (together with FASTTRACK)	
Further strategic planning for adaptation activities	Support strategic planning for adaptation activities within RESIST	

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Improved Climate Risk and Vulnerability Assessment	Good practices compilation for conduction Climate Risk and Vulnerability Assessments and exchange with other regions	Exchange with Centro Portugal on best practices

Potentials for transfer

Baixo Alentejo stands out with long experience in forest fire management, both from a regional and municipal perspective: all 13 municipalities have detailed Forest Fire Defence Plans. The region additionally expressed interest in exchanging on other topics, namely screening adaptation measures to prevent maladaptation, implementing natural water management solutions to mitigate water scarcity risks, and integrating the tourism sector into innovative adaptation financing solutions. The region's expertise and interests are summarized in Table 32.

Table 32: Expertise and transfer potentials in Baixo Alentejo.

Strengths and expertise	Topics of interest	Transfer to other regions
Forest fire management, also on municipal level (Municipal Forest Fire Defence Plans)		Share knowledge and experience in effective municipal forest fire management. Exchange with Extremadura (region with experience in modelling of fires, identification and mapping of high-risk areas, and building suppression infrastructures).
	Screening adaptation measures for maladaptation	
	Natural water management solutions to reduce risk of water scarcity	Exchange with Normandy and EMT on utilising NbS and management of freshwater ecosystems
	Including the tourism sector in new adaptation financing solutions	Exchange on possible activities within the tourism sector with Puglia

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3.9 Needs assessment Puglia

3.9.1 Introduction

Located at the south-east tip of the Italian Peninsula (Figure 16), the territory of Puglia (Apulia) comprises an area of 19,345 km² with a population of about 4 million (approx. 210 inhabitants per km²). The region is bordered by the Adriatic Sea and the Ionian Sea, giving it the longest coastline of any Italian region (Santini et al. 2014). Puglia has a typical Mediterranean climate with long hot-dry summers with irregular and scarce precipitation and mild wet winters (Lionello et al. 2014; Elferchichi et al. 2017). Between 400 and 550 mm of rainfall each year occur primarily in winter (Renna et al. 2018).

Figure 16: Location of Puglia.

Puglia stands out for having the most agricultural land used (about 66.4%) and the most farms per area in Italy. The sector is mainly driven by wine, olive oil and wheat production (Santini et al. 2014). As a result, both economically and socially, agriculture is crucial in Puglia (Labianca et al. 2016). Additionally, the region plays an important role in the Italian tourist economy. Although the sector is characterised by a rather pronounced seasonality, with about half of the total arrivals concentrated in the summer months. In the region Tourism activities generate a value added of about 9 billion euros, which represents 13.6% of the regional GDP. A total of 52,000 businesses, or 15.4% of the labour force in the region, employ more than 135,000 people across the entire tourist value chain (CDP S.p.A 2021).

3.9.2 Climate risks

3.9.2.1 Regional climate risk assessments and identified risks

The Puglia region has developed Guidelines for a Regional Climate Change Adaptation Strategy (SRACC) (“Indirizzi per la stesura della Strategia Regionale di adattamento ai cambiamenti climatici”) in 2023. This document includes an analysis of the climate risks and climate scenarios of the last 30 years and provides climate projections for the next 100 years. For each municipality in Puglia a separate detailed climate risk assessment sheet is made available.

The document provides a detailed overview of current and future climate risks in eleven territorial areas, which are mapped according to the Regional Territorial Landscape Plan (PPTR):

1. Gargano

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2. Monti Dauni
3. Tavoliere
4. Ofanto
5. Puglia Centrale
6. Alta Murgia
7. Murgia dei Trulli
8. Arco Ionico Tarantino
9. La Piana Brindisina
10. Tavoliere Salentino
11. Salento delle Serre

Figure 1: Territorial areas of Puglia according to the Regional Territorial Landscape Plan (PPTR).

Main dangers are **floods, landslides, droughts, fires, water safety and heat waves**. For each of the dangers a risk map is presented, where Puglia and neighbouring regions show the current risk levels for the respective risk. To evaluate the future climate risks RCP 4.5 and 8.5 are compared to a reference time period between the years 1979 and 2005. The RCPs are given for the years 2020-2050, 2045-2075 and 2070-2100.

In every territorial area the risk for **flooding** (indicated by total annual precipitation in mm) is constant or slightly increasing: High risk is predicted for the Tavoliere Plain in northern Puglia. Medium to high risks for flooding are around the Ofanto river, Central Puglia and in Salento delle Serre. There is a possible increase in the danger of **forest fires** and lengthening of the fire season (indicated in number of days per year in which the maximum temperature exceeds 25°C) indicated. This could lead to a reduction of areas with conifers, broad-leaved trees, mixed and commercial forests, sclerophyllous vegetation. The risk for **water scarcity** and **droughts** (indicated in cumulative precipitation in the summer moths / consecutive days without rain) is increasing in every area in Puglia. Especially in the Tavoliere plain, Central Puglia, Alta Murgia, Murgia dei Trulli, Arco Ionico Tarantino, Tavoliere Salentino are already showing a medium to high risk for droughts. **Heat waves** (indicated by the number of days with a minimum temperature of 20°C) will be more frequent and intense, leading to higher mortality among the population, a decrease in water quality and availability, an increase in peak summer energy demand and change of the attractiveness of Puglia as a tourist destination (e.g. explosion of the population of algae and jellyfish; decrease in the level of navigable lakes). Most regions predicted to have a medium risk for heat waves in the future. **Coastal erosion or landslides** (indicated by maximum value of daily precipitation) will occur as clear retreats of most sandy beaches and significant portions of the regional coastal territory. Affected areas will be characterised by low altitudes above mean sea level and depressed areas inland the areas facing the gulfs of Manfredonia and Taranto). (Regione Puglia 2023)

This information also overlaps with the climate projections from the EU project Orientgate from 2014, which has analysed Puglia's climate risks, among other regions in south-eastern Europe. Santini et al. shows that the calculations come to the result that the average annual temperature will increase

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by at least 1.4 °C by 2050 and by at least 2.3 °C by 2070 (both RCP4.5). This is accompanied by a reduction of the mean precipitation by at least 3% by 2050 and at least 14% by 2070 (both RCP4.5). The increase in temperature will lead to an increased evapotranspiration rate (until 2070 +7-10%). The northernmost area of Puglia, which is agriculturally productive, will experience the most significant increase in evapotranspiration. In combination with the decrease in precipitation arid conditions will spread all over Puglia. The projections of the worst emission scenario RCP8.5 revealed a mean sea level anomaly of around 10 cm (2021-2050) and 21 cm (2041-2070). In both scenarios, only 2% of the coastal lands of the Puglia Region are at risk. In the mid-term scenario, around 25% (212 km) of the 865 km Puglia coastline were classified as at risk (falling within the low and very low risk categories). In the long-term SLR scenario this risk extended to approximately 29% (250 km) (Santini et al. 2014).

Table 33: Different RCPs for Puglia region (M. Santini et al. 2014).

	Baseline 1976 - 2005	2021-2050 RCP4.5	2021-2050 RCP8.5	2041-2070 RCP4.5	2041-2070 RCP8.5
Mean Annual Temperature	15.4°C	16.8°C	17.1°C	17.7°C	18.4°C
Annual Precipitation	348.3 mm	309.3 mm	337.9 mm	298.1 mm	281.8 mm

The literature indicates that the region is one of the hotspots for desertification risk in Southern Europe as well as one of the most vulnerable regions to degradation in Italy (Nickayin et al. 2022)The literature indicates that the region is one of the hotspots for desertification risk in Southern Europe as well as one of the most vulnerable regions to degradation in Italy (Nickayin et al. 2022). There are few rivers and little surface water due to the high substrate permeability. Therefore, water scarcity is a persistent and aqueducts convey drinking water from neighbouring regions (Lionello et al. 2014). The limitation of available water stocks could trigger severe limitations on productivity in different sectors and worsen the water quality (Ronco et al. 2017). Statistically significant climate trends in Puglia were observed regarding decreasing rainfall intensity and increasing temperature, landslides as well as damaging hydrogeological events (Polemio and Lonigro 2015). Coastal zones, where one can find numerous industries such as tourism and fishing that are crucial to the socio-economic growth of the area, are also vulnerable to climate risks (Santini et al. 2014).

3.9.2.2 Comparison with ESPON data

The ESPON project has identified several prevalent risks for the region of Puglia under current climate conditions. These include:

- flash floods posing a risk to the cultural sector,
- river floods with dangers for population,

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- droughts affecting the primary sector and
- wildfires impacting the environment.

Additionally, risks from heat stress on the population are projected to become increasingly prevalent during the time period 2070-2100 (under a the RCP8.5 high emission scenario). In this category Puglia shows the highest risk among the three regions of LSDT3 while the previously mentioned risks remain high.

3.9.2.3 Potential improvements for climate risk information

It is evident that the gender agenda for Puglia, which was approved in 2021, makes no reference to climate issues or the vulnerability of specific groups to climate risks (Puglia Region 2023). A reference to the Strategy for Sustainable Development for the Puglia region is made on the website, but it is not clear to which aspects exactly.

The civil protection plans of Puglia addresses forest fires in detail and touch upon “predicting, preventing and mitigating risks, managing emergencies and overcoming them”. However, other “meteorological, hydrogeological and hydraulic risk scenarios” or “natural disasters or those caused by human activities” are only vaguely mentioned, for example there are no specific measures to protect the population from flooding, the consequences of heavy rainfall or tectonic events (SAS 2019).

3.9.3 Adaptation measures

3.9.3.1 Existing plans and measures

Important policy documents at national level

The **National Climate Change Adaptation Strategy** (“Strategia Nazionale di Adattamento ai Cambiamenti Climatici” - SNAC) was finalised by the Italian government in July 2014 and approved by the State-Region Conference in October 2014. Presently, the **National Plan for Adaptation to Climate Change** (“Piano Nazionale di Adattamento ai Cambiamenti Climatici - PNACC) is in its final stages of approval process after its release in December 2022. It contains 361 measures within five macro-categories (information, organisational and participatory processes, governance, adaptation and improvement of systems / infrastructures, nature-based-solutions). The PNACC also includes a national observatory for climate change adaptation for monitoring and updating of the adaptation plans (Moraca 2023). Also in 2022 the Ministry of Environment and Energy Security launched a National Platform on Climate Change Adaptation “(…) to promote the exchange of information between the central administration, local authorities and all stakeholders, starting from citizens, with respect to the issue of adaptation to climate change (…)” (MASE 2023b). Another plan approved in 2021 is the National Recovery and Resilience Plan (“Piano Nazionale do Ripresa e Resilienza” –

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PNRR) which includes the “Green revolution and ecological transition” – mission. The Ecological Transition Plan (Piano per la Transizione Ecologica - PTE) from 2022 is another plan to support environmental and energy policy objectives. The objective is the climate neutrality by 2050 and reduction of greenhouse gas emissions by at least 55% by 2030 with a broad range of measures reaching from promoting sustainable mobility to restoring biodiversity and combating hydrogeological instability.

In addition, the region applied to the European Commission to serve as the Territorial Coordinator of the Covenant of Mayors for Climate & Energy in 2018. The aim is to establish a “Climate Pact” with the mayors of Puglian municipalities, assisting in the implementation of a common strategy and in the planning of coordinated actions to deal with the potential impacts of climate change and mitigation policies.

Important policy documents at regional level

The region has developed the Guidelines for Drafting the **Regional Climate Change Adaptation Strategy** (SRACC) in 2023 to support the future drafting of the SRACC. It consists of three main sections, giving an overview of existing plans and programmes, analysing the climate context, assessing the risks and dangers and giving suggestions on possible actions and measures to be applied. It is being developed by an external agency, which includes some climate change projections for the next 15 and 30 years together with risk sheets for each municipality in Puglia (Regione Puglia 2023). The document includes a “Platform of Action”, which defines 109 actions within 16 sectors for five macro categories that specify the project typology into information, organisational and participatory processes, governance, adaptation and improvement of systems and infrastructures and solutions based on ecosystem services. These actions are aimed at floods, landslides, droughts, fires, water safety and heat waves. Six actions are specifically aimed at the tourism sector:

1) Risk: Landslides

- Conservation and reconstruction of natural coastal environments

2) Risk: Heat Waves

- Monitoring and warning systems in case of extreme weather events in urban areas
- Sustainability monitoring systems (environmental, social and economic) of tourist destinations
- Conservation and reconstruction of natural coastal environments
- Reforestation of urban areas and the creation of green spaces within cities

3) Risk: Water security

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- Conservation and reconstruction of natural coastal environments

Additionally, a strategic document has been prepared in the framework of the Interreg project ADRIACLIM, focusing on coastal areas. In Puglia the Brindisi municipality was part of the case study to implement a climate change monitoring system.

In 2021 an “Experimental programme of interventions for adaptation to climate change in urban areas” (“Programma sperimentale di interventi per l’adattamento ai cambiamenti climatici in ambito urbano”) was launched in 2021 by the Italian Ministry of Environment and Energy Security. This programme subsidises adaptation measures in urban areas with a population of more than 60.000 inhabitants targeting the implementation of green, blue and grey measures (e.g. creation of green spaces, rainwater collecting systems, removal of existing pavement) as well as “soft interventions” (e.g. awareness raising, training, participation measures, forecasting, improving local knowledge) (MASE 2023a). At the time of this report, the contact persons from Puglia were not aware of any measures supported by this programme.

The National Committee for the Fight against Drought and Desertification (“Comitato Nazionale per la Lotta alla Siccità e alla Desertificazione” - CNLSD) has promoted the creation of local action plans (LAP) to fight desertification in some Italian regions, including the Puglia region. The Plan is therefore composed of a descriptive part of the region for its physical, demographic and economic aspects, followed by a section dedicated to the environmental vulnerability of the LAP area and finally by a section dedicated to the identification of specific actions in the various territorial areas. The Province of Foggia was chosen as a pilot area representative of the territory of the Puglia Region to implement integrated measures to combat drought and desertification. (Regione Puglia 2023)

Various former EU programmes had been implemented at the municipal level in the region several years ago. For example, the EU funded LIFE MASTER ADAPT programme supported municipalities of Northern Salento with the identification of main vulnerabilities and intervention priorities in the field of food and drought management. Participatory activities and workshop were carried out to select the priority objectives (Regione Puglia 2023).

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3.9.3.2 Planned adaptation measures within RESIST

As the tourism sector has become economically very important for Puglia in the last 10 to 20 years, the measures of the project will be centred around strengthening the resilience of the sector. Climate change impacts in coastal regions were identified as particularly critical, as there is a lot of pressure on these regions in the summer months, with high tourist numbers and the public sector under stress. The historical problem of water scarcity comes to a peak during these months. However, the region's counterparts do not want to focus exclusively on the water issue, as there are other challenges posed by climate change. For example, fires are a big problem because there are many pine trees along the coast in the tourist areas. Other extreme weather events such as small tornadoes could also be of relevance to include in the RESIST adaptation actions.

In addition, the future of tourism in Puglia should be thought of in a very fundamental way due to the more extreme heat periods. The main tourist season could be spread more around the summer months and the tourist flows could also shift northwards. This requires innovative policies that are important for the development of tourism. So far, no climate adaptation measures have been implemented in the tourism sector but some cities have started to work on this themselves, still relatively at the beginning.

The region therefore would like to focus on the development of guidelines or policy recommendations that promote climate adaptation in the tourism sector. Various stakeholders are to be involved in this process. To this end, one or more pilot regions are to be identified in which local pilots of adaptation measures in the tourism sector can be tested and it can be investigated whether and how they can be scaled up.

Of the six measures developed in the SRACC for the tourism sector (see previous chapter), these three are initially the most interesting and feasible for the regional partner to focus on as part of the RESIST project:

Risk: Landslides

- Conservation and reconstruction of natural coastal environments (for example sustainable beach management)

Risk: Heat Waves

- Sustainability monitoring systems (environmental, social and economic) of tourist destinations
- Reforestation of urban areas and the creation of green spaces within cities

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Once again, it is particularly important to emphasise that these are preliminary considerations and that much of the final effect depends on the results of participatory processes and exchanges with other regions or best practice overviews.

3.9.3.3 Support needed

The regional partners have emphasised the need for methodological support for the two overarching objectives within the project.

- Developing innovative policy recommendations or guidelines within the tourism sector → methodological support needed for:
- Analysis of the regional potential and strengths that can be derived from the SRACC
- Involvement and consideration of vulnerable groups, linking climate adaptation and gender agenda of Puglia
- Informing and convincing local stakeholders, politicians to participate in the process of development and deliberations
- Dealing with scepticism from the stakeholders
- Planning and implementing adaptation measures → methodological support needed for:
- Provision of an overview of good practices for climate adaptation measures in tourism sector from other regions
- Support and facilitate exchange with other (RESIST) regions
- Clarification of which of the SRACC measures are actually most likely to be suitable for implementation in the pilot project(s)
- Organisation of territorial animation activities in pilot regions using the “bottom-up”-approach
- Analysis of insights gained from stakeholder meetings to understand their needs and prioritise actions
- Identification of the measures for implementation in the pilot activities
- Design inclusive and collaborative stakeholder engagement processes

3.9.4 Stakeholders and capacities

The stakeholders comprise various entities and organisations with an interest in climate change adaptation and mitigation and sustainable tourism development in the Puglia region. The notable stakeholders are depicted in Figure 17 and further elaborated in Table 34.

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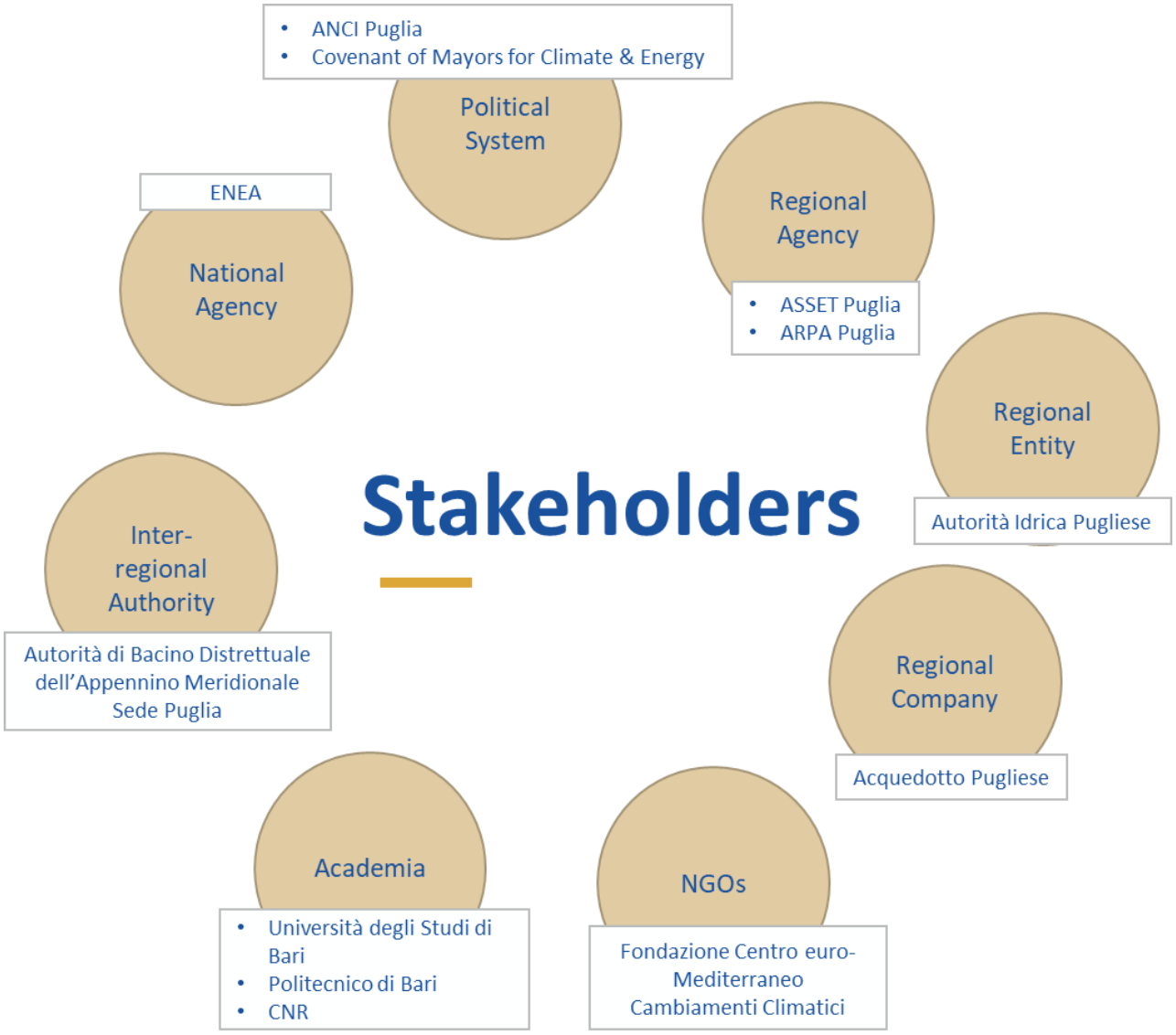

Figure 17: Overview of relevant stakeholders for climate change adaptation in Puglia region.

The discussion with the regional partners highlighted the need to focus efforts on specific areas, such as a particular region within the Salento peninsula, and to focus on engaging a select number of municipalities. However, stakeholders at the regional level remain important, particularly for policy-level activities. In addition to the overview provided, it was mentioned in the interview that stakeholders in the tourism sector in particular are missing. For example, those responsible for coastal / beach management (which is partly organised by the region and partly privately) are not listed here, but will be important if measures under RESIST are to target adaptation in coastal areas.

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There might be a lot of resistance from some stakeholders as they find it hard to accept that the current very positive trend in tourism will change. Some adaptation measures might not be very feasible due to this kind of resistance. In general, the need for capacity and the need to develop guidelines for professionals in the tourism sector for emergency preparedness and response were highlighted.

Table 34: Descriptions of stakeholders in Puglia relevant for measures within RESIST.

Type	Organisation name	Short description
Political System	Municipalities adhering to Covenant of Mayors for Climate & Energy	Supports local authorities in planning actions to address the potential effects of climate change and mitigation policies in a coordinated way with a common strategy. The Regional Coordination Structure utilises the support of the Technical-Scientific Committee.
Political System	Associazione Nazionale Comuni d'Italia (ANCI) Puglia	Regional association, comprising 248 municipalities out of a total of 258 in the region. ANCI Puglia serves as the primary point of contact for the regional institutions regarding all matters of interest to the municipalities. It represents the local councils to the Region, and in coordination with the National Association, to the State, and also to the European Community via the Region.
NGO	Fondazione Centro euro-Mediterraneo Cambiamenti Climatici	Carries out studies, produces forecasts, conducts quantitative analyses on the climate system and its interactions with society.
Regional Company	Acquedotto Pugliese	Manages the integrated water cycle which includes the collection, purification, adduction, accumulation and distribution of water for civil use, but also the sewerage, purification, disposal and reuse of treated water. → Main stakeholder in water supply
Regional Agency	Agenzia Regionale per la Prevenzione e la Protezione dell'Ambiente (ARPA) Puglia	Responsible for carrying out activities and tasks in the field of prevention and environmental protection as a technical Body of the Puglia Region. → Monitoring climate change
Regional Agency	ASSET Puglia	It is a regional strategic agency for the eco-sustainable development of the territory. It is an operational technical body in support of the Region for the definition and management of policies for mobility, urban quality, public works, ecology and the landscape, for the prevention and protection of the territory and hydrogeological and seismic risk. Also, the agency is dedicated to strategic planning, integrated programming, design and implementation of public works.
Regional Entity	Autorità Idrica Pugliese	Representative entity of the municipalities for the public governance of water.
Inter-regional Authority	Autorità di Bacino Distrettuale dell'Appennino Meridionale Sede Puglia	It deals with the defence, protection, use and sustainable management of soil and water resources, the protection of environmental aspects and contributes to the defence, protection and rehabilitation of the soil and subsoil, the qualitative and quantitative protection of water resources, the mitigation of hydrogeological risk, the fight against desertification, the protection of the coastal strip and the rehabilitation of the coast.
Academia	Università degli Studi di Bari	University of Bari
Academia	Politecnico di Bari	Polytechnic University of Bari
Academia	Consiglio Nazionale delle Ricerche (CNR)	Conducts thematic research activities within the Department of Earth System Sciences and Environmental Technologies. The institute is involved in European projects.
National Agency	Agenzia nazionale per le nuove tecnologie, l'energia	Public law body dedicated to research, technological innovation and the provision of advanced services to businesses, the public administration and citizens in the fields of energy, the environment and sustainable economic development.

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	e lo sviluppo economico sostenibile (ENEA)

3.9.5 Potentials for transfer

As the region is still at the beginning of the project activities and the RESIST project will primarily be used to filter the appropriate activities for climate adaptation in the tourism sector, it has not yet been possible to propose any current transfer activities. However, as the project will enable Puglia to build up more expertise and know-how with a special focus on tourism, this will open up transfer opportunities to other regions that wish to become active in this area.

Regarding Puglia's perspective on its interests, the region would welcome to receive input and exchange with other regions on the following topics:

- **Interest in innovative policies.** Puglia expressed a strong interest in developing innovative policies within the tourism sector. This interest extends to seeking support from external sources and exploring potential synergies with other regions.
- **Local-scale piloting.** Puglia intends to initiate pilot projects at the municipality level. This involves considering the adoption of solutions and activities from other twinning regions or LSDTs that align with their specific needs. The discussion highlighted the need to focus efforts on specific areas, such as particular regions within the Salento peninsula and engaging a select number of municipalities.
- **Development of a forecasting tool.** Interest in modelling the impact of climate change on the tourism sector in the coming decades.
- **Nature-based-solutions in tourism**. As other regions are working on different ways to integrate NbS into the project activities, the interest was expressed to see which NbS could be used in the tourism sector, on the one hand as an adaptation measure and on the other hand as something that benefits tourism and increases the attractiveness of a region.

The region would welcome inputs from partners on how they could assist in the process of refining project ideas. Suggestions from partners including overviews of what other LSDTs are currently implementing are very much appreciated.

KU Leuven offered support in developing digital tools once the main issues are identified. These tools could be instrumental in implementing adaptation measures effectively in Puglia's tourism sector.

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3.9.6 Results

The regional strategy was published in autumn 2023 and it still needs to be worked out how the region can use the findings from this guideline. So far, however, the following points can be noted on the basis of a literature research and interviews conducted with regional partners.

Within the context of the needs assessment several critical climate risks have been identified in the Puglia region for focused attention. These risks, as presented in Table 35, encompass water scarcity, forest fires, extreme weather events such as heatwaves and the potential for flooding and landslides. To address these challenges, a set of potential measures aimed at enhancing the region's resilience to climate change were discussed with the regional partners. The primary areas of focus include the development of interventions specifically tailored to make the tourism sector in Puglia more resilient to the impacts of climate change. This involves not only safeguarding the region's vital tourism industry but also fostering sustainability in the face of changing environmental conditions.

Table 35: Climate impacts, planned adaptation measures and relevant stakeholders in Puglia.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Increasing temperature, heat waves, droughts, wild fires **Water scarcity** **More variable rainfall → Erosion, landslides, instability of slopes** **Coastal floods, river floods, hydrogeological instability**	Tourism sector Residents Vulnerable groups	Development of guidelines / policy recommendations for adaptation and mitigation activities in the tourism sector Implementing interventions in pilot area(s)	Regional agencies (civil protection, protection of the environment, mobility) Technical experts (consultants) National Council of Research, Universities Pilot municipalities Private stakeholders in tourism: Beach/ coastal managers, hotel owners, aquaculture value chain

To do so, the region plans to develop guidelines or policy recommendations for adaptation and mitigation activities in the tourism sector. This should also include the implementation of pilot projects within one or more municipalities.

Challenges and support

Table 36 summarises key challenges and needs and possible support activities by adelphi. The central challenges in Puglia relate to the lack of concrete policies and guidelines for climate adaptation measures and greater sustainability in the tourism sector. As a possible support activity an overview of various projects, initiatives, and studies related to understanding and mitigating the

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impact of climate change on tourism in Puglia can be offered. Also compiling a set of "good practices" for conducting Climate Risk Assessments and facilitating the exchange of successful approaches with other regions, was requested by the region. Since the guidelines for the SRACC were published only recently in autumn 2023, the regional partners asked for an analysis of the possibilities and possible strengths within the strategy and how these findings could help with the objectives within RESIST.

Another challenge could be the scepticism towards climate adaptation activities from different stakeholders which can lead to a lack of participation in the activities and less successful implementation of pilot projects. To also support the pilot projects further, the organisation of bottom-up animation activities is needed. On the one hand, these activities are targeting the civil society and depend on successful involvement and participation processes. On the other hand, they also lead to an awareness raising and sensitisation for the topic.

Table 36: Challenges, needs and support opportunities in Puglia.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Lack of concrete policies and interventions towards more sustainability in the tourism sector	Providing an overview of projects / initiatives / studies related to the effects of climate change to tourism sector “Good practices compilation” for conducting CRA and exchange with other regions (outside of RESIST project) Development of a concrete plan within the RESIST framework, outlining Puglia’s objectives and strategies for sustainable tourism development Analyse strengths and possibilities within the SRACC	All LSDTs
Scepticism towards the topic, which can lead to lack of participation	Involvement and consideration of vulnerable population into planning (methodological support) Identification of relevant stakeholders Analysing the insights gathered through stakeholder meetings to understand their needs and prioritise areas for intervention	Catalonia, Normandy, Centro Portugal

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Organising territorial animation activities	Designing inclusive and collaborative stakeholder engagement processes Support local-scale piloting methodologically to initiate pilot projects at the municipality level	Catalonia, Centro Portugal

Potentials for transfer

As the focus of the RESIST project is clearly on the tourism sector, know-how and lessons learned as well as insights into the risks, vulnerabilities and adaptation best practices for the region will be available in the course of the project. This knowledge can be transferred to the regions of Baixo Alentejo and Extremadura in particular (Table 37).

There is also interest in integrating NbS into adaptation measures in the tourism sector, possibly even utilising such measures for tourism. In addition, the interest in a forecasting tool that moderates the climate scenarios and their effects on the tourism sector was mentioned several times.

Table 37: Expertise and transfer potentials in Puglia.

Strengths and expertise	Topics of interest	Transfer to other regions
	Connecting Nature-based-Solutions with touristic activities	
	Development of a forecasting tool to model climate change impacts on the tourism sector in the coming decades	
Potential: Tourism sector vulnerability and risk assessment / lessons-learned		Baixo Alentejo (LSDT 3), Extremadura (LSDT 4)

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3.10 Needs assessment Centro Portugal

3.10.1 Introduction

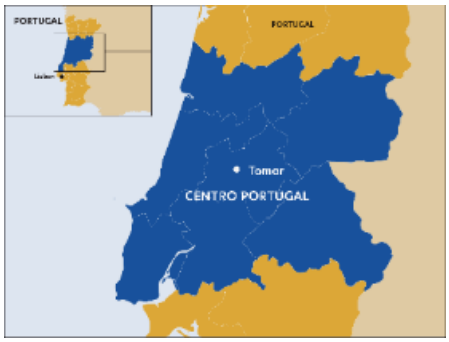

Figure 18: Location of Centro Portugal.

Centro region of Portugal (PT16) has approximately 2.3 million inhabitants and is closely located to Lisbon and Porto (the two bigger cities in Portugal), as well as to the Spanish border (Figure 18). With a geographical position that boasts a central location in mainland Portugal, the Médio Tejo (NUTS3) spans an area of 3,344 km^2 and accommodates a population of nearly 250,000 people (CIM-MT 2019). Coimbra region (NUTS3) covers a total area of 4,336 km^2 with 460,000 inhabitants (Loureiro et al. 2017). According to the Koeppen Climate Classification, they fall within the CsA and CsB climate groups, indicating a temperate climate with either hot (a) or warm (b) summers (Loureiro et al. 2017; CIM-MT 2019). Both regions face similar demographic challenges, such as low birth rates and a growing age dependency rate as well as decreasing population in rural areas due to migration to urban centres and coastal areas. In addition, the small and fragmented land structure was identified as a major challenge in the region during the interviews.

3.10.2 Climate risks

Within this section, the results of the ESPON-CLIMATE assessment and climate risks were described. Regional adaptation endeavours rely on Coordination and Regional Development Commissions (CCDR), Inter-Municipal Councils (CIM) and Metropolitan Areas to address aspects that concern the NUTS2 and NUTS3 level (OECD 2023). CIM's in Médio Tejo and Coimbra developed Intermunicipal Climate Change Adaptation Plans (PIAAC). They assess climate risks and select suitable adaptation measures in the region and on municipal level. Both the PIAAC for the Coimbra region (PIAAC-RC) and the PIAAC for Médio Tejo (PIAAC-MT) have a full list of climate adaptation measures with a focus on sectors identified in the ENAAC and P-3AC (see Chapter X). This approach facilitates a decentralised and context-specific response to climate change, ensuring that local communities could actively engage in climate adaptation efforts (adapt.local - Rede de Municípios para a Adaptação Local às Alterações Climáticas 07.06.2023).

Coimbra Region

The PIAAC-RC summarises information on meteorological parameters, including temperature and precipitation as well as historical data for wind, relative humidity and cloud cover. Changes in temperature and precipitation are depicted in Table 38, including projections for short- and medium-term changes with RCP4.5 and RCP8.5. Annual precipitation is projected to decrease while

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temperature is projected to rise further up to 2°C with RCP8.5. In addition, climate risks such as flood, heavy rainfall, forest fires, SLR and periods with extreme heat (>32°C) are projected to have negative impacts on the region (Loureiro et al. 2017).

Table 38: Projections for temperature and precipitation for the Region Coimbra.

Variable	Historical (1971-2000)	RCP4.5 (2011-2040)	RCP4.5 (2041-2070)	RCP8.5 (2011-2040)	RCP8.5 (2041-2070)
Average monthly temperature "anomalies" (in °C)	13	+1.0	+1.8	+0.6	+2.0
Average monthly precipitation (RCP scenarios: "anomalies") (in mm)	1290.22	-167		-103.4	

Similarly, the ESPON-CLIMATE database identified flash floods, heat and wildfires as the main climate hazards for the Coimbra Region in both the baseline and high emissions scenario. In the high emissions scenario, coastal flooding is added as an additional important hazard. Population is found to be specifically exposed to heat, whereas agricultural, forested, protected and mixed areas are specifically exposed to droughts and wildfires. Population, specifically old-aged and young population groups are specifically sensitive to heat and river floods. Additionally, sensitivity to floods is based on employment in the industry and the overall gross value added of industry located in coastal areas and river basins. Overall, the main climate risks identified for the region are heat, flash floods, wildfires and droughts (Navarro et al. 2022). Within the PIAAC-RC, identical climate hazards are identified, however not for all hazards, vulnerabilities and exposures to these hazards are identified and clearly outlined.

Médio Tejo

In the PIAAC-MT, meteorological parameters are assessed, namely temperature, precipitation and wind speed. As identified in the PIAAC-RC, temperature is projected to increase together with an increase in heat waves with very hot days (>35°C) and a decrease in cold spells. The number of hot days will increase by the end of the century to up to 25 days under RCP4.5 and 59 days in RCP8.5 by the end of the century. Forest fires are accounted as a major risk to the region, based on past events, however no projections are included in the assessment. Precipitation and wind speed are both projected to decrease in both scenarios, with precipitation significantly decreasing in summer months (up to 28%) and increasing in winter months (up to 16%) with PCP8.5 as depicted in Table 39**Fehler! Verweisquelle konnte nicht gefunden werden.**. However heavy and very heavy precipitation events are likely to increase in the future (CIM-MT 2019).

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Table 39: Projections for temperature, precipitation and wind speed for Médio Tejo.

Variable	Historical (1971-2000)	RCP4.5 (2011-2040)	RCP4.5 (2041-2070)	RCP8.5 (2011-2040)	RCP8.5 (2041-2070)
Average monthly temperature "anomalies" (in °C)	13.1	+1.6	+1.6	+2.1	+3.8
Average monthly precipitation (RCP scenarios: "anomalies") (in mm)	895	-64	-31	-42	-47
Average annual wind speed "anomalies" (in km/h)	12.6	-0.1	-0.1	0.0	-0.1

Similarly, in the ESPON dataset, heat, flash floods and wildfire are accounted as the major climate hazards in the region in the baseline scenario with additionally the risk of droughts in the high emissions scenario. Population is specifically highly exposed during heat spells while agricultural, forested, protected and mixed areas are having a high exposure level to droughts and wildfires. Regarding sensitivity, heat and river floods are the aspects to which the population is most susceptible to. Additionally, employment in the industry and the overall gross value added of industry within prone flood zones in river basins are sensitive to floods. Overall, the major climate risks, composed of hazard, exposure, sensitivity and adaptive capacity indicators, are thus heat stress, flash floods, wildfires and droughts (Navarro et al. 2022). The hazards identified by the ESPON dataset are in line with the ones identified in the PIAAC-MT, however the additional dimensions of exposure, sensitivity and adaptive capacity indicators have not yet been taken up in the PIAAC-MT and it'd thus be interesting to additionally include these in further updates to the plan.

The forest sector and its climate risks in Coimbra and Médio Tejo

Within RESIST, a specific focus is laid on forest fires. In the climate risk assessments (CRA) of both regions, forest fires are accounted as one major risk. 23% of the intermunicipal area in Coimbra was affected by fires at least twice between 1990-2013. Between 2010 and 2022, 154179ha burned in the Coimbra region, and around 100269ha in the mid-Tejo region, , giving a total burnt area for the two regions of 254448ha. Forest areas were the most affected (72%), compared to scrubland (21%) and agricultural areas (6%) (ICNF/MAAC 2023).

With climate change, the meteorological fire risk is on the rise, as evidenced by the data from the CIM-RC. Within the forest sector, forest fires represent the most important risk. The meteorological fire risk is predicted to increase for up to 5.2 days of extreme fire risk and 41.3 days of high fire risk under RCP8.5. In addition, water deficit with differing spatial distribution will increase from west to east in the Coimbra region in future scenarios, leaving municipalities in the east with higher water deficit levels which are projected to lead to 46.6% of Region Coimbra's territory area being affected

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by very high and extreme water deficit under RCP8.5. Within the needs assessment interview with the regions, the pulp and paper industry were highlighted as an important economic sector. This is confirmed in the risk assessment of both regions, Coimbra and Médio Tejo, as 33% of gross value added (GVA) of the national turnover of the paper industry is concentrated in the Coimbra region (Loureiro et al. 2017). In Coimbra, 12% of the total GVA is accounted for by the pulp and paper industry. Indicated in the assessment, the forest industry in the region is heavily reliant on a small number of species, namely maritime pine and eucalyptus, for its raw materials. This narrow focus leaves both the wood industry and, to a lesser extent, the paper and pulp industry more vulnerable to the impacts of climate change. A total of 216 forest fires were recorded in 2016 in the Médio Tejo region, resulting in a burnt area of 2,607 hectares. Within many municipalities, forest fire danger is listed as high and very high (CIM-MT 2019).

3.10.2.1 Existing climate risk assessments

PIAAC-RC

The plan was conducted by the CIM of the region of Coimbra with support from researchers of different disciplines from Coimbra University and several external researchers. In the first section of the strategy, a general analysis was conducted to assess current changes in climate variables, including temperature, precipitation, relative humidity, wind speed, insulation variation, and cloud cover across each municipality (Loureiro et al. 2017). Temperature and precipitation were then modelled for both RCP4.5 and 8.5. The plan assesses the main impacts and vulnerabilities in the sectors of agriculture, food, forests, natural areas and biodiversity, water resources, estuaries and coastal zones, infrastructure and energy, tourism, and health. Within each sectoral chapter, a different methodology, models, data etc. were used and analysed by the researchers. Additionally, two workshops were conducted to integrate perspectives of municipal officers. In a last section, the plan describes the adaptation measures identified. Additionally, a survey among different population groups was conducted to integrate the perspectives in the development of the adaptation measures (Loureiro et al. 2017). The strategy is in line with ENAAC 2020 and POSEUR (see Chapter 3.10.1) proposed approach. This targeted approach ensures that the plan effectively addresses the unique vulnerabilities present in the CIMRC.

The PIAAC-RC is a very thorough analysis of climate change effects in the region and the corresponding municipalities. It does not specifically follow a common standard like ISO 14091, however it integrates many best practices following the IPCC AR5 in the PIAAC-RC (Loureiro et al. 2017). However, within the plan, the depth of analysis and methodology varies between sectors that are analysed. It is therefore not possible to directly compare the thematic chapters in their setup and methodology used. This assessment thus considers the overall structure with some specificities of thematic areas. The PIAAC-RC incorporates two climate projections using the IPCC AR5 based emission scenarios RCP4.5 and RCP8.5. It PIAAC-RC focuses both on historical data and on climate change projections and thus considers both short-term (2011-2040) and medium-term (2041-2070)

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changes, with a baseline period of 1971-2000. Within the first part of the assessment a general analysis of current changes in climate variables, such as temperature, precipitation, relative humidity, wind speed and cloud cover was conducted per municipality. Regarding future projections, temperature and precipitation were considered. In the sectoral assessments of the report, different hazards are taken into account, depending on their relevance for the sector.

The assessment covers both extreme events and slow onset events in the respective thematic chapters. However, in some chapters, such as the Human Health thematic area, not all relevant extreme events and their impacts were thoroughly analysed due to a lack of specific data, such as the effects of floods on human health. The assessment incorporates a comprehensive analysis of the socio-economic structure in the region, considering factors such as employment per sector, education levels, housing structures, and the overall economic fabric, all of which are indicators of sensitivity. Due to the diverse authors responsible for writing the sector chapters, there is variation in the analysis and terminology employed throughout the chapters. In certain chapters, a vulnerability framework was developed, focusing on sensitivity and adaptive capacity, and incorporating specific indicators for the analysis. In addition, exposure parameters are included in the assessment, however they are not always clearly named as such. Within the chapter on physical, socio-economic and demographic characterisation of Coimbra Region population changes in the region are modelled, considering current trends in mortality, birth rates, and assumptions about fertility levels and life expectancy. The scenarios are disaggregated by sex and age structure to understand future sensitivity, including age dependency rates. However, the integration of modelled changes is not integrated consistently in the analysis. Within some of the sector chapters, impact chains are defined and analysed, such as Health, Agriculture, Food and Infrastructure, while other sectors like Forest, Biodiversity, Tourism or Energy lack a clear description of impact chains.

The assessment acknowledges uncertainties at the beginning but lacks further elaboration on them. While data sources are provided, uncertainties are occasionally mentioned without a further detailed explanation. Regarding the spatial component of the CRA, there is a specific municipal-level analysis conducted for each thematic area. The spatial component varies depending on the sector and parameters being examined, but overall the analysis incorporates a spatial element to identify areas within the municipalities where certain risks are most prevalent (Loureiro et al. 2017). The fact that there is a municipality-specific analysis in almost all chapters eases the development of adaptation options that are tailored to the very local needs and increase integration of local stakeholders (Ramalho et al. 2022).

Recommendations for improvements

In the needs-assessment of the PIAAC-RC some minor gaps and needs can be identified, highlighting the areas where improvements might be necessary for a more comprehensive understanding of climate risks. Firstly, there is a need for streamlining the development of impact chains, making it easier to comprehend the causal relationships between hazards, exposure and

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vulnerabilities. Additionally, adopting a consistent approach for identifying sensitivity and adaptive capacity per sector would enable a systematic evaluation of each sector's vulnerability, as it was done e.g. in the thematic area of health. In addition, a stronger focus on cross-sectoral interrelations would be beneficial, by considering multiple sectors simultaneously and examining their interrelations, synergies and trade-offs for adaptation measures.

During the analysis it was observed that vulnerable population groups and gender were not always considered. To address this, a clearer focus on vulnerable population groups and gender could be emphasized throughout the analysis. By ensuring their consistent integration in the risk assessments, a more comprehensive understanding of the unique challenges and risks faced by these groups can be achieved. Lastly, a need for an action plan on communication and more citizen engagement was identified, both from the PIAAC-RC and the interview with regional stakeholders. The survey results demonstrated the importance of engaging with the population and municipal technicians on the topic of climate change and adaptation. Only 2.5% of respondents of the population survey ranked climate change as the most important problem. Therefore, developing a strategic communication plan would ensure effective dissemination of the assessment's findings and enhance public awareness and understanding of climate risks. It is also important to decrease resistance of stakeholders from various sectors to changes in the “business as usual” of resource management, as it was mentioned in the stakeholder interview (Loureiro et al. 2017).

PIAAC-MT

The PIAAC-MT was developed in 2017 and is an integrated intermunicipal climate change adaptation strategy. The overall methodology used in the PIAAC-MT draws from the Guidebook of the ClimAdapt-Local project mentioned earlier. It follows a series of steps, including the identification of current and future climate vulnerabilities, and of adaptation options. To gain a comprehensive understanding of past so-called climate events and their impacts on the municipalities and the region, a survey was conducted involving economic agents, associations, media, and other stakeholders. Based on that, projections of climate drivers were developed (CIM-MT 2019). In a second part, options for adaptation are elaborated as well as an implementation and monitoring plan. For each municipality in Médio Tejo, a “Profile of Local Climate Impacts” was developed outlining the main climate hazards (so-called occurrences and climate events), such as number of floods in the municipalities (incl. a brief description of the event and if available, pictures, precipitation data and flow velocity). The information enables the analysis of relevant factors, including the prevalence of specific so-called weather events, the actors involved in response and their planning efforts, past actions and responses implemented. In addition, thematic sections based on nine sectors, including forestry, were developed that include adaptation measures (CIM-MT 2019).

The PIACC-MT encompasses two RCP scenarios, namely 4.5 and 8.5, providing a comprehensive assessment of potential climate outcomes. It also examines medium and long-term changes by integrating historical (1971-2000), mid-century (2041-2070), and end-of-century (2071-2100) time horizons. PIAAC-MT encompasses a range of extreme hazards, including heat spells, cold spells,

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and floods and forest fires, among others, initially identified with surveys among municipal officers. Slow onset changes are only considered to a certain extent, such as changes in precipitation patterns and temperature (CIM-MT 2019). Changes like land loss, degradation and erosion are not considered in the assessment (IPCC 2014). Extreme events were based on temperature-related factors, such as the number of tropical nights and the number of summer days. Precipitation was also assessed, specifically the number of rainy days. Projections were conducted exclusively for precipitation, temperature, and wind, focusing on how these variables are expected to change in the future (CIM-MT 2019).

Regarding the definition of risk, within the PIAAC-MT, it is defined as the probability of harmful consequences or losses resulting from the interaction between climate, human-induced hazards, and the vulnerability of systems. This definition is adapted from ISO 31010 (2009[9]) – Risk assessment techniques - and encompasses a range of potential impacts, including death, injuries, damage to property, disruption of economic activities, and environmental impacts (CIM-MT 2019). Consequently, there are variations in the definitions of vulnerabilities and risks, sometimes leading to confusion. It seems that the terms vulnerability and risk are occasionally used interchangeably, however errors in translation cannot be ruled out. Additionally, the terminology used in the assessment is not always clear, as the distinction between hazards and exposure (referred to as impact) and consequences (referred to as sensitivity) becomes blurred. While adaptive capacity is not explicitly mentioned on a regional level, it is addressed in some municipal plans under the concept of response capacity, which is interpreted differently in various contexts. Within the study a table identifies climate hazards (so called climate events), impacts and so-called consequences. Consequences identified include both exposure and sensitivity factors, such as “damages to health” or the ”increase in the number of deaths and respiratory diseases” (CIM-MT 2019).

It has to be pointed out that the definition of climate risks differs in the report from the current internationally accepted definition according to the IPCC 2014. It is thus important to acknowledge the differences in the terminology and definitions used in this assessment, as it may influence the interpretation and understanding of climate risks. Impacts in the assessment are understood as hazards (floods, fires) mixed with exposure and sensitivity (damage to production chains; diseases related to heat; damage to vegetation). These so-called impacts are then coupled with so-called consequences which include the loss of agricultural crops, closure of public spaces or loss of vegetation. The assessment thus does not have clear impact chains that are disaggregated by hazards, exposure and vulnerability. Instead, the plan identified the most important climatic events in the region and links them to consequences and affected sectors. The analysis of adaptive capacity is not directly based on impact chains but describes it on a more general level, including the identification of agencies and institutions that were and will be active in the response to past or future events. Data sources are detailed. However, a clear referral to the matter of uncertainties is missing

[9] A newer version is available, ISO 31010:2019.

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in the report (CIM-MT 2019). Incomplete knowledge, disagreements or the lack of information should be transparently reflected in the PIAAC-MT, based on the robustness of evidences of findings (IPCC 2014).

Recommendations for improvements

The assessment of climate risks both in present and future could be enhanced in future updates when including an explicit consideration of exposure, sensitivity, and adaptive capacity within the analysis. Currently, these aspects are indirectly mentioned, however clearly pointing out which population groups are most at risk and which infrastructure is most exposed and sensitive to climatic changes would enhance the clarity of the assessment. Furthermore, climate risks such as floods should be modelled based on the two RCPs used in the analysis to get a more thorough risk analysis. Another aspect is the development of clear impact chains and the integration of models specifically designed for assessing further climate hazards. Using impact chains would also support the development of adaptation options based on a comprehensive understanding of all climate risk components. Using a standardized terminology ensures a common understanding among stakeholders, enabling effective communication and collaboration in addressing climate risks. Furthermore, there is a need to show the link between adaptation options developed and the hazard, exposure and vulnerability of a respective sector. This allows for a more targeted and efficient allocation of resources and enables decision-makers to prioritize actions based on their potential for effective risk reduction.

3.10.3 Adaptation measures

3.10.3.1 Existing plans and measures

Important policy documents on national level

The **Climate Law** of 31 December 2021 (n.º 98/2021) establishes the right to a balanced climate and sets ambitious targets for various sectors regarding mitigation and adaptation. It introduces novel concepts like climate refugee, climate justice, and environmental health into the country's legal framework. The primary aim of the law is to achieve carbon neutrality by 2050, with provisions for the government to explore the possibility of attaining this goal even earlier, by 2045. In addition, a significant part is dedicated to climate adaptation (Assembleia da República 2021).

The first Portuguese CRA was conducted in 2002 with the name SIAM. The deliverable at hand does not go into details of this assessment as currently a new CRA for Portugal is being carried out, the so-called **National Roadmap for Adaptation 2100** (RNA 2100). It will contain information on current and future vulnerabilities of Portugal and an assessment of investment needs for adaptation until 2100, including an analysis of the costs of inaction (Agencia Portuguesa Do Ambiente 06.06.2023).

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The **National Adaptation Strategy** (Estratégia Nacional de Adaptação às Alterações Climáticas (ENAAC), is the foundation for national climate adaptation and is valid until 2025 (Agencia Portuguesa Do Ambiente 2015). The strategy aims at integrating adaptation measures into sectorial policies and territorial planning. The priority sectors for ENAAC include agriculture, biodiversity, economy, energy and energy security, forests, human health, safety of people and goods, transport, communications and coastal areas. It additionally provides support to central, regional, and local authorities in identifying effective methods and resources for implementing adaptation strategies (Agencia Portuguesa Do Ambiente 2015). Within the strategy, climate change impacts were identified for Portugal and sectorial working groups were established to achieve a better understanding of climate risks and to develop sectoral adaptation plans. The programme **POSEUR**, a program created by the European Commission in 2016 as part of the Portugal 2020 Strategy supports the implementation of adaptation measures and focuses on promoting sustainable growth and addressing the challenges of transitioning to a low-carbon economy. The programme aims to achieve this by encouraging the efficient use of resources and enhancing resilience to climate risks and disasters (Portugal 2020 and European Commission n.d.).

Based on the ENAAC, a **National Adaptation Plan (P-3AC)** was developed with the goal of implementing adaptation measures, based on planning exercises at national, regional and municipal level. The strategy comprises eight lines of action. It emphasizes the importance of preventing rural fires through structural interventions in agricultural and forestry sectors. The strategy also focuses on minimizing flood risks, increasing coastal protection, and developing decision support tools, capacity building initiatives, and awareness-raising actions (Agencia Portuguesa Do Ambiente 06.06.2023; UNFCCC 2021).

Overview of relevant policy documents at regional and municipal level

PIAAC-MT and PIAAC-RC

As mentioned in the ENAAC, its goal is to develop and implement adaptation strategies on a regional level. To further promote the integration of climate adaptation strategies and plans at the intermunicipal level, the ClimAdapt.PT project was initiated. This project specifically focused on supporting intermunicipal associations in the development of local adaptation plans, thereby fostering a bottom-up approach. Through trainings for local officers, the project aimed to build capacity and empower municipalities to effectively address climate change challenges. By developing guidance documents developed by the project, municipalities were equipped with the necessary tools and resources to formulate their own tailored adaptation strategies, the above mentioned PIAACs.

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PIAAC-RC

The PIAAC-RC incorporates specific lines of action based on relevant thematic areas identified for the region. Through detailed sector descriptions and assessments, a total of 39 adaptation measures, consisting of 68 individual actions, are proposed for implementation (Loureiro et al. 2017). Each adaptation measure was developed upon a clear so-called *diagnosis*, which is based on the respective sectoral risk assessment (Loureiro et al. 2017). The identified adaptation measures were classified into four types: acceptance of impacts/losses, prevention measures and risk reduction, compensation of losses and risk sharing, and new opportunities. The actions were further categorized based on their urgency for implementation, estimated effectiveness, no-regret actions, and win-win actions. The integration of no-regret actions and win-win actions as a category for adaptation measure can be seen as a first indication that the avoidance of maladaptation was considered (Loureiro et al. 2017). Furthermore, sector-specific action sheets were developed, providing an elaboration on the adaptation measures for each sector, including their objectives, typology, costs, effectiveness, and monitoring indicators. Moreover, for each action, other sectors that are touched upon, alignment with European, national and regional strategies and programmes of financing are outlined. However, no ex-ante cost-benefit analysis or similar assessment was done so far to get a clearer picture on the overall effectiveness of the measure. While reviewing the adaptation measures, it is evident that the majority of measures lack a specific focus on gender and vulnerable groups. However, some measures do address specifically vulnerable groups, such as the Action I XII.3.1, which involves the creation of an intersectoral team to intervene in the community during crises. This measure specifically targets vulnerable populations, including the elderly, children, pregnant women, and chronically ill individuals. Vulnerable groups are particularly addressed in the sector human health and the “Measure I XII.3 Improving knowledge and support for the most vulnerable social groups“ (Loureiro et al. 2017). Nature-based solutions (NbS) are discernible in the outlined actions, such as in measures that entail the creation of green infrastructures or conservation of biodiversity in urban areas (Loureiro et al. 2017). Nonetheless, based on this first assessment of the adaptation plans, a prioritisation of NbS cannot be ascertained. When looking **at the forest sector**, most adaptation measures are aimed at boosting the forestry industry. One example is Action | VI.4.2 Support for innovative projects in the forestry sector. Here the aim is to support and stimulate the revitalization of less competitive sub-sectors of the forestry industry, such as cork, and hence support a diversification of income sources. The adaptation measure includes an ideation competition for innovative ideas on products (Loureiro et al. 2017).

PIAAC-MT

In a first step, adaptation options were identified. Based on that first selection, 21 core adaptation options for Médio Tejo were chosen in the first round, clustered according to the thematic areas/ sectors. The measures were additionally grouped by type of measure (grey infrastructure, green infrastructure, non-structural options) as well as scope (improve adaptive capacity, reduce vulnerability and/or seize opportunities). More general measures are consolidated into an action

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guide that focuses on four overarching measures: "risk and impact assessment," "planning and preparation," "communication and awareness-raising," and "civic participation". Within the municipality-specific measures, 187 specific measures were evaluated. The 21 core adaptation measures for Médio Tejo are further described including objectives, planned activities, barriers, estimated costs, indicators for monitoring and involved agencies and financing options. Adaptation options are allocated into the categories of no-regrets, low-/limited-regret, always win-win and flexible/adaptive management and hence the risk of maladaptation is reduced (CIM-MT 2019). Furthermore, each option is assessed according to their additional impacts in the different sectors and hereby, the intersectionality of options highlighted. Regarding transformational adaptation actions, some can be classified as such, such as the action of promotion and dissemination of innovative techniques and good behavioural practices on circular economy (water, waste, forest biomass). Out of the 21 priority actions, 14 actions include at least some aspects of green infrastructure. Vulnerable groups and gender are only partially addressed in the adaption guide, for example in measure No. 16 “Development of a contingency plan to cope with extreme temperatures-heat waved and cold spells in Médio Tejo” (CIM-MT 2019). Even though the specific vulnerability of particular groups is highlighted in the sector of human health, the corresponding adaptation measures do not exhibit a specific consideration of these groups. In addition, gender is not taken up as a distinct dimension in adaptation measures, thus gender-sensitive planning does not seem to have been a priority for adaptation planning. In total, PIAAC-MT has five adaptation measures that are directed towards the forestry sector, all with the goal of reducing the risk of forest fires and increasing resilience (CIM-MT 2019). The measures include trainings and mechanisms on good practices in forest management. Regarding forest fires, there is one specific measure dedicated to this climate risk. The main objectives are to reduce the biomass fuel and thus reduce the risk of forest fires in the region. This is intended to be achieved by increasing the use of best practices and creating a working group at inter-municipal level for steering the process on updating municipal plans on forest fire fighting. Economic valorisation of biomass should additionally be enabled through the collection and intermediate storage of biomass left over from forestry and agricultural activities in rural areas (CIM-MT 2019). Important barriers are characterized by institutional complexity and the intricate task of liaising with multiple stakeholders, which was reiterated in the interview conducted with regional stakeholders (CIM-MT 2019).

Summary

The assessment of the two PIAAC adaptation measures revealed certain aspects that could be enhanced in future updates:

- rather **low presence of a gender and vulnerable groups dimension** in the formulation of adaptation measures, highlighting the need for their integration
- thorough examination of potential maladaptation of proposed adaptation measures
- more importance of transforming incremental adaptation measures into transformative measures

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- assessment revealed a lack of sufficient attention to cross-sectoral issues, which should be addressed for more holistic planning

3.10.3.2 Planned adaptation measures

Within RESIST, the forest sector and its associated risks concerning climate change play a significant role (see 3.10.2.1). In response, the Coimbra region has set goals to promote improved land use, forest management, and the bio-circularity of green bio-waste within its PIAAC-RC (Loureiro et al. 2017). This involves implementing changes in land use and promote active management measures, as well as effectively managing biomass around settlements. There is a focus on enhancing the participatory and governance model of the Integrated Areas of Landscape Management (AIGP) and "village condominiums" regional programs (DG Território n.d.a, n.d.b). Additionally, the plan explores innovative economic models for private owners to increase the resilience of territories to rural and forest fires. One of the key objectives is to **develop new systems for the valorisation of lignocellulosic biomass, transforming it into high-value bio-based products**. This involves implementing a new planning and governance mechanism for biomass collection that is economically viable and to increase the value and efficiency in the biorefinery process. In the Region Médio Tejo, the project has a specific focus on collecting and transporting local biomass to an existing gasification reactor operated by the Instituto Politécnico de Portalegre. The primary objective is to contribute to the region's energy source diversification, thereby enhancing the overall security and resilience of the regional energy system. The goals include the valorisation of biomass derived from fuel management actions, the conversion of biomass into renewable gases, and the reduction of wildfire risk in the pilot areas. The anticipated results for this multifunctional bio-economy pilot region encompass:

- the optimisation of forest management practices,
- enhanced fire prevention measures,
- the promotion of circular economy principles, and
- the establishment of business models based on the outcomes of the pilot area.

Both regions thus intent to integrate AIGPs and measures for forest resilience and economic development which involves implementing a series of measures to facilitate changes in land use and occupation, as well as managing fuels around the vicinity of settlements, which is in line with adaptation measures outlined in both PIAACs (Loureiro et al. 2017; CIM-MT 2019). The pilots will involve the following key stakeholders in the region:

- Regional Authority (CCDRC),
- Subregional administrations the CIM in Coimbra and Médio Tejo,
- Polytechnic Portalegre for R&D,

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- Médio-Tejo 21,
- CoLAB Forestwise, and
- The interface/technology center BLC3.

The AIGP is a transformative adaptation measure as it integrates forest fire management, sustainable land use practices, and economic valorisation of biomass to build resilience and adapt to climate change. It aims at managing the forest in an integrated way to create enduring changes in land management and promote collaboration among stakeholders. In addition, it is intended to involve stakeholders at various stages. Within both projects, stakeholder consultations and meetings are planned and some were already conducted. They form an important step in ownership, and the importance of stakeholder engagement, and effective communication. In Coimbra, CoLAB Forestwise has actively participated in the process and conducted on-site visits. The initial meetings played a pivotal role in comprehending the requisite methodologies. A comprehensive work plan will be developed to incorporate the knowledge acquired from these meetings.

According to the regional partners and additional sources, the following challenges could affect the project:

- **Fragmented and small land structure sizes, large number of land owners and abandonment of land**: leads to the built up of fuels, increasing thus the risk for wildfires. In addition, it makes communication activities and streamlining actions a challenge
- **Convincing land owners to adapt their land management practices and recognize private forest owners' prevention measures:** Private forest owners are vital for preventing wildfires through land management, yet their efforts often go unrecognized in government policies.
- **Old-age dependency in project regions**: considering the needs and vulnerabilities of elderly as old-age dependency was considered a contributing aspect to exposure and vulnerability within both PIAACs as well as the ESPON CLIMATE assessment (CIM-MT 2019; Loureiro et al. 2017; Navarro et al. 2022). In addition, a study conducted recently outlines the importance of integrating elderly within adaptation measures: "In the face of a fire situation, and in addition to the difficulties associated with age and illness, indirect fire products such as smoke and gases substantially affect these people" (Rodrigues et al. 2022).
- **Inclusion of the private sector (specifically pulp and paper factories)**: As mentioned in chapter 3.4.2., the industry accounts for a substantial percentage of the region's GVA (Loureiro et al. 2017). Within the region, the industry is characterised by two major companies - important stakeholders that could be considered in involving the RESIST action as they were said to act as certain role models concerning forest management.

From six case study areas that are defined and set for 2024, four are selected as village condominiums (in the Municipalities of Mortágua, Condeixa, Coimbra and Góis) and two as AIGPs

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(in the Municipalities of Tábua and Vila Nova de Poiares). In total, 14 areas (municipalities) will be part of the project. In the other areas, exchanges are currently underway with political leaders.

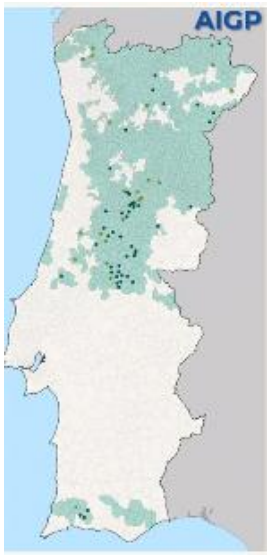

Figure 19 & Figure 20: Maps showing locations of the AIGPs and the village condominiums.

Coimbra

In 2023, the first meetings with stakeholders in the project areas took place until mid-December 2023. In addition, it is intended to conduct a study on the participatory and governance model of the regional AIGPs and village condominiums. In addition, the development of a guiding document for the functional bioeconomy tool methodologies is underway that will be published soon. Furthermore, communication/ stakeholder engagement plans were developed for the pilot areas, that includes ways on how communities and stakeholders can be approached, with, in the initial phase, a specific focus on local authorities. Lastly, capacity development measures started, including trainings for technicians and of operational staff with CoLAB ForestWISE. Field visits will be promoted to show landowners' best management practices. Furthermore, BLC3 will start collecting samples in the pilot areas of interest to start carrying out the analyses. The following tables depict the interventions planned for 2024:

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Table 40: Potential planned intervention areas of 2024, size and year of Centro Portugal.

Municipalities	Area (ha)	Intervention year
Vila Nova de Poiares	10,7	2024
Tábua	12,0	2024
Góis	8,7	2024
Condeixa-a-Nova	9,9	2024
Coimbra	12,0	2024
Mortágua	10,0	2024

Table 41: Planned intervention areas of 2025 and 2026 in Centro Portugal.

Municipalities	Intervention Year
Mira	2025
Penela	2025
Soure	2025
Lousã	2025
Pampilhosa da Serra	2025
Cantanhede	2025
Montemor-o-Velho	2026
Oliveira do Hospital	2026
Figueira da Foz	2026
Mealhada	2026
Arganil	2026
Miranda do Corvo	2026
Penacova	2026

Médio Tejo

In 2023, the first meetings were held with the project partners and stakeholders in the project areas. Technical site visits were also carried out, and two pilot areas (two municipalities) were selected to start the fuel management work, based on integrated landscape management and village condo-miniums / protection of urban settlements.

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After selecting the areas, an initial meeting was held with the landowners to present the project and involve them in it. In addition, a shredder was purchased to support the fuel management work and the collection and transportation of biomass from the forest to the gasifier is being prepared. Two municipalities have been selected (Mação and Sardoal), covering a total of 160 hectares. Fuel management activities will begin in 2024 in the municipality of Mação.

3.10.4 Stakeholders and community engagement

The regional partners mention the following organisations as the stakeholders involved for the work envisioned:

- Regional Authorities (CCDR-C)
- Intermunicipal Communities of the Coimbra region (CIM-RC, covering 19 municipalities) of Médio Tejo (CIMT, 11 municipalities in the 2021-2027 framework period)
- Polytechnic Portalegre
- CoLAB ForestWISE
- MédioTejo21 (regional agency for energy and the environment)
- BLC3 - Campus de Tecnologia e Inovação

In the survey conducted at the project start, the additional stakeholders mentioned in the table below were named as important. They include certain municipalities, bodies from the central administration, an organisation focussed on nature conservation, two associations dealing with land use (forestry mostly, but one also with agriculture) as well as local universities.

Table 42: Relevant stakeholders in LSD4.

Organisation	Type	Location	Short description	Involvement/Importance for RESIST
Municipality of Mação	State, government, political system	Mação	Municipality from Médio Tejo region	Not directly involved in the pilot but still important because the management role of AIGP (Intervention Landscape Management Areas) together with Aflomação
Municipality of Sardoal	State, government, political system	Sardoal	Municipality from Médio Tejo region	Not directly involved in the pilot but still important because the management role of AIGP (Intervention Landscape Management Areas) together with the Association of Farmers of the Municipalities of Abrantes, Constância, Sardoal and Mação
ICNF	State, government, political system	Médio Tejo	Institute for the Conservation of nature and forests, is an indirect	Not directly involved in the pilot but still important because of ICNF important role in the preservation of the forest

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			administration body of the Portuguese State	
Associação dos Agricultores de Abrantes, Constância, Sardoal e Mação	Environment/natural protection NGOs and civil society	Abrantes	Forestry and agriculture Association	Not directly involved in the pilot but still important because Association manages the ZIF (Forest Intervention Zones) and the AIGP (Integrated Landscape Management Areas) of Mação
Aflomação	Environment/natural protection NGOs and civil society	Mação	Forestry Association	Not directly involved in the pilot but still important because Aflomação manages the ZIF (Forest Intervention Zones) and the AIGP (Integrated Landscape Management Areas) of Mação
APA	State, government, political system	Centro	Central Administration	Checking interventions along water lines
IPC	Academia, universities, higher education system	Coimbra	Polytechnic Institute.	Incorporation of scientific knowledge
UC	Academia, universities, higher education system	Coimbra	University	Incorporation of scientific knowledge
ANEPC	State, government, political system	Coimbra	Central Administration	Implementation of the Safe Village and Safe People programme
AGIF	State, government, political system	Centro	Central Administration	Incorporating knowledge into the project

Going beyond this, it seems plausible that the following actors constitute relevant stakeholders for the activities planned:

- Private landowners including commercial landowners such as farmers or companies from the pulp and paper industry as the project activities will focus on exploring innovative economic models to private landowners;

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- Environmental NGOs aside from ICNF that is mentioned above as they might have an interest with respect to the impact of land use changes on biodiversity;
- National government as future national regulation or incentives might affect how landowners make use of their land;

The main activities in LSD 4 will be aimed at private landowners. Hence the project partners in Médio Tejo will schedule meetings with the entities involved in the AIGP (Integrated Areas of Landscape Managements) that are closely in touch with private landowners. The meetings have not yet been scheduled but the current work plan foresees such meetings and discussions. Partners in Coimbra have done first site visits for the demonstration activities and are scheduling the next meetings with stakeholders in the area in July.

3.10.4.1 Opposing actors and interests

Regarding possible opposition to project activities, it will be essential to demonstrate that the solutions for better land use that are piloted in the context of RESIST in LSD 4 can also offer economic benefits to those who could be implementing them later on, i.e. private landowners. If the land use changes however would not lead to direct economic benefits for those implementing them, it seems a lot less likely that they will be implemented. Thus, it is important to keep the incentive structure of private landowners in mind. It is important to identify areas which, although they present a high risk to the population, currently have economic value for forest owners, such as eucalyptus stands. In these cases, alternative measures should be considered to minimise economic losses.

Companies that own forest land have not been involved in the project so far but are seen as important stakeholders. However, it is unclear in how far they would support or oppose activities or outputs from the project. This shall be investigated further in the coming months.

Overall, it is worth mentioning that landownership in the area is very fragmented, i.e. land is parcelled into rather small cells so there is a large number of individuals who all own a small piece of land. Thus, it is quite challenging to involve all of them in systematic way.

3.10.5 Capacity and capacity constraints

Funding and financial capacity

Past activities for adaptation to the impacts of climate change as well as the village condominiums in LSD 4 received funding via the Operational Program of Sustainability and Efficiency in the Use of Resources (POSEUR) or from funds from the Fundo Florestal Permanente/Fundo Ambiental or, most recently, from the EU Recovery and Resilience Facility.

For the financing of planned adaptation measures in the region it is planned to tap into one or more of the following sources:

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- Operational Program of Sustainability and Efficiency in the Use of Resources (POSEUR)
- PT2030 – Strategy framed in the regional operational program.
- Horizon Europe
- Interreg POCTEP

Regarding innovative financing approaches it is worth mentioning that CIMT is cooperating with entities of the private sector in the scope of the Just Transition Fund, regarding the closure of Pego (Coal) Thermoelectric Plant. With respect to additional financing needs, specifically upscaling of the adaptation measures is at the core. Additionally, economically incentivising land owners for participating in adapted land management is another issue that was raised, which will require financial means. An analysis of these incentives can support reasoning for additional financing.

Institutional capacity

Looking at all of Portugal, the assessments, strategies and measures mentioned above make it seem plausible that the institutional context for adaptation is improving and capacities to deal with impacts of climate change are available. This is also reflected by the fact that the Portuguese municipalities' coverage by adaptation strategies and plans has increased from only 1 percent to 88 percent in the last six years (UNFCCC, 2021, p. 24).

However, there are a number of limitations and barriers that should be kept in mind as the Portuguese environment agency states on its website (see https://www.apambiente.pt/clima/politicas-e-medidas-de-adaptacao).

- "Limited knowledge of the nature and magnitude of current and/or future climate risks and vulnerabilities;
- Absence of policies, regulations, norms or guidelines that encourage the perpetuation of the status quo;
- Existence of legal or regulatory restrictions that represent real impediments to the adoption of measures;
- No or restricted access to appropriate technologies;
- The prohibitive costs of the adaptation measures identified in relation to the available budgets;
- Lack of human capacity and competencies within the organization;
- Rigidity and social, cultural or financial conflicts and aversion to change (existing or perceived as such);
- Decision-making and planning processes with a focus on the short term;
- Lack of ability to deal with uncertainty;
- Lack or reduced awareness of the need to adapt on the part of decision-makers;
- Believing that there is plenty of time to start deciding on adaptation;

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- Lack of knowledge and precedent in the implementation of adaptation measures;" (translated by adelphi)

Focusing on the capacity needs and constraints in the region at hand, a number of challenges were mentioned by the regional partners:

- Demographic challenges, i.e. aging and decreasing of rural population ;
- Disappearance of traditional activities linked to the rural world (i.e. pastoralism, resin harvesting, beekeeping, etc.)
- Microeconomic structure: businesses are made up of small units with low capacities for innovation or take up of new technology; also: very low capacities for exporting products;
- Rather small labour pool with a limited number of skilled workers;
- Networking culture is still incipient, which does not allow for the harnessing of the region's technical, human and material resources of the region;
- Fragmented and small land structure size;
- Inefficient mobility and transport system;
- Difficulty in obtaining financial resources.

Needless to say, the regional partners are well aware of these limitations and are working with or around them. Below, activities and solutions are listed that address these challenges, such as stakeholder engagement formats, and economic analyses.

3.10.6 Results

Overall, forest fires and droughts are the main climate risks in Centro Portugal (Table 43**Fehler! Verweisquelle konnte nicht gefunden werden.**). Having a risk assessment that informs about the hazards, exposure and vulnerabilities is thus key to adequately adapt to climate risks. The RESIST measures tackle the forest fire risk by implementing adapted land management coupled with the valorisation of biomass of forest residues. This leads to new economic chances for the region and specifically the pilot sites. Other climate risks relevant to the region, which are however not addressed within the RESIST project include erosion (loss of fertile soil), flash floods, and heat stress.

Table 43: Climate impacts, planned adaptation measures and relevant stakeholders in Centro Portugal.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities

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Droughts (Water deficit)	Private sector companies in forestry Population in villages Private land owners (Forestry)	Genetic mapping of best performance plants (trees/shrubs) against hydric stress /Molecular Biology & Plant Health & Preventing models by BLC3	BLC3 (ICNF)
Forest Fires	Private sector companies in forestry Population in villages (specifically vulnerable groups such as elderly) Private land owners (Forestry)	Setup of Village Condominiums and AIGPs (sustainable land-use practices to prevent forest fires and economic valorisation of biomass)	CCDRC CIM MT CIM RC CoLAB ForestWISE BLC3 MédioTejo21 IPP Local authorities (municipalities of Mação, Sardoal, Mortágua, Condeixa, Coimbra and Góis, Tábua and Vila Nova de Poiares) Forest owners Local population ICNF and other NGOs Associação dos Agricultores de Abrantes, Constância, Sardoal e Mação Aflomação APA IPC UC ANEPC AGIF

Challenges and support

The main challenges include aspects related to the socio-economic and environmental aspects, such as a relatively high old-age dependency and scattered, unmanaged forest plots with many different land owners. Throughout the analysis of the CRA of Coimbra and Médio Tejo, and the assessment and needs of the RESIST measures, there are a number of options for supporting and broadening the activities in LSD 4 (Table 44):

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- **Future updates of PIAACs**: Overall the two existing PIAACs are integral documents for adaptation planning in the regions. There are some aspects that could be enhanced within future updates of the plans, such as the integration of clear climate risks disaggregated by exposure, sensitivity and adaptive capacity. Furthermore, a more specific focus could be laid on vulnerable groups and gender aspects within the two plans, to ensure equity and the perspective of the most vulnerable in adaptation measures planned upon identified climate risks.
- **Cross-sectoral stakeholder engagement** is an integral part for success of the pilots and is already planned to be integrated within the project. One aspect could be the involvement of actors from the private sector to support and potentially scale up activities in addition to outlining benefits to forest owners beyond the reduction of the forest fire risk to increase the interest in participating.
- **Outlining benefits of adapting land management**: For the solutions to be adopted by private landowners, it is important that they offer adequate economic benefits. This needs to be kept in mind all along the way of implementing the demonstrator activities. In this context, it seems beneficial to gather and compile data on the economic benefits that targeted landowners are currently achieving with their land use in addition to providing incentive mechanisms. Once there is a clear picture on this, it might be easier to demonstrate the attractiveness of alternative land use solutions.
- **Integration of the perspective of vulnerable population groups**: Regarding the adaptation measures planned within the RESIST project, integrating the perspective of vulnerable population groups is also an important aspect that should be considered. RESIST can assist with integrating that perspective by identifying potential vulnerable groups in the planned pilot areas and taking respective measures into account for needs of these groups, based on the ethics and gender framework that will be developed. adelphi can additionally support Forest Wise with, e.g. identifying adequate workshop formats and further fostering community engagement.
- **Supporting screening with Maladaptation Tool.** adelphi can support the screening of the pilot measures for potential maladaptation.
- **Inclusion of the pulp and paper companies in the project areas**: There are quite a few Portuguese companies from the pulp and paper industry in the region[10] or connected with the region. Larger companies that are publicly traded – like “The Navigator Company” for example – are currently facing several new regulations like the EU Taxonomy or the Corporate Sustainability Reporting Directive that will require them to investigate and address physical climate risks. Hence, there might be quite some interest of the private sector to engage with the RESIST team and to contribute to making solutions work in the region. Hence, it would make sense to investigate how the pulp and paper industry is perceiving and adapting to climate risks. Building on

[10] see https://www.europages.pt/empresas/portugal/centro/fabricante%20produtor/papel%20-%20fabricantes.html

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this, options of possible collaborations with these actors could be drawn up and subsequently be discussed with them.

Table 44: Challenges, needs and support opportunities in Centro Portugal.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Ageing population (age dependency) and low population density (emigration from rural areas) → addressing vulnerable groups and social equity dimension (protection from forest fires)	Vulnerability assessment Mapping of needs and interests of stakeholders	
Fragmented and small land structure sizes & large number of land owners & abandonment of land → Adaptation of land management practices → Designing inclusive and collaborative stakeholder engagement processes	Guidelines for inclusive stakeholder engagement; design of formats, potentially based on TRANSFORMAR Playbook Design of citizen engagement formats and brochures	Best practice exchange on stakeholder engagement
Convincing land owners of land management adaptation needs → Recognition of private owner prevention measures (not reflected in policy yet)	Mapping of needs and interests of stakeholders & provide guidelines for inclusive stakeholder engagement Assessing of economic benefits of adapted land management practices & analysis of co-benefits for increasing the willingness to adapt land management for land owners (incentives) Policy recommendation on integration of forest owners in land management (incl incentives) Communication toolkit and products (together with REVOLVE) Integrate usage of GDT (with AugmentCity) Support of the development of a training concept for land owners	Extremadura is interested in policy brief for both highlighting the importance of private land owners in land management adaptation and for assessing incentives and benefits beyond the reduction of fire risk
Involvement pulp and paper industry	Workshop concept for private company involvement	

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Enhance fire prevention mechanisms beyond land management adaptation	Facilitate stakeholder discussion with DRR (fire department etc.)	Exchange with Extremadura on creating a suppression infrastructure so that official fire services can more easily extinguish fires
New governance mechanism for biomass collection and valorisation → economic assessment of new bioeconomy approach	Economic assessment of new bioeconomy approach, e.g. through a CBA approach	Best practice CBA approaches from Central Denmark, SW Finland
Monitoring of measures implemented (new bioeconomy approach)	Support in the development of a monitoring framework, e.g. with exchange with ORORATECH (AI company working on monitoring forest fire risks and beyond) (together with KU Leuven)	
Screening for maladaptation and unintended consequences of measures (ex-ante)	Adelphi can facilitate session on applying the REGILIENCE maladaptation tool	
Identification of new financing mechanisms/ adaptation finance	Session of REGILIENCE financing tool for finding adequate financing sources	

Potentials for transfer

One of RESIST's core activities is the exchange of knowledge, good practices and learnings. In the following table, strengths and expertise of Centro Portugal are summarised, that can be shared with other regions and will be part of a transfer framework.

Table 45: Expertise and transfer potentials in Centro Portugal.

Strengths and expertise	Topics of interest	Transfer to other regions
Stakeholder engagement practices	Motivation of forest owners to participate	Stakeholder engagement
Development of a sound CRA (specifically Coimbra)		CRA best practice exchange
Drought-adapted tree/shrub analysis		Extremadura
Approach for implementing AIGPs and village condominiums (adapted land management and monetarisation of forest fuel)		Extremadura, Baixo Alentejo

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	Development of new economic models for attracting investment	
	Assessment of economic benefits for land-owners	
	Synergies of adaptation measures for biodiversity	
	Monitoring of fire risks (GIS-based)	

Going beyond RESIST

A successful and well-documented demonstration of the innovative solutions would be most important for upscaling the approach that leads to transformative adaptation. As set out above, it is difficult to achieve change in the face of these obstacles like an aging population and little capacities for innovation. The bio-economy approach that is implemented and tested within RESIST can be a valuable forest-management and revenue-generating resilience measure that has the potential to be upscaled in regions across the Mediterranean facing similar challenges. Implementing an incentivising policy framework to do so is thus of utter importance to advance the economic valorisation of biomass also in other regions.

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3.11 Needs assessment Extremadura

3.11.1 Introduction

Extremadura is a region renowned for its warm climate in Spain, has an average maximum temperature of 22 °C. It encompasses a substantial land area of approximately 41,634 km^2, making it one of the country's large regions. Extremadura faces distinctive demographic patterns with a low population density of 25.55 inhabitants per km² (Pérez Fernandes et al. 2011c). Around 1.09 million people live in the region, distributed across 388 municipalities, where Las Hurdes and Sierra de Gata constitute two distinct municipalities in which the RESIST project will be active in 24 municipalities (Interview with University of Extremadura; Junta de Extremadura; Fundecyt, 2023).

Figure 2: Location of Extremadura

The landscape of Extremadura is characterized by thick forests. The region experiences an annual forest growth rate of approximately 2%, further contributing to the complexity of its ecological dynamics. These dense forests hold an abundance of fuel wood resources, rendering the susceptibility to the emergence of forest fires. In addition, population decline and the decline in land management increase the risk of forest fires. Climate change also plays an important role in the increased risk for forests. Rising temperature and a decline in precipitation lead to higher fire risks, whereas torrential rainfall can lead to erosion and the loss of fertile soil, threatening the forests.

Las Hurdes and Sierra de Gata

Northern Cáceres mountainous province in which Las Hurdes and Sierra de Gata are located is characterized by a sub-humid Mediterranean climate. Las Hurdes covers 46,268 ha across five municipalities, while Sierra de Gata encompasses 111,024 ha across 18 municipalities. Despite its vast area, the population in this region is relatively sparse, with only 17,675 inhabitants and a population density of 11.9 persons per km² (Interview with University of Extremadura; Junta de Extremadura; Fundecyt, 2023). The prevailing demographic trend reveals the highest rate of rural population in overall Spain with 49.1%, with the majority (59%) residing in municipalities with fewer than 5,000 inhabitants in the region (dRural 03.04.2023). One notable demographic trend in the region is the age distribution, where a significant fraction of the population is over 60 years old (Pérez Fernandes et al. 2011c).

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Table 46: Facts about Las Hurdes and Sierra de Gata.

Facts	Las Hurdes	Sierra de Gata
Area (ha)	46,268	111,024
Population decline since 1960s	48.4%	41.4%
Forest cover (of total area)	81.0%	91.7%

Over the years, both areas have experienced a substantial decline in population, with Sierra de Gata witnessing a decline of 41.4% since 1960, and Las Hurdes experiencing an even more significant decline of 48.4% during the same period.

Sierra de Gata is predominantly covered by forests, accounting for 91.7% of its area, while Las Hurdes has 81.0% forest cover. The most prevalent forest stands in these regions are pine (31.1%) and oak (15.5%). However, the dense shrubland, covering 43.8% of the landscape, and a dense shrub layer especially in the pine-dominated regions, makes it susceptible to forest fires. Large forest fires, with an area greater than 100 ha, have been relatively frequent. The population decline has had significant effects on land management practices. With fewer people living in the area, the direct involvement of the population in land management has decreased drastically over the years. In 1976, 48.4% of the population was engaged in direct land management activities, whereas by 2021, this number had reduced to 14.8% (Interview with University of Extremadura; Junta de Extremadura; Fundecyt, 2023).

3.11.2 Climate risks

3.11.2.1 Regional climate risk assessments and identified risks

In 2014, regional bodies developed the **Estrategia de Cambio Climático de Extremadura 2013-2020** (2014), based on the **Estrategia de Cambio Climático para Extremadura 2009-2012** (2009) with a simplified but more ambitious structure. The strategy summarises targets and activities to be taken in order to tackle challenges regarding climate change. Actions and targets are based on the following sectors, integrating approaches to reduce GHG emissions and promote adaptation measures: transport, industrial, residential and urban planning, tertiary sector, administration, waste, governance, research and development, agriculture, and energy. The strategy includes 187 measures compared to previously 51 in the former strategy, that comply with a total of 46 objectives, structured into 11 activity sectors. Per sector, objectives and measures are proposed, mainly for mitigation within a limited number also for adaptation to climate change, such as the optimisation of irrigation techniques in the agricultural sector and the reduction of water consumption. Out of the 187 measures, there is one measure (No. 151) on forest fires, namely the development of prevention plans in Extremadura (Pérez Fernandes et al. 2009; Bastos Martín et al. 2014).

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Within the previous climate change strategy (2009-2012), one immediate measure was implemented by Junta de Extremadura, the development of a study mapping the climate risks in Extremadura and the most important sectors. The **Mapa del Cambio Climático en Extremadura** (hereafter abbreviated as MCCE) was conducted in 2011. It serves as a baseline knowledge for climate risks in the region is so far the central document analysing the impacts and risks of climate change in the region. The MCCE analyses changes in precipitation and temperature patterns as well as extreme weather events within the twelve geographical areas of Extremadura. The MCCE includes the following sectoral plans: livestock, agriculture, forest, biodiversity, water, energy, tourism, health and insurance. The sectoral analyses entail specific climate risks relevant for the specific sectors and outline suitable adaptation measures (Pérez Fernandes et al. 2011c).

Within the scope of the MCCE and the relevant sectoral plans, the RESIST project area encompassing Las Hurdes and Sierra de Gata (Zone I in the MCCE) has undergone an analysis of key meteorological parameters, namely temperature and precipitation (Table 47). Regarding future maximum temperatures in the project area, it is projected that temperatures will increase. Maximum temperatures are expected range between 25 °C and 26 °C in the project areas by 2025 and 2050. At the same time, projected minimum temperatures exhibit a significant increase, with a rise of 2 °C compared to the reference period, reaching up to 12-13 °C by 2050 in the RESIST project area. This projected rise in minimum temperatures will also lead to a decrease in the number of frost days (Pérez Fernandes et al. 2011c).

Table 47: Increase and decrease of climate variables (Pérez Fernandes et al. 2011b).

Variations compared to 1961-1990	2011-2040 Scenario A2	2011-2040 Scenario B2	2041-2070 Scenario A2	2041-2070 Scenario B2
Minimum Temperature (°C)	1.5-2	1.5-2	3-3.5	2.5-3
Maximum Temperature (°C)	2-3	2.5-3	4.5-5	3.5-4.5
Average Precipitation (mm)	-150 to -100	-150 to -100	-150 to -250	-150 to -100

The region's annual rainfall during the baseline period exceeded 700mm. Nonetheless, concerning projections reveal a substantial decrease in precipitation, with an annual reduction of up to 115mm until 2025 and an estimated decline of 500mm per year until 2050. This reduction in rainfall poses a significant threat to the native flora and fauna, as well as the agricultural, energy, and industrial sectors within the area. The implications are particularly concerning for rainfed agriculture. Notably, in the B2 scenario, projections reveal an increase in rainfall for the project area by 2050 (Pérez Fernandes et al. 2011c).

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Extreme events

Extreme events in the RESIST project area pose significant challenges and potential risks. *Flooding* is a concern, as it can cause severe damage to the infrastructure of the livestock sector. Moreover, *heavy precipitation* is associated with *soil erosion*, leading to loss of crop productivity and soil quality, as well as reduced soil retention capacity. In Extremadura, rainfall-induced erosion is the primary cause of fertile soil loss and ultimately contributes to desertification. Some regions within the RESIST area are at high and medium risk of erosion, future projected occurrence varies for different climate scenarios, with a decreasing probability for A2 scenario and an increasing probability for the B2 scenario for 2041-2070 (over 176 mm of rainfall in 24 hours). The RESIST project areas, with their geomorphological characteristics of steep slopes and narrow valleys, are particularly prone to flash floods after heavy rain (Pérez Fernandes et al. 2011c).

Regarding *forest fires*, Extremadura has experienced a considerable number of fires, with intentional human activities triggering almost half of the incidents in 2009. The evolution of extreme temperatures associated with climate change plays a crucial role in the ignition and propagation of forest fires. Higher temperatures increase the likelihood of fires starting on forested land and facilitate their spread due to heightened flammability of materials under increased heat. Climate change will likely influence the fire regime, leading to more ignitions and easier propagation, as aridity increases, summer rainfall decreases, and extreme temperatures become more likely, drying out fuels and promoting ignition. It is projected that in 2045-2054 in both A2 and B2 scenarios, the number of days with extreme fire risk (>41°C) will reach up to 150-275 days/ decade and 300-450 days/ decade for high risk (>39°C) (Pérez Fernandes et al. 2011b; Pérez Fernandes et al. 2011c). The following risk levels were used:

Table 48: Temperature thresholds for fire risk (left) and number of days per decade where thresholds are exceeded under the emission scenarios (right) (Pérez Fernandes et al. 2011a).

Risk Type	Temperature threshold (°C)
Moderate risk	35
High risk	39
Extreme risk	41

Number of days per decade above	2021-2030 A2	2021-2030 B2	2045-2054 A2	2045-2054 B2
Moderate risk >35 °C	500-650	500-600	650-750	600-700
High risk >39 °C	250-350	150-300	300-450	300-450
Extreme risk >41 °C	50-200	50-200	150-250	150-275

In addition, *heat waves* pose a significant threat particularly to the RESIST project area, where the percentage of the elderly population is higher compared to other areas in Extremadura. The frequency, duration, and intensity of heat waves are expected to increase from June to September

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(Junta de Extremadura 2011). The heat wave intensity index for the project region indicates the severity of heat waves for different periods. In the baseline, the index ranges from 40-50 °C, while under the A2 and B2 scenarios, it varies from 30-40 °C to 40-45 °C and 45-55 °C to 35-45 °C, respectively (Junta de Extremadura 2011). Droughts and aridification are likely to affect Zone I, with a reduction in precipitation and more unequal distribution. The annual water balance is projected to decrease significantly under both A2 and B2 scenarios, leading to water deficits ranging from -275 to -250 mm for 2011-2040 and -500 to -475 mm for 2041-2070, compared to the average baseline period. Zone I will experience one of the greatest water deficits, and reservoirs will suffer from reduced water levels (Corzo Pantoja et al. 2011c).

The entire area is classified as arid, with a trend towards *aridification* in both scenarios and time frames. By 2041-2070, 70% of Extremadura will have desert characteristics under the A2 scenario, and 20% of the area will be arid. For the B2 scenario, 66% of the area will have desert characteristics, and 33% will be arid. This aridification, coupled with reduced water resources and higher temperatures, can lead to desiccation of forest fuels, increasing the risk of *forest fires* and a loss in agricultural production and livestock rearing. Additionally, agriculture and rainfed farming in Las Hurdes and Sierra de Gata will face specific challenges due to the adverse effects of heat waves and aridification on the edaphic and agrological potential of the area (Pérez Fernandes et al. 2011b).

3.11.2.2 Comparison with ESPON data

The ESPON CLIMATE dataset provides valuable insights into climate hazards, exposure, and vulnerability in Extremadura, Cáceres region (in which Las Hurdes and Sierra de Gata are located in). In the baseline scenario, the main climate risks identified are wildfires affecting forests and protected areas, flash floods impacting cultural heritage, and heat stress affecting the population living in the area (Navarro et al. 2022).

Looking specifically at the RCP8.5 scenario and considering the hazard component, wildfires emerge as the most prominent, followed by heat stress and droughts affecting the primary sector. The risk of heat stress is high due to the region's high population exposure, rising temperatures, and a significant rise in the number of tropical days and nights. Additionally, a high level of sensitivity, as measured by the age dependency ratio, contributes to the risk. Furthermore, wildfires pose a dominant risk as the region experiences numerous days with fire danger, and there is a large exposed area of forests and protected areas. Droughts affecting the primary sector also present a risk, given the hazard of reduced annual mean precipitation and an increased number of consecutive dry days. The agricultural, forested, and mixed areas of the region are exposed to these droughts. On the other hand, flash floods on cultural heritage lose significance in the high emissions scenario, as the hazard (precipitation) reduces. Sensitivity analysis shows that the population is highly sensitive to river floods, but the exposure and hazard levels are relatively low, resulting in less dominant risk compared to other hazards in the region (Navarro et al. 2022; Pérez Fernandes et al. 2011c).

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The identified risks in the ESPON dataset align with the results of the climate risk assessments (CRA) conducted in Extremadura. Droughts, wildfires, and heat waves are indeed among the most pressing risks in the region, supported by available data. These findings underscore the importance of addressing these climate risks and implementing appropriate measures to enhance the region's resilience.

3.11.2.3 Potential improvements for climate risk information

The MCCE, along with its sectoral plans, serves as a knowledge base for the Extremadura region to plan further adaptation actions to address climate risks. Although the MCCE does not follow all aspects relevant to a standard CRA, it provides crucial data and knowledge regarding affected sectors and risks. The assessment includes two climate projections (A2 and B2) based on IPCC AR4 with emission scenarios based on IPCC SRES from 2000 and compares them with the reference period of 1961-1990, short-term projection period of 2025, and medium-term projection period of 2050. Complementarily, an analysis of the averages of the variables has been carried out for the periods 2011-2040 and 2041-2070. The analysis involves the variability of temperature and rainfall, utilizing data from weather stations downscaled to the regional scale by regionalized climate models of the State Meteorological Agency of Spain (Pérez Fernandes et al. 2011c).

Various climate hazards and extreme events, such as heat waves, flooding, forest fires, erosion, snowfall, and heavy precipitation, are considered relevant for the region, more specifically in the sectoral plans. These risks are based on regional data but are assessed based on general literature reviews for each sector. The analysis is thus not necessarily regional-specific but rather outlines potential risks and its consequences in a broader term. For each risk simple cause-and-effect relationship matrices are established between temperature and rainfall changes, the affected sectors, and their implications on sustainable development. However, the analysis lacks specific impact chains that are disaggregated by hazard, exposure, sensitivity, and adaptive capacity. Solely within the sectoral plan on health, sensitivity and exposure are considered as relevant factors contributing to the overall climate risk on e.g. heat.

While the assessment acknowledges uncertainties in broader terms regarding climate projections, further elaboration is limited. The assessment acknowledges uncertainties at the beginning but lacks further elaboration on them. The spatial component of the CRA is considered to identify areas in the region, where certain risks are most pertinent. The analysis incorporates a spatial element, varying depending on the sector and parameters under examination (Pérez Fernandes et al. 2011c; Junta de Extremadura 2011; Pérez Fernandes et al. 2011d; Pérez Fernandes et al. 2011b; Corzo Pantoja et al. 2011b; Corzo Pantoja et al. 2011c; Corzo Pantoja et al. 2011a).

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Recommendations

The most important need that is to mention is an update of the MCCE and its sectoral plans based on the current standards of the IPCC AR5 by using RCP4.5 and RCP8.5 with medium and long-term projections (IPCC 2022). By updating the datasets and models used in the assessment (conducted in 2011), more concrete recommendations and actions regarding adaptation could be extracted and more recent data used. Additionally, the development of impact chains would significantly enhance the quality of the MCCE. By disaggregating the aspects of hazards, exposure, sensitivity and adaptive capacity, the main drivers of risk and vulnerability can be better understood and tailor-made adaptation measures can be developed. Specifically, the identification and modelling of hazards can be improved by integrating more variables besides solely temperature and precipitation for further analysis of certain hazards, such as forest fires or floods. Within the sectoral strategies, it is valuable to establish a clear link between the adaptation options developed per sector and the specific hazard, exposure, and vulnerability. By understanding the unique challenges faced by each sector and tailoring adaptation measures accordingly, the region can maximize its capacity to cope with climate risks and enhance its overall resilience by efficiently allocating resources to the most harmful climate risks and to solutions, that offer the most effective risk reduction. In addition, the development of a dedicated sectoral plan for forests should be considered, since forest fires are a very important risk in the region. In the forestry sector, valuable and up-to-date information and assessments are readily available from various projects, as outlined in chapter 3.11.3.1. These resources can serve as a solid foundation for designing effective adaptation measures tailored to the specific needs of the forestry industry.

3.11.3 Adaptation measures

3.11.3.1 Existing plans and measures

Important policy documents at national level

The **National Plan for Adaptation to Climate Change (PNACC) 2021-2030** serves as the fundamental planning instrument for the country's climate change adaptation and resilience efforts and is part of the strategic energy and climate framework of Spain. It focuses on 18 areas of work, including health, water resources, and biodiversity. The plan advocates for improved governance to enhance coordination and innovation in climate action, encompassing legislation, cost-benefit assessment, planning, and management for both public and private sectors. The Climate Change Adaptation 3° Working Programme of the PNACC has established a three-year work program to ensure continuity and progress, outlining specific adaptation measures for each sector. It consists of four axes and two pillars to continue the PNACC's ongoing efforts effectively. The axes involve generating knowledge related to climate change impact assessment, vulnerability, and adaptation, integrating adaptation into regulations, mobilizing key actors, and establishing a system of indicators and evidence for climate change impacts and adaptation in Spain. The work programs within the

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PNACC provide detailed measures and plans within specific timeframes, with the first program covering 2021-2025 and specifying relevant organizations, budgets, and timelines to effectively implement the adaptation measures outlined (Ministerio para la Transición Ecológica y el Reto Demográfico 2020).

A recent **royal decree-law of 2022 adopting urgent measures on forest fires** (15/2022, of 1 August), based on the forest law of 2003 (43/2003, of November 21), has the goal to manage forest fires more effectively on a national, intersectoral level, considering growing threats like global warming and rural demographic changes. It forces autonomous regions to adapt their services and provisions regarding prevention, extinction and maintenance and restoration of affected forest land. The Ministerio para la Transición Ecológica y el Reto Demográfico aims at developing a tool for forest fire zoning with the goal to improve forest fire forecasts and decision-making of actions. In addition, it eases state aid for forest restoration in respective fire-prone areas (Jefatura del Estado 2022).

Based on the national strategies and the actions defined that affect the regions such as regionalised climate assessments, the autonomous communities have developed their own adaptation strategies and plans as outlined in chapter 3.11.2.1.

Overview of relevant policy documents and adaptation measures at regional level

The **Plan Extremeño Integrado de Energía y Clima 2021-2030 (PEIEC)** focuses on climate change actions in Extremadura, prioritizing mitigation, adaptation, research, innovation, and social engagement. It addresses decarbonization, renewable energies, and energy efficiency while considering the region's unique challenges and opportunities, while tailoring them to the reality of Extremadura. PEIEC currently has two adaptation measures compared to 33 mitigation measures, as one major measure within adaptation is to develop an updated Climate Change Adaptation Strategy that will contain adaptation actions within sectoral adaptation plans (Consejería para la Transición Ecológica y Sostenibilidad 2021). Within the PEIEC, the outline of the Climate Change Adaptation Strategy is already developed, following the IPCC AR5 for CRA, as proposed in chapter 3.11.2.3.

As there is currently no updated version, the Climate Change Strategy of Extremadura 2013-2020, the MCCE together with the sectoral adaptation plans (see chapter 3.11.2.1) are the most recent documents outlining adaptation measures in the region (Bastos Martín et al. 2014; Consejería para la Transición Ecológica y Sostenibilidad 2021). Adaptation plans were developed for the following sectors: agriculture, livestock, risks and securities, energy, tourism, water resources and health. They all contain a dedicated assessment of risks based on the MCCE document with a specific focus on the sectoral risks (Pérez Fernandes et al. 2011c; Junta de Extremadura 2011; Pérez Fernandes et al. 2011d; Pérez Fernandes et al. 2011b; Corzo Pantoja et al. 2011b; Corzo Pantoja et al. 2011c; Corzo Pantoja et al. 2011a). The plans outline dedicated measures supporting the adaptation

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process in the region. They were intended to be dynamic documents that needed constant updating and revision. This to our knowledge however has not been the case.

Another important document that takes a wider approach is the **Estrategia para el Desarollo Sostenible de Extremadura**. It contains a framework for a broader field of action based on sustainable development regarding the environment, economic and social aspects. Within the chapter on environment, climate change is taken up and mainly includes aspects based on the Climate Change Strategy for Extremadura 2009-2012 (Pérez Fernandes et al. 2011a).

The **Extremadura 2030 Plan** is a visionary Green and Circular Economy Strategy that sets ambitious goals for sustainable economic and social development in the region. It aims to enhance the region's economic power while addressing pressing environmental and climate change issues, including biodiversity loss and aridification. The strategy follows international frameworks such as Agenda 2030 and the Paris Agreement, aiming at alignment with global sustainability targets. It emphasizes broad inclusion, targeting the entire region with a specific focus on empowering women and young people. Public participation is central to the plan, ensuring that stakeholders have a say in shaping its implementation. Within the framework, a **new forest plan is proposed**, aiming to foster sustainable forest management practices and maximize the positive impact on the environment. An essential aspect of the Extremadura 2030 plan is the envisioned strategy for forest bio-economy, which seeks to unlock the potential of forests as a source of sustainable economic activities. By integrating a circular approach, the plan envisions using forest resources in a manner that ensures their regeneration and long-term viability, while simultaneously supporting the economic prosperity of the region, e.g. through biomass valorisation (Junta de Extremadura 2017).

The Plan Forestal (PFEx) is an instrument of strategic planning of the forest policy. It includes an assessment of the current status of Extremadura forest landscapes and regulates forest management, including a methodology for forest fire defence and risk management. The **Plan de Prevención de Incendios Forestales de Extremadura** (PREIFEX) is a comprehensive framework aimed at addressing specifically the forest fire risks in the region. Extremadura is categorized into four zones based on forest fire danger, with the RESIST region falling into zone 4, representing high risk areas. The plan mandates the establishment of prevention plans for all forest areas >400 ha or if located in high risk areas with a forest size >200 ha, encouraging forest owners to collaborate by forming unions known as prevention and extinction groups to jointly develop these plans. To ensure effectiveness, the prevention plans encompass detailed descriptions of the existing vegetation, available infrastructure such as accessible water points, roads, and constructed fire breaks. Additionally, city councils are obligated to create peri-urban prevention plans to safeguard areas at the interface between urban centres and forested landscapes. In addition, it includes actions that have to be taken for fire prevention. Reviews of the prevention plans are scheduled every four years to incorporate new data and adapt strategies to evolving conditions, reinforcing the region's commitment to proactive forest fire management and safeguarding its valuable natural resources (Junta de Extremadura 2006).

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The **Plan de Lucha contra los Incendios Forestales de Extremadura** (INFOEX) is an action plan designed to actively combat forest fires in the region. It uses the same categorisation as the plan named above, and organizes forest fire fighting actions and efforts through management plans. The plan emphasizes social participation in fire extinction activities and is overseen by a technical advisory body and a permanent commission. During firefighting operations, coordination is ensured through a regional operating centre responsible for managing fire response and resources effectively (Junta de Extremadura 2010).

The sectoral adaptation measures developed by Junta de Extremadura are based on the MCCE and the Climate Change Strategy 2009-2012 of Extremadura. In general, the adaptation section of the sectoral strategies is organized into adaptation programs, addressing thematic areas with specific goals. For example, one program might aim to "[i]ncrease the availability of water resources through the application of water retention and storage techniques." These programs are developed based on climate impact assessments relevant to each sector. They outline intended objectives, impacts, and benefits, as well as reference documents from international, national, and regional levels, such as frameworks, laws, plans, and ongoing projects that pertain to the adaptation actions. However, the descriptions of actions within each program are relatively brief and generic and the link to the climate risk is not outlined via a clear impact chain that outlines the exposure, sensitivity and adaptive capacity of the system considered (Corzo Pantoja et al. 2011c).

For instance, an action may focus on “Development and implementation of technologies for rainwater and dew collection, water storage, and distribution,” with the indicator “annual volume of rainwater collected.” The actions often lack specific baseline or target values for impact monitoring. This makes it challenging to measure and track the effectiveness of the adaptation measures over time. To enhance the effectiveness of adaptation strategies, it would be beneficial to provide more detailed and quantifiable targets for each action, allowing for better assessment and accountability in achieving the intended benefits and goals of the adaptation programs. To increase the focus further, one could also formulate the overall goals for each programme in a way that makes the progress towards each goal more measurable.

Additionally, gender and vulnerable groups are not specifically considered in the adaptation measures with one exemption that is the adaptation plan for the health sector. Within that sectoral plan, vulnerable groups, including the elderly, children under ten years, and individuals with health conditions, are given significant consideration. These groups are recognized as sensitive populations, as they are more susceptible to the impacts of climate change. Both sensitivity and adaptive capacity are assessed and considered for the development of adaptation measures. In every adaptation program and action, special attention is devoted to acknowledging and addressing the specific needs and challenges faced by these vulnerable populations (Junta de Extremadura 2011).

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Specifically considering forest fires as an important climate risk, it is barely presented in adaptation measures within the sectoral plans although it was determined as a significant threat within the MCCE. Forests are recognized as important areas for water retention and storage to ensure a functioning hydrological cycle in the sectoral plan of water resources, in addition within the energy sectoral plan, adaptation measures consider forests as valuable sources for biomass for energy production (Corzo Pantoja et al. 2011b; Corzo Pantoja et al. 2011c). Lastly within the sectoral plan of Natural Risks and Insurance, forest fires are considered and analysed (Pérez Fernandes et al. 2011b). Aside from this, forests do not play a significant role within the adaptation actions.

A dedicated sectoral plan for forestry is necessary to account for needed and important adaptation actions that are assessed and tailored to the specific hazard, exposure and vulnerability within Extremadura. The plan should specifically have an intersectoral perspective, considering the effects of forest fires on other sectors such as tourism, energy, water, livestock and agriculture. There are numerous projects that already provide a good database for adaptation measures in the region. Additionally, floods are solely indirectly addressed in adaptation measures, another climate risk that should be represented in adaptation measures more prominently.

The adaptation actions in the current strategy are primarily incremental, addressing specific issues such as water deficits in agriculture through the proposal of new irrigation technologies and water loss reduction. However, there is a lack of direct focus on general changes in management. To enhance the effectiveness of the adaptation strategy, it would be beneficial to incorporate adaptation measures with a cross-sectoral character. This would allow for a more comprehensive and integrated approach, considering the interconnectedness of various sectors and their vulnerabilities to climate change. By adopting a cross-sectoral perspective, the adaptation strategy can better address complex climate challenges and promote synergies among different sectors, ultimately leading to more effective and sustainable climate resilience.

Furthermore, the sectoral plans should be revised and updated with the latest available data and information. As the existing plans are more than 11 years old, they may not accurately reflect the current conditions and vulnerabilities in the region. Updating the plans with recent data will ensure that they are based on the most relevant and up-to-date information, enabling more effective and targeted adaptation actions.

Lastly, it would be very beneficial to introduce maladaptation screening (e.g. based on the Self-Assessment Tool for Maladaptation developed by the REGILIENCE project) as part of the adaptation planning process. This involves assessing potential unintended negative consequences. By identifying and addressing maladaptation risks, the plans can be optimized to avoid actions that might inadvertently exacerbate vulnerabilities or create new problems in the long term (Institute for European Energy and Climate Policy (IEECP) et al. 2023).

3.11.3.2 Planned adaptation measures within RESIST

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The RESIST project's pilot areas cover 82,990 ha in Sierra de Gata and 37,477 ha in Las Hurdes (see chapter 3.11.1 for description of the area). It aims to create a Fire Smart Landscape (FSL), by implementing cost-effective fire prevention actions through social engagement and multi-actor cooperation. The FSL concept is based on cost-effective productive fuel breaks (like mosaic patterns of the landscape, a traditional management technique for reducing the risk of forest fires) managed by local farmers to prevent fires, and suppression infrastructures, so that official fire services can more easily extinguish fires. The project will leverage traditional knowledge and coordinate efforts of local forest owners, farmers and shepherds to diminish fuel in the forests and shrubland. Collaboration with fire suppression bodies and strategic farming activities in designated areas will enhance the region's capacity for fire resilience. The University of Extremadura, Regional Government, and Fundecyt will work together to design and execute the first FSL in the region, building upon their previous experiences for building social-ecological networks. The project benefits from a network of around 300 local land managers and in-depth scientific knowledge of the pilot area, focusing on wildfire management. The project partners are the Junta de Extremadura, University of Extremadura and Fundecyt, who are currently in the process of conducting a stakeholder survey and are updating maps of wild fire risks in the region by the end of the year. To implement fire prevention measures effectively, the project focuses on pilot regions and selects critical areas within them using complex fire modelling. These selected areas hold particular importance for fire prevention efforts. Once identified, the project engages with the local communities and stakeholders living and working in these areas. Regarding vulnerable population groups, the survey that will be conducted will bring more clarity, however to the current status, old-aged people, people dependent on the forest for economic income as well as people depending on the tourism sector are vulnerable to forest fires.

In line with the sectoral plan for Tourism, the project aims to promote the FSL initiative through various activities. The RESIST project aligns with the sectoral adaptation plan for Tourism by proposing actions to adapt and specialize tourist activities and attractions. The main objective is to capitalize on the changing climate and its consequences to diversify tourism offerings and attract tourists through specialized experiences and educational activities in the region. Tourism companies will design trails and tours that showcase productive fuel breaks and the agro-silvo-pastoral practices of local farmers engaged in fire prevention. Restaurants will contribute by offering products from the FSL areas on their menus, emphasizing the connection between tourism, local culture, and sustainability. Additionally, shops will sell Mosaico products to tourists, creating a market for goods produced within the FSL and supporting the economic development of communities involved in fire prevention efforts (Pulido et al. 2023; Corzo Pantoja et al. 2011a).

According to the regional partners and additional sources, the main challenges and obstacles for the successful implementation of the CATA activities in the pilot area include:

- **Coordination and governance**: Effective fire prevention requires the collaboration and participation of various stakeholders, including forest owners, farmers, herders, fire services, and

government agencies. Establishing a well-coordinated governance system that involves all relevant parties is crucial for the successful implementation of fire prevention measures.

- **Recognition of private forest owners' prevention measures**: Private forest owners play a significant role in fire prevention efforts through land management changes, but their contributions are often not recognized or considered by the government and are not reflected in policy yet. There is a need to acknowledge and involve private owners as key partners in fire prevention initiatives.
- **Complex bureaucratic procedures**: The dispersion of property ownership and small plot sizes make bureaucratic procedures complicated, especially due to the low profitability of the plots. Simplifying administrative processes can facilitate fire prevention measures.
- **Abandoned areas and fuel build-up**: Abandonment of large private areas has led to the accumulation of fuel, increasing the difficulty of wildfire prevention and suppression. Revitalizing and managing these abandoned areas are crucial for effective fire prevention.
- **Carbon farming***:* Carbon farming can pose a challenge to fire risk prevention, as companies buy carbon certificates of forests and leave them unmanaged which increases the fuel accumulation in these forests. These stakeholders should be approached and involved in the project and stakeholder consultations.
- **Low human population density***:* The low human population density in the farming and forestry sectors can pose challenges in implementing fire prevention measures. Ensuring engagement and participation of communities from these sparsely populated areas is essential.

In the second half of 2023, Extremadura organised an event with more than 40 participants to share details of the RESIST project with regional stakeholders, public authorities, technological centers, research groups and companies. The feedback that was given at the event is currently structured and will define next steps on communication and outreach measures in smaller target groups and beyond. Within 15 successful meetings, the project partners of Extremadura carried out consultations with the pilot municipalities, clarified outcomes of the project, identified the commitment of the municipalities for collaboration and reached agreements on the properties that will be involved. Additionally, a survey to citizens was redistributed to get more feedback on risk perceptions. The results are available soon.

3.11.3.3 Support needed

There are a few areas and activities where support within the adaptation measure and beyond is needed:

- **Identification and integration of vulnerable population groups into planned measures.** RESIST can assist in stakeholder involvement processes and adaptation of activities that specifically focus on identifying and integrating vulnerable groups, including women, into the planned

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adaptation measures. By ensuring the inclusion of vulnerable communities, the effectiveness and equity of the adaptation actions can be enhanced.

- **Facilitation and support stakeholder consultations together with municipalities.** RESIST can support stakeholder consultations, bringing together various actors such as municipalities, NGOs, carbon farming companies, small-scale private companies in the forestry sector, restaurants, and the tourism cluster to take up and contribute to implementation of resilient land management practices. By fostering collaboration and engagement among these stakeholders, the uptake of measures can be enhanced and implementation can be speeded up.
- **Support for avoiding maladaptation.** RESIST can provide expertise and assistance in conducting maladaptation screening to ensure that the adaptation measures do not inadvertently lead to negative consequences or exacerbate vulnerabilities. Through a robust screening process, potential risks and unintended impacts can be identified and mitigated, leading to more sustainable and climate-resilient outcomes.
- **Governance, policy and legal framework.** The project can serve as an exemplary model for fire prevention, with insights and recommendations for future plans for fire prevention; RESIST can support the development of policy recommendations to involve private forest owners in fire prevention efforts through effective legislation and governance.

3.11.4 Stakeholders and capacities

In the project, important stakeholders include farmers and forest owners and associations who will play a crucial role in implementing landscape modifications for fire prevention. The project also aims to integrate vulnerable population groups who will be identified based on survey results, acknowledging socio-economic vulnerabilities. The forest industry as well as carbon farming companies is another key stakeholder, and getting them on board may require addressing changes in their management systems. Additionally, engaging NGOs in the field of conservation is crucial, with the need to resolve potential conflicts of interest (conservation of forests versus active landscape management through FSL) through co-creation, joint planning, and dialogue. For the involvement of the tourism sector, collaboration with municipalities and the tourism cluster is essential, with potential engagement plans to foster cooperation. The following table outlines the main stakeholders:

Table 49: Main stakeholders of the RESIST action in Extremadura

Organization name	Type	Website	Location	Short description	Involvement/Importance for RESIST	Contact
University of Extremadura	1	www.indehesa.unex.es	Plasencia	Leading R+D centre for NBSs	Long term experience with NBS in pilot area	UNEX

CICYTEX	1	www.cicytex.juntaex.es	Extremadura	Leading R+D in agricultural sector	General support for implementing productive initiatives	UNEX
ADISGATA	2	https://sierradegata.org/	Pilot area	Local rural development	General support for disseminating RESIST activities + financial support for microprojects	UNEX
ADICHURDES	2	https://todohurdes.com/	Pilot area	Local rural development	General support for disseminating RESIST activities + financial support for microprojects	UNEX
Asociación Mosaico	2	https://www.facebook.com/asociacionmosaico/	Pilot area	Association of local farmers	Land use initiatives promoting fire prevention and local development	UNEX
Asociación de Propietarios Forestales del Valle del Árrago	2	https://www.facebook.com/carlosgardelgado	Pilot area	Association of local forest owners	Forestry and agricultural initiatives on private land	UNEX
Asociación de Propietarios del Castañar de Hoyos	2	https://www.facebook.com/asociacionmosaico/	Pilot area	Association of local forest owners	Forestry and agricultural initiatives on private land	UNEX
TURISGATA	2	https://turisgata.com/	Pilot area	Association for local agrotourism	Dissemination and marketing of routes and local products	UNEX
ATHUR	2	https://todohurdes.com/athur/	Pilot area	Association for local agrotourism	Dissemination and marketing of routes and local products	UNEX
ASOMANCA	2	https://www.facebook.com/people/Agricultores-Manzanilla-Cacere%C3%B1a/100089491552657/	Pilot area	Local association of olive producers	Recovery of mountain olive groves which are essential for fire prevention	UNEX
APIHURDES	2	https://apihurdes.es/	Pilot area	Local association of beekeepers	Marketing of local products	UNEX
AMBIENTA INGENIERÍA	2	https://www.ambientaing.es/	Plasencia	SME with large experience in ecosystem restoration, landscape management and forestry	Forestry and agricultural initiatives on private land Support in forestry management and ecosystem restoration	FUNDECYT-PCTEX
AGROECOLOGY SOLUTIONS	2	https://asociacionaprisco.org/?lang=es	Plasencia	Spin-off from the Agricultural Ecology group at ETH Zurich, Switzerland, dedicated to applied research and consulting in agroecology	Support in education activities Lab facility for processing of plant, animal and soil samples 50 ha of mapped agroforest	FUNDECYT-PCTEX

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ECOHABITAT	2	https://www.ecohabitatiberico.com/	Plasencia	SME with large knowledge of forestry problems and especialised in engineering projects and studies, consulting and technical assistance services.	Synergies with company innovation projects in different fields related to the forestry sector and agribusiness.	FUN DEC YT- PCT EX
AGROFOREX	2	https://www.agroforex.com	Plasencia	Company specialised in the protection, conservation and improvement of the environment.	Experience in reforestation and regeneration works on agricultural land, recovery, restoration and improvement of degraded surfaces.	FUN DEC YT- PCT EX
AREX	2	https://arexmedioambiente.es/	Mérida	SME with 40-year experience in the agricultural, forestry and environmental sectors in rural areas.	Experience in the execution of environmental monitoring plan' measures.	FUN DEC YT- PCT EX
ADENEX	5	https://www.adenex.org/	Extremadura	Association for the Defence of Nature and Resources of the region that informs, promotes, encourages the preservation of natural resources.	Support in regional engagement and communication activities	FUN DEC YT- PCT EX
FUNPASOS	5	https://www.funpasos.org/	Extremadura	Foundation for the participatory sustainability aimed at promoting research, inclusive development and advice for the implementation of public policies, in terms of social and environmental sustainability and civic participation.	Support to foster inclusive and participatory processes to improve the application and design of regulations	FUN DEC YT- PCT EX

3.11.5 Results

In Extremadura, the main climate risk that is tackled within RESIST is very similar to Centro Portugal, namely forest fires (Table 50). The main groups affected are farmers, forest owners, the tourism sector private companies, carbon capture companies and civil society. The RESIST measures that will be implemented are intended to reduce the risk of forest fires through adapted land management and by integrating the tourism and private sector in the measures. Further climate risks entail erosion (loss of fertile soil), droughts and desertification, heat, and flash floods.

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Table 50: Climate impacts, planned adaptation measures and relevant stakeholders in Extremadura.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Forest Fires (decline in precipitation, rise in temperatures)	Private sector companies in forestry Population in villages (specifically vulnerable groups such as elderly) Private land owners (Forestry)/ Farmers	Adaptation of land management practices (FSL mosaic landscape)	Forest owners, farmers, local government, regional government, civil society, private sector (tourism sector, private timber/ biomass companies)

Challenges and support

Throughout the interview and screening process, several challenges and needs were named. Within the assessment of the existing CRA, the following aspects arose:

- **Update of MCCE and sectoral adaptation plans.** The existing MCCE requires together with the sectoral adaptation plans updating, as they stem from 2011/2012 and are based on outdated data not the state-of-the-art CRA methodology. To achieve this, it is essential to integrate impact chains based on hazards, exposure, and vulnerability into the analyses and to incorporate the latest available data. Also, the assessment should integrate climate scenarios from the latest IPCC AR6 report, RCP4.5 and RCP8.5 with a long- and medium-term time span.
- **Sectoral adaptation strategy for forest management.** A dedicated sectoral adaptation plan is recommended for the forestry sector, with a particular emphasis on fire management, as currently, adaptation measures regarding forests are only partly reflected in the other existing sectoral plans. The plan should account for climate change impacts, including potential shifts in fire patterns and intensity.

When looking at implementing and developing RESIST measures, there are additional needs and challenges that should be taken into account, namely:

- **Establishing a supportive political setting.** From a policy and legal perspective, modifications that enable and encourage both public and private preventive actions should be proposed. It is crucial to recognize private individuals and organizations as essential stakeholders in prevention efforts that are based on FSL.
- **Integration of gender and vulnerable groups.** The action will consider gender and vulnerable groups to ensure inclusive and equitable adaptation to forest fires, as incorporating their perspectives and needs will result in more effective and sustainable solutions. This however needs dedicated approach and strategy, an aspect that RESIST can support with.

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- **Engaging the private sector and NGOs.** The successful implementation of FSL strategies relies on robust partnerships with the private sector and NGOs. It is essential to foster collaboration, understanding, and mutual goals to effectively integrate these stakeholders into the adaptation solutions.
- **Supporting screening with Maladaptation Tool.** A screening for maladaptation could be considered, both in general terms for adaptation measures developed within the sectoral adaptation plans and within the RESIST action.

Table 51 outlines the main challenges and needs together with support that can be offered from the RESIST consortium. Additionally, transfer knowledge from other LSDTs is matched with the identified needs, such as:

- Central Portugal and Extremadura can jointly explore **strategies to engage the private sector** in enhancing forest management practices more actively, in Centro Portugal specifically the pulp and paper industry whereas in Extremadura carbon credit companies.
- Collaboration can extend to **improving economic incentives for private forest owners** who adopt FSL management practices, which would ease the adoption of the management technique.
- Both regions can exchange concepts on including vulnerable populations in FSL management and **community engagement** efforts.
- Lastly, the exchange of **data and models** for enhancing fire management systems should be encouraged between the regions (also see Table 52).

Table 51: Challenges, needs and support opportunities in Extremadura.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Drought-resistant/ drought adapted trees and shrubs	Facilitate exchange with BLC3 (Centro Portugal partner)	Drought-resistant tree species assessment from Centro Portugal
Tick forest (annual growth rate 2%) → loads of fuel wood, areas covered by more than 80/90% with forest	Exchange sessions and lessons learned documentation from Centro Portugal implementation of AIGPs and village condominiums/ biomass valorisation	Bioeconomy governance approach (biomass valorisation) from Centro Portugal to make use of fuel
Complex bureaucratic procedures (simplification of admin. processes to facilitate FSL; establish a well-coordinated governance system for forest owners, farmers, herders, fire	Policy brief/ recommendation	Potentially: Exchange with Centro Portugal on establishment of new governance approach

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services, and government agencies)		
Carbon farming companies forest management not sufficient (fuel build up; hard to integrate areas in FSL)	Workshop concept for private company involvement	Exchange with Centro Portugal on private company engagement in forest management practices
Ageing population (age dependency) and low population density (emigration from rural areas)→ addressing vulnerable groups and social equity dimension	Vulnerability assessment (with KU Leuven) Mapping of needs and interests of stakeholders	Exchange with Centro Portugal
Fragmented and small land structure sizes & large number of land owners & abandonment of land → Adaptation of land management practices → Designing inclusive and collaborative stakeholder engagement processes	Guidelines for inclusive stakeholder engagement; design of formats, potentially based on TRANSFORMAR Playbook Design of citizen engagement formats and brochures	Exchange with Centro Portugal
Convincing land owners of land management adaptation needs → Recognition of private owner prevention measures (not reflected in policy yet)	Mapping of needs and interests of stakeholders Assessing of economic benefits of adapted land management practices & Analysis of co-benefits for increasing the willingness to adapt land management for land owners (incentives) → very soon! Identification of financing mechanisms for land owners to enhance the adaptation of their practices Communication toolkit and products (together with REVOLVE/ZSI?) Integrate usage of GDT (together with AugmentCity)	Exchange with Centro Portugal
Microeconomic structure: businesses are made up of small units with low capacities for innovation or take up of new technology	Development of new economic models to attract new investments (together with Fasttrack)	Exchange with Centro Portugal

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Monitoring resilience based on measures implemented (FSL approach)	Support in the development of a monitoring framework, e.g. with exchange with ORORATECH (AI company working on monitoring forest fire risks and beyond) (together with KU Leuven)	
Screening for maladaptation and unintended consequences of measures (ex-ante)	Adelphi can facilitate session on applying the REGILIENCE maladaptation tool	
No specific CRA for the forestry sector	Support with the conceptualisation of a CRA for the forestry sector	
Identification of new financing mechanisms	Session of REGILIENCE financing tool for finding adequate financing sources	
Involvement of tourism sector	Analysis of the impacts of climate change on tourism, specifically forest fires (incl. further adaptation strategies and usage of Mosaico products)	Exchange with Puglia

Potentials for transfer

In the following, the strengths of Extremadura that can be of value of transferring are identified together with topics of interests the region has. Table 52**Fehler! Verweisquelle konnte nicht gefunden werden.** depicts the main strengths of the region together with the activities and knowledge that is relevant for transfer to other regions.

Table 52: Expertise and transfer potentials in Extremadura.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions
Modelling & monitoring of fires and mapping wildfire risks (identification of high-risk areas);		Centro Portugal, Baixo Alentejo
Collaboration with fire services (building a suppression infrastructure, so that official fire services can more easily extinguish fires)		Centro Portugal; Baixo Alentejo

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Fire-smart landscape implementation with different stakeholders		Baixo Alentejo
Monetising FSL products through tourism (e.g. selling of "mosaico" products in restaurants and shops; tourism activities related to the FSL landscape)		Centro Portugal; Puglia
	Collection of best practice examples	

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3.12 Needs assessment Vesterålen

3.12.1 Introduction

Figure 21: Location of Vesterålen.

Vesterålen, situated in northern Norway within Nordland County (Figure 21), encompasses a vast expanse of islands covering approximately 3,100 km², where approximately 32,000 residents live. This island region is characterized by its steep topography, with steep terrain. Vesterålen boasts a notable competency in marine technology and entrepreneurial industries, with fishing and salmon aquaculture serving as pivotal pillars of the local economy. However, this region is not without its vulnerabilities, particularly in the face of seal level rise (SLR), which poses risks to both residential buildings and industrial areas within Vesterålen (Description of the Action).

Generally, Nordland is one of the cooler regions in Norway. The coastal areas of Nordland are categorized with a mild, precipitation-rich climate, primarily due to the moderating effects of the North Atlantic Ocean, whereas inland parts of Nordland have colder temperatures and less precipitation. Winters in these coastal regions are relatively mild compared to more inland areas. This maritime influence also results in a significant amount of rainfall throughout the year, with over 3000 mm in some areas, specifically in the coastal area. During the winter season in the outer regions of Vesterålen, polar low-pressure systems can bring rapidly increasing winds and heavy snowfall. This phenomenon can lead to challenging weather conditions, including snowstorms and storms (Norsk Klima Service Senter 2022). From 1900-2014, temperature increased in the wider region of Nordland with 1.2 °C with the highest temperature increase occurring in spring and autumn (Hanssen-Bauer et al. 2017).

3.12.2 Climate risks

3.12.2.1 Regional climate risk assessments and identified risks

For the region of Vesterålen, no climate risk assessment (CRA) exists up to now. Within this analysis, the authors thus used the Climate Profile of Nordland and Climate in Norway2100 study. The Climate Profile is currently the central document outlining future climate risks, it however does not specifically include details of the region of Vesterålen (Norsk Klima Service Senter 2022). Data for the Climate Profile was retrieved by the Norsk Klimaservicesenter platform.

It has to be noted that the effects of climate change and the overall climate differentiates among Nordland due to its differing geography. Under RCP4.5 (2071-2100), a temperature increase is expected by 3 °C for Nordland whereas under RCP8.5 an increase of up to 5 °C is expected. Winters are expected to experience the most significant temperature increase, with a rise of up to 5 °C, while

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summer temperature will increase by about 4.5 °C under RCP8.5. This warming will lead to an extended growing season, particularly noticeable in the outer coastal areas, and a decrease in the occurrence of winter days with extremely low temperatures (see Table 53). There will be a notable reduction in snowfall and the number of snow days, resulting in a snow season up to 3-4 months shorter. Nonetheless, high mountain ranges may experience an increase in snowfall until the middle of the century (Norsk Klima Service Senter 2022; Hanssen-Bauer et al. 2017).

Precipitation patterns are also set to shift, with an estimated annual increase of approximately 20% in Nordland. Winters are expected to become wetter with a 10% increase, while for summer, a substantial 30% increase in precipitation is projected. These changes come with rise in episodes of heavy precipitation in all seasons, intensifying both in frequency and intensity by approximately 20%. Flood calculations thus predict a 20% to 40% increase in water flow, particularly impacting smaller rivers that react swiftly to heavy rainfall, posing a threat to populated areas. Landslide risks are also on the rise, influenced by local terrain conditions and weather factors, including snowfall, rainfall, and snowmelt. Landslides, rock falls/slides, and avalanches are exacerbated by periods of heavy rainfall, further heightening the region's vulnerability. The region currently experiences a fall in number of snow days. The number is expected to fall by 180 days under RCP8.5. Summer precipitation is anticipated to increase significantly, accompanied by greater evaporation, which may result in longer periods of low river flow, groundwater deficits, and elevated forest fire risks (Norsk Klima Service Senter 2022; Hanssen-Bauer et al. 2017).

Table 53: Climate change in Nordland (Norsk Klima Service Senter 2023).

Changes compared to baseline period (1971-2000)	**Mid-term future (2031-2060)**		**Long-term future (2061-2100)**	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Mean temperature (°C)	1 – 2	2 – 3	2 – 3	4 – 5
Change in Days below 0°C	-20 – -10	-30 – -20	-40 – -20	<-40
Change in precipitation (%)	2.5 – 17.5	-2.5 – 17.5	7.5 – 22.5	7.5 – 27.5
Growing season increase (No. of days)	30 – 60	30 – 60	30 – 90	90 – 120

SLR, averaging 1.9 mm per year along the Norwegian coast, is expected to extend storm surges and waves further inland, posing a threat to buildings and infrastructure which were not previously impacted (Hanssen-Bauer et al. 2017). The projected SLR under different emission scenarios (RCP2.6: up to 0.3 m, RCP4.5 up to 0.35 m, RCP8.5 up to 0.55 m) indicate a relative SLR for most of Norway, albeit below the global mean rise. The closest metering to Vesterålen is in Andenes, which indicates a return level in 200 year storm surge of 208 cm above mean water level (Direktoratet

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for samfunnssikkerhet og beredskap 2016). Ocean acidification is an additional risk that is stated in the Norwegian Report on climate vulnerability, by 2010 the pH level has been falling by 0.1 pH units, a threat that can have impacts on marine life (NOU 2010).

In addition to these challenges, changes in sea temperature and ocean acidification are can disrupt commercial fish stocks and aquaculture breeding, which needs a deeper understanding of climate change consequences on marine ecosystems for effective adaptation within the fisheries and aquaculture. The migration of fish can have effects on fisheries, as fishing quotas might need to be changed. Additionally, fish composition will change, as already new fish species were identified at the Norwegian coast, such as sea bass and swordfish. An increase in ocean temperature can also raise the risk of salmon lice, which is already observed in Norway (NOU 2010).

Additionally, NORADAPT, the Norwegian Centre on Sustainable Climate Change Adaptation, has issued a climate ranking of all municipalities in Norway, based on 12 indicators, disaggregated by hazards, vulnerability and adaptive capacity. In general, Nordland was rated with a high vulnerability level and hazard-proneness together with a low adaptive capacity due to future increased impacts amongst others of storm surges and sea -level rise. Municipalities of Vesterålen are, compared to other Norwegian regions, most exposed with mostly least adaptation measured in place. Housing is in some areas of Vesterålen more exposed compared to other areas and the business and industry sector is more vulnerable compared to other Norwegian regions, mainly due to a larger share of primary industry (such as fishing, aquaculture). Adaptation efforts were so far mixed in Vesterålen, with some municipalities that are taking climate risks into account while others don't, based on surveys of the Directorate for Civil Protection (Rød et al. 2023).

3.12.2.2 Comparison with ESPON data

The ESPON dataset is used as a comparison and backup for the region. It also solely exists on county-level (NUTS3) in Norway, and thus for Nordland. As ESPON is disaggregated by hazard, exposure and vulnerability, it provides valuable insights specifically on exposure and vulnerability level for the region. As stated above, there are in total seven risks considered, ranging from heat and drought to wildfires, coastal floods, and river and flash floods. In the baseline scenario (1981-2010), climate hazards are low besides flash floods from pluvial rain. The exposure is highest for droughts on primary sector, thus agricultural and forested land, as well as heat and river floods on population, followed by flash floods on museums and world heritage sites. Concerning sensitivity, Nordland is specifically vulnerable to river floods on population, where young- and old-age dependency play a significant role, flash floods, where vulnerability is measured in terms of touristic arrivals and droughts on primary sector, based on the gross value added (GVA), employment rate in the sector and the share of irrigated land, followed by coastal flood (also measured in terms of employment rate in industry as well as generated GVA) and wildfires (Navarro et al. 2022).

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Considering the medium emission scenario RCP4.5, flash floods and coastal floods, are ranked as the most pressing hazards in the region, whereas under the high emission scenario RCP8.5, the same hazards are relevant but the region becomes even more prone to coastal floods.

This is in line with the Climate Profile of Nordland which also identifies SLR and storm surges as a main risk together with flooding both flash floods and river floods. At the same time, some risks pertaining to SLR to fisheries and aquaculture as well as land-slides in different forms was not captured by ESPON and it thus undermines the importance of developing a regional-specific assessment.

3.12.2.3 Potential improvements for climate risk information

As stated above, the Climate Profile of the county of Nordland, which encompasses diverse geographical features, including both islands and inland areas. This presents a challenge as the data provided is not tailored to the specific circumstances of Vesterålen, an island region facing unique climate-related challenges. The Climate Profile gives a first overview on climate hazards which are prevalent in the county, with information based on the “Climate in Norway 2100” assessment (Hanssen-Bauer et al. 2017; Norsk Klima Service Senter 2022). The Climate Profile is a rather short document, summarising the complex information and data given in the report for whole Norway. It thus lacks precision regarding the utilization of RCPs, which are critical for understanding the emissions scenarios used in the analysis. While the Norway 2100 document is referenced clearly, it is not clear which RCPs were employed in the Climate Profile. To enhance transparency, specifying the RCPs used in the analysis within the Climate Profile report would be beneficial. Moreover, the Climate Profile predominantly emphasizes long-term climate changes (2071-2100) while largely neglecting medium-term changes. Medium-term assessments, which are available in other reports, provide valuable insights into climate risks that might have more immediate implications.

The report briefly highlights various climate-related hazards, encompassing both extreme events (e.g., flash floods) and slow-onset events (e.g., SLR and ocean acidification). However, the analysis remains shallow, lacking the development of impact chains. The absence of impact chains, which outline the causal relationships between hazards (such as temperature rise or SLR), exposure (such as infrastructure, buildings, land), sensitivity (old-aged population, GDP, irrigated area etc.), and adaptive capacity (social, institutional, economic, infrastructure and technological capacity), represents a significant limitation. A robust understanding of climate risks necessitates the comprehensive evaluation of these elements. Furthermore, the report omits the consideration of vulnerable population groups, a crucial aspect in CRA. Failing to account for the specific needs and vulnerabilities of these groups hinders the development of effective adaptation strategies.

Additionally, cross-cutting risks, which could have far-reaching and interconnected impacts, receive insufficient attention in the report. These risks require a more in-depth analysis to identify potential cascading effects and interdependencies. To enhance the utility of the assessment, it is highly

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recommended to conduct a more spatially explicit analysis tailored to Vesterålen. This would provide a nuanced understanding of region-specific climate risks and their geographic prevalence, thereby enabling the targeted development of adaptation measures and risk mitigation strategies.

3.12.3 Adaptation measures

3.12.3.1 Existing plans and measures

Important policy documents at national level

The 2012 developed white paper on climate adaptation in Norway "**Meld. St. 33 (2012–2013) Klimatilpasning i Norge**" serves as a foundational guide for climate resilience. It introduces climate change risks and potential associated policy instruments, with a focus on core objectives related to climate impacts on nature and society (mainly on food production, health, infrastructure, economy, cultural heritage and the indigenous Sami culture and heritage). It lays out a framework for developing adaptation strategies and measures across sectors. It additionally proposes the establishment of a National Center for Climate Services and emphasizes the importance of disaster risk reduction, understanding uncertainties and clear roles and responsibilities to address climate risks effectively. Additionally, it provides insights into sector-specific impacts, such as agriculture, environment, and fisheries, underlining the need for targeted adaptation measures and outlining sectors, for which adaptation strategies are already existing, such as for fisheries and aquaculture, where the Ministry of Fisheries and Coastal Affairs has developed an adaptation strategy to adapt to warmer ocean water, SLR and storms (Det Koneglige Miljødepartment 2013).

The **Statlige planretningslinjer for klima- og energiplanlegging og klimatilpasning** (State planning guidelines for climate and energy planning and climate change adaptation) updated in 2018, aims to prioritize greenhouse gas emission reduction and climate adaptation in municipal and county planning and enhance energy efficiency. The dedicated section on adaptation it emphasizes the need for updating and developing county and municipal climate profiles, developing adaptation plans, and assessing the impact of climate change on long-term goals and strategies of municipalities. It requires municipalities to map ecosystems and relevant land use, consider climate-related impacts on societal security, critical infrastructure, environment, health, and industries. It also requires risk and vulnerability assessments of areas that are to be developed, particularly for areas vulnerable to hazards like floods and landslides. The guidelines also promote the use of Nature-based Solutions for preservation, restoration, or establishment (Kommunal- og distriktsdepartementet 2008).

In addition to the mentioned reports, Norway has a public report on climate change adaptation and vulnerabilities **Tilpassing til eit klima i endring** (2010:10; Norway's public reports: Adapting to a changing climate) along with an update **Oppdatering av kunnskap om konsekvenser av klimaendringer i Norge** (2018:14; Updating knowledge about the consequences of climate change

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in Norway). These reports provide a detailed overview of climate risks and vulnerabilities, thus a CRA, categorized by sector, including physical infrastructure, health, natural environment, and businesses (agriculture, fisheries and forestry). The update also highlights extreme events and elaborate on the associated risks, along with their socio-economic consequences, mostly through CBA using gathered studies. Furthermore, it emphasizes the importance of considering the social costs of maladaptation. Additionally, there is a dedicated chapter addressing adaptation at regional level, underscoring the significance of localized approaches to climate resilience. It concludes with an assessment of Norway's adaptive capacity regarding the different hazards, the exposure and sensitivity of the country. It also integrates data from the "Climate in Norway 2100" study and the data platform developed for climate data of Norway, the National Center for Climate Services. The assessment of socio-economic consequences show a relatively low impact with a temperature rise of up to 2.5 °C for 2031-2060, whereas impacts are called "dramatic" concerning a temperature increase of 4.5 °C by 2100 (Cicero and Vestlandforsking 2018; NOU 2010). Regarding SLR, the report outlines the importance of strengthening the planning system so that climate change risks are accordingly included in community planning and it emphasizes the use of ecosystem-based adaptation approaches.

Based on documents relevant for climate adaptation in Norway between the period of 2013-2021, such as the Act on Municipal Preparedness, Civil Protection Measures and Defense, the Forestry Act, or the Act on Protection against Natural Damage, the **Riksrevisjonens undersøkelse av myndighetenes arbeid med å tilpasse** assessment was conducted to understand how Norway manages climate adaptation, to understand gaps and chances for future improvement. One finding is that there is a concerning lack of knowledge and understanding among authorities in municipalities and on county level regarding climate risks and climate adaptation. This knowledge gap raises significant concerns, as it implies that municipalities may be permitting development in areas prone to future hazards or in areas vulnerable to climate change. Moreover, a deficiency in comprehending the vulnerability of transportation infrastructure to climate-related future impacts has been identified at national level. Additionally, at the national level, there exists an information shortage regarding adaptation actions on national/ regional and local level (implementation and monitoring) and key sectoral challenges, hindering effective evaluation of the current state of climate change adaptation. Another finding corresponds to weak coordination efforts for climate change adaptation that have been noted nationally, emphasizing the need for improved collaboration and communication. Furthermore, the assessment highlights that a substantial number of municipalities (71%) are not adequately considering future climate conditions with a 50-year time horizon when conducting risk and vulnerability assessments, potentially overlooking the impact of climate hazards on existing and planned infrastructure and buildings which heightens the risk of not taking preventive measures. Lastly, the underutilization of regional climate profiles (Climate Profile) prepared by the Norwegian Climate Service Center in municipal planning processes has been identified as a significant challenge. The overall recommendation included that national authorities should be stronger in

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pinpointing on existing documents, frameworks and solutions for enhancing climate adaption (Riksrevisjonen 2022).

The **Meld. St. 26 (2022-2023) Klima i endring– sammen for et klimarobust samfunn** (Changing climate – together for a climate-robust society), presents a follow-up to the **Meld. St. 33 Klimatilpasning i Norge report** from 2012-2013 and is aimed at establishing a climate-robust environment in Norway. It focuses on creating an integrated and coordinated framework for climate adaptation efforts with an improved management system. The government aims to enhance climate considerations in risk and vulnerability assessments at local and regional levels, emphasizing the impacts on various sectors, such as food production, economy and business, health, cultural heritage, infrastructure and buildings as well as nature and ecosystems. The government plans to develop a national climate vulnerability assessment every four years, with the first scheduled for 2026, along with regular updates to adaptation policies. The second part of the report outlines the structure of the 2024-2028 national adaptation framework, emphasizing cross-sectoral measures, integrating climate change considerations into sectoral decision-making, expert committees, amendments to the Planning and Building Act for outlining minimum considerations that have to be included for vulnerability and climate change analysis, data and hydrological projections provision to municipalities, stronger focus on stormwater management, development of county-level risk and vulnerability assessments for both regional and local levels, improved natural hazard event notification, and tools for climate adaptation in fisheries and aquaculture, including mitigating ocean acidification (Det Koneglige Klima- og Miljødepartment 2023).

The 2021 **Klimarisiko i kommunene** report (Climate risks in municipalities) published by the Miljødirektoratet focuses on climate risks at the municipal level in Norway. The basis for this report stems from the Ministry of Climate and the Environment and the Ministry of Local Government and Modernization, which recognized the lack of a solid foundation for assessing how municipalities incorporate climate risk into their administrative processes. The report underscores the need for increased knowledge of municipalities on how they are exposed to climate risks and how they manage it. The Norwegian Environment Agency was tasked with reviewing and describing the nature of climate risks faced by municipalities, the current state of climate risk description, and an assessment of municipalities' competence and efforts in addressing climate risk. Municipalities play a crucial role as both authorities and owners/operators, particularly in managing physical risks associated with climate change. This includes considering climate change implications in spatial planning and maintaining municipal buildings and infrastructure. For instance, municipalities must assess the suitability of future building locations in light of flood and landslide risks, rising sea levels, and ensure that drainage networks can withstand more frequent and intense rainfall events. CRA is relevant across various planning levels but is especially critical in the overall municipal plan to guide underlying plans effectively. The report provides municipalities with suitable tools and guidelines for assessing and addressing climate risks. It highlights relevant data sources, climate profiles of counties, and other data and it showcases best practice examples on reducing vulnerability and exposure levels (Miljø-Direktoratet 2021).

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There are additionally several other guidelines on SLR and municipal planning that this needs assessment will not go into detail that could however be important for further project activities (Simpson et al. 2015; Direktoratet for samfunnssikkerhet of beredskap (DSB) 2016). A central document is the **Integrating SLR and Storm Surges in Local Planning guidance**, which provides guidance on planning and building infrastructure in sea-level-rise-prone areas, advising municipalities on strategies to minimize exposure risk, including redirecting construction areas. It also outlines assessment methods for existing infrastructure, and on how to utilise the Risk and Vulnerability Assessment described in the Civil Protection Act (Norwegian Directorate for Civil Protection 2017).

Overview of relevant policy documents at regional level

On a regional level, as mentioned above, only documents for Nordland were identified, no dedicated strategy was identified for Vesterålen.

The **Regional plan for klima og miljø - Grønn omstilling i Nordland** (Nordland regional plan for climate and the environment) 2022 serves as a crucial link between state, municipal, and regional authorities, with Nordland County Council taking responsibility for aligning national goals and guidelines within a regional and local setting. This strategic plan aims to enhance regional climate and environmental efforts while promoting a collaborative and comprehensive approach involving municipalities, the county council, the state, regional authorities, businesses, and voluntary organizations. The plan sets forth clear goals, subgoals, and strategies, with the primary objective being the readiness of Nordland's municipalities to adapt, manage climate risks, and capitalize on opportunities arising from climate change. Subgoals encompass regional cooperation for conserving natural diversity, promoting holistic climate action, and enhancing regional collaboration. Another subgoal focuses on knowledge and innovation, emphasizing locally relevant knowledge and preventive measures. Furthermore, the plan highlights the role of regional spatial planning in mitigating financial damages caused by flood, erosion, and landslides, with support from the building act. Nature-based solutions take precedence in the plan's approach to environmental challenges and climate resilience (Nordland Fylkeskommune 2022b).

The **Handlingsprogram 2022/2023** (Action Plan), derived from the Nordland Regional Plan for Climate and Environment, shares the primary goal of enabling Nordland to adapt effectively to climate change and manage climate risks. It includes three parts of which the last is dedicated to climate adaptation. Municipalities are encouraged to participate in regional conferences and meetings on municipal planning such as the Klimapartnere Nordland forum. Key actions include renewing regional cooperation assessing and potentially implementing advice from the Directorate for Cultural Heritage's climate strategy, and promoting the UN decade for nature restoration. The plan emphasizes the importance of generating local knowledge through vulnerability analysis and a broader focus on climate adaptation in relevant areas. It additionally includes a catalogue with indicators for monitoring and evaluating progress of adaptation in Nordland. These include the age

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of municipal plans, climate-related claim payments, grant applications for climate adaptation, and the presence of planning and climate networks. Additionally, the plan mandates to include climate risks in the risk and vulnerability analyses for new infrastructure projects in communities to enhance preparedness (Nordland Fylkeskommune 2022a).

On a regional level (both Nordland and Vesterålen) a dedicated adaptation plan or adaptation action plan with detailed measures exists, however rather superficial in its nature. The Nordland Action Plan. The measures identified are rather on a strategic level not directed towards a climate risk. A clear link between measures identified and identified climate risks and impact chains is thus missing. It identified focus areas like participation in events, following up on ongoing projects and including recommendations in municipal guidance documents. A major aspect is the development of a vulnerability analysis for Nordland as a dedicated action area. In addition, within the strategic document, a focus on nature-based solutions was given, which is however so far not reflected in the Action Plan. Overall, measures appear rather incremental than systemic.

Generally, though not per action, indicators were elaborated that are intended to measure progress on adaptation:

- Age of municipal plans
- Claim payments linked to natural events
- Number of applications for the grant scheme for climate adaptation
- Number of regions with planning and climate networks.
- Number of applications for the grant scheme for climate adaptation

The identified measures do not touch upon vulnerable groups or gender and are not developed with a focus on social equity. These are aspects that should be taken up in future updates of the documents, to ensure that measures are targeted towards population groups that have fewer adaptive capacity and a higher sensitivity compared to other groups. Groups that were identified vulnerable in Vesterålen are communities located at the coast with low adaptive capacity, fishermen and people working for fish farms, as through changes in ocean temperature, migration patterns might change and thus fish stock might decrease. Additionally, indigenous communities are vulnerable population groups, as their dependencies on natural resources, such as reindeer herding and fishing is threatened by climate change impacts. Lastly, elderly people and children are a vulnerable group, being more sensitive to changes in temperature and to extreme events.

3.12.3.2 Planned adaptation measures within RESIST

The planning of measures within RESIST is ongoing, and within the first three quarters of the project, some activities have already been implemented. The adaptation measures within RESIST are of a

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different nature and follow the goal of enhancing climate resilience towards SLR, ocean acidification and ocean warming. The tasks can be grouped in four different aspects:

- **Modelling and mapping:** Setup of the GaiaVesterålen platform with mapping of SLR, climate change impacts (such as algae blooming, effects on fish) on coasts and exposed elements under different climate scenarios in Vesterålen and Lofoten; showcasing of direct effects that climate drivers have as well as showing possible solutions, such as displaying and mapping Andfjords technology; the goal is to showcase the fishing and aquaculture industry, industry at the shore, as well as coastal population and public planning offices the impact of climate change on the coast
- **Informing and assessing risks:** Development of a Regional Risk and Vulnerability Assessment together with a Regional plan for adaptation and a toolbox for urban planners
- **Communicating and collaborating:** Organisation of the GAIA Vesterålen summit; Expert Network development and consolidation of the structures to support decision-making in the future; Setup of environmental contracts with households and businesses for climate resilient actions through a WebApp; stakeholder workshops for the development of the GaiaVesterålen platform with AR and VR technology with youth, fisheries, aquaculture industries etc.
- **Usage of residues:** Andfjord Salmon intends to recycle bio waste from salmon production for biogas and other products
- **Support municipal planning:** Support of regional/ municipal planners in integrating adaptation measures in planning process with tools/ guidelines

To move forward with understanding the perceptions of climate change, climate risks and the understanding of climate adaptation of the local population, GaiaVesterålen has developed and executed a citizen survey which outlined that the overall risk perception of climate change is rather low. The survey revealed that only 54% believed that climate change is mainly caused by human activity, indicating an overall need for heightened awareness about the main drivers behind climate change.

Furthermore, the preparations for the 4th RESIST Consortium meeting (04.-06.06.2024) and the GAIA Arctic summit (06.-07.06.2024) are ongoing.

Additionally, GaiaVesterålen has started implementing the environmental contract with support of the WebApp with 30 pilot families in the region to test the App and understand how support to the families and, at one point, businesses can be enhanced. With that, youth and children are also engaged in measures.

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Challenges

A main obstacle is the lack of a CRA in the region. Many stakeholders are aware of climate risks in the region, however a clear and concise document outlining the most important impact chains is so far lacking. The region thus requires assistance for creating a comprehensive CRA and action plan in collaboration with municipalities and the Vesterålen Regional Council. Within this action plan, RESIST can play a vital role in identifying adaptation measures tailored to the region, especially those based on NbS.

The proposed model and mapping approach show significant promise in enhancing climate change awareness, and facilitating the simulation of existing solutions. By employing the interactive map and model, it becomes possible to not only raise awareness about climate change but also to simulate and assess solutions. While the technical details and capacities necessary for developing these maps and models are clear, they require further organization and the clear assignment of roles and responsibilities among the participating organizations. This need for a more defined framework has been emphasized by a partner, highlighting the importance of expertise in modelling and access to relevant data. Careful organization and allocation of these resources are essential for project success.

Identifying vulnerable population groups is essential. While Vesterålen has made progress in this area, further refinement is necessary within a CRA or a separate assessment. This refinement will provide a clearer understanding of the sensitivities and adaptive capacities of these groups to key climate risks. Additionally, RESIST can ensure that vulnerable groups and gender considerations are integrated into existing and planned measures to promote social benefits, equity, and acceptance of these measures.

Maladaptation has not been adequately considered so far, with a primary focus on communication and data-related actions. RESIST can provide support in facilitating a maladaptation screening to avoid adaptation measures unintendedly leading to unplanned or even harming outcomes, thus increasing vulnerability.

3.12.4 Stakeholders and capacities

An overview of the project partners in Vesterålen can be found in Table 54. The primary objective of the RESIST Vesterålen project is to engage the local population in building climate resilience. Various activities, as mentioned earlier, are being carried out to raise awareness and involve young individuals and families specifically. Initial survey results were presented during the interview, indicating that the public is relatively uninformed about climate change risks and adaptation. The citizen survey serves as the first step in engaging the public and stakeholders. It will guide the customization of further actions based on the results. Given that some stakeholders demonstrated a lack of interest or knowledge about climate change, it is crucial for RESIST to take measures to

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reach these population groups through their activities and initiate communication with them. Addressing opposing interests, the survey results highlighted a certain degree of disinterest and scepticism regarding climate change and adaptation. Therefore, it is crucial to leverage these survey results to develop communication campaigns, offer information, and organize easily accessible events at the Gaia Museum. These efforts aim to enhance understanding of the importance of climate action and ensure that the interests and needs of the community are acknowledged and heard. Additionally, these initiatives will emphasize the urgency and necessity of taking adaptation measures in Vesterålen, particularly considering the severe implications of SLR for some communities.

Furthermore, RESIST plans to involve public planners, who are accessible through a professional network that is planned to be formalized and equipped with advisory authority in public administration and decision-making processes. This becomes particularly important when developing a CRA for Vesterålen, as this group can play a pivotal role in shaping the content and process.

Another significant stakeholder group that certain activities target comprises local companies, including those in the fisheries and aquaculture industries and agriculture. By utilizing the GaiaVesterålen platform with AR and VR technology, the industry can obtain a visual overview of algae bloom locations and visualize the effects of rising sea temperatures on different fish species due to climate change. To get them engaged and informed of the opportunity, workshops and dialogue events can be of importance. Additionally, these companies will participate in trials and at a later stage in the implementation related to environmental contracts, meaning that the project's goal is to involve these stakeholders in contributing with voluntary environmental actions, such as recycling, to climate resilience in Vesterålen.

Table 54: Project partners in Vesterålen.

Organisation	Type	Website	Location	Short description	Involvement/Importance for RESIST	Contact
Andfjord Salmon	Seafood company, Salmon farming on land	https://www.andfjordsalmon.com/en/	Andøya og Sortland	Andfjords goal is to build the world's most environmentally friendly and fish-friendly aquaculture facility.	Is involved in research and development of a digital twin. The aim is to be able to show technological solutions and ocean models for the seafood industry and other companies in the region.	Stig H. Pettersen
SINTEF	Academia research organisation	https://www.sintef.no/en/	OSLO	SINTEF is one of Europe's largest independent research organisations.	Is involved in the development of GAIA-tech and the digital twin for the region. The GAIA model. (Vesterålen)	Konstantinos Boletsis Jan Håvard Skjetne
Museum Nord Gaia Vesterålen	Museum and research	https://www.museumnord.no	Melbu/ Sortland	Museum Nord is a non-profit, government-supported	Is involved in developing the digital twin for the region.	Ane Høyem

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	organisation			organisation within the national museum network,	Is involved in GAIA Arctic Summit	Marie Flakstad Bunes
Vesterålsrå-det (Vesterålen regionråd)	Public administration	https://vestreg.no/	Sortland Vesterålen	Vesterålsrådet is an inter-municipal political council for the municipalities of Andøy, Bø, Hadsel, Sortland and Øksnes.		

3.12.5 Results

Vesterålen's main climate risk that is tackled within RESIST is SLR together with rising ocean temperatures and the acidification of the ocean. The region additionally faces risks such as flash floods, avalanches, and storm surges. Sea-level rise has tremendous implications on the exposure of the coastline, buildings, infrastructure but also on the vulnerability of urban and rural population along the coastlines, on the fishing industry and aquaculture, as depicted in Table 55. Within RESIST, adaptation measures are planned that tackle these climate risks, such as the development of a 3D-model with projection mapping together with the fishing industry and the awareness raising among civil society.

Table 55: Climate impacts, planned adaptation measures and relevant stakeholders in Vesterålen.

Climate impacts being addressed	Groups affected by climate impacts	Planned adaptation activities	Stakeholders involved in/ relevant for planned activities
Sea-level rise (SLR)	Local population Industry	Modelling and projection mapping of SLR	
Rising ocean temperature	Salmon aquaculture companies Local fishermen Population	On-land salmon production	
Ocean acidification	Salmon aquaculture companies Local fishermen Population	On-land salmon production	

Challenges and support

Major challenges and specifically needs that were identified were amongst others:

- **Developing a Climate Risk Assessment for Vesterålen** holds paramount importance, as it enables the understanding of specific risks and establishes clear impact chains upon which adaptation measures can be constructed.
- **Developing an adaptation plan** grounded in the CRA, with a strong emphasis on transformative adaptation, and a dedicated area that considers sectoral adaptation measures is essential for effective climate resilience.

When looking closer at the planned RESIST measures, the following needs can be highlighted:

- **Ensuring the active participation of vulnerable groups** both in activities as well as in developing strategies and plans is vital to guarantee an inclusive and equitable adaptation process.
- **Further assistance** is essential for the development of a visual and interactive platform, particularly regarding the integration of data and maps into the interactive tool using VR and AR technology by the organizations involved.

In Table 56 additional challenges and needs are identified, together with possible support actions by the RESIST consortium and with transfer possibilities from RESIST regions that are implementing similar measures and concepts, such as:

- **Knowledge exchange on citizen engagement.** In this context, Vesterålen should also explore strategies and involvement processes from other regions to ensure that adaptation measures are inclusive and address the specific needs and vulnerabilities of marginalized or vulnerable population groups.
- **Exchange on best practices for developing Climate Risk Assessments with LSDs.** For Vesterålen it can be very beneficial to exchange with other regions from RESIST on developing sound and thorough CRA, how to best structure it and how to involve stakeholders. This way Vesterålen can potentially avoid pitfalls that other regions faced when developing the assessments.
- **Successfully mainstreaming Climate Risk Assessments and getting stakeholders to use the information.** Learning from regions that have successfully integrated CRA into decision-making processes and engaging stakeholders effectively to ensure that the valuable information is put to practical use, both in the public and private sectors.

Table 56: Challenges, needs and support opportunities in Vesterålen.

Challenges and needs	Support by adelphi (together with RESIST partners)	Transfer from other regions

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No existing regional CRA	Exchange of best practices for CRA/ adaptation strategy and regional action plan development together with local planners of municipalities Development of a methodology for a CRA (based on latest standards and research)	
Identification of vulnerable groups for adaptation measures	Vulnerability assessment (with KU Leuven) Mapping of needs and interests of stakeholders	
Low climate change awareness among population	Communication strategy for population, potentially based on the GAIA Vesterålen model Best practice exchange on citizen engagement Communication toolkit for different stakeholders	
Development of models and analysis of climate data specifically regarding SLR	Support by Augment City	Normandy/ SW Finland/ Central Denmark/ Blekinge/ EMT
Tools and guidelines for local public planners in Vesterålen on how to integrate climate adaptation (specifically SLR) into strategic planning	Support in developing a workshop concept/ format for supporting policy and toolkit development for local and regional planners	SW Finland/ Normandy
Upscaling of on-land salmon farming technology	Support in upscaling Andfjord Salmon' on-land farming technology (facilitation of webinar for other interested regions and companies)	
Mapping of main threats to aquaculture businesses	Support in evaluating the survey results together with desk research	
Screening for maladaptation and unintended consequences of measures (ex-ante)	adelphi can facilitate session on applying the REGILIENCE maladaptation tool	
Financial support for adaptation measures/ CRA development	Session with REGILIENCE financing tool to identify potential sources	

Potentials for transfer

In Table 57 the strengths and expertise of Vesterålen are summarised which is mainly based on stakeholder engagement and modelling SLR for an accessible model that showcases impacts through projection mapping. Exploring digital mapping and–technology to visually convey climate change risks to industry, agriculture, public planning and the general public is an interesting

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approach that, if it proves successful, it may demonstrate the potential benefits of adopting similar technology in other regions.

Table 57: Expertise and transfer potentials in Vesterålen.

Strengths and expertise	Topics of interest	Transfer to other regions
Modelling and showcasing through projection mapping of SLR and its consequences on coastlines, society and the fishing industry		Blekinge, Normandy, SW Finland, Central Denmark, EMT
Stakeholder engagement through the organisation of the GAIA Arctic Summit		
	Strategies for climate change communication based on citizen survey	

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4 Results

Despite diverse regional contexts and different stages of adaptation, the needs assessments for the four large scale demonstrator and the eight twinning regions reveal common challenges and needs as well as areas of expertise and transfer potential between regions. Individual results for each region can be found in the respective results chapters of the regional needs assessment (3.1.6 to 3.12.5). The following summary aggregates the regional-specific results and focuses on commonalities regarding climate risks and adaptation solutions, challenges and potentials for support by RESIST partners, and illustrates opportunities for knowledge transfer between the regions.

The composition of the LSD and twinning regions cluster (abbreviated as LSDT) is depicted in Table 1. LSDT1 consists of Southwest Finland (SW Finland), Normandy and Eastern Macedonia and Thrace (EMT). LSDT2 is composed of Central Denmark, Zemgale and Blekinge. LSDT3 includes Catalonia, Puglia and Baixo Alentejo. Centro Portugal, Extremadura and Versterålen make up LSDT4.

4.1 Commonalities in addressed climate risks and adaptation solutions

By project design, the regions within one LSDT face similar climate change impacts and develop comparable adaptation activities. However, commonalities can also be identified beyond LSDT clusters, regarding the impacts addressed within RESIST as well as regarding planned adaptation solutions.

Central **climate change impacts addressed** within the project are sea-level rise (SLR), flooding, wildfires, water scarcity and drought, erosion, heat, and degradation of biodiversity (see Figure 22, Table 58). Most of the coastal regions within RESIST plan to address SLR as well as coastal flooding and erosion. Additionally, several of these regions also explicitly consider biodiversity loss and degradation of both terrestrial and marine ecosystems in their measures. In the southern regions, heat and wildfires are of high importance, presenting major hazards already today. Furthermore, prolonged water scarcity and droughts will most severely affect southern Europe. Hence, these regions focus on developing corresponding adaptation solutions within RESIST. Besides coastal inundation, several regions will also address river flooding and flash floods arising from heavy rainfall in combination with a low water retention capacity. Certain regions with geomorphological conditions increasing the risk of erosion from coastal flooding, heavy rainfall or forest fires also feel a strong need to adapt to this hazard within RESIST.

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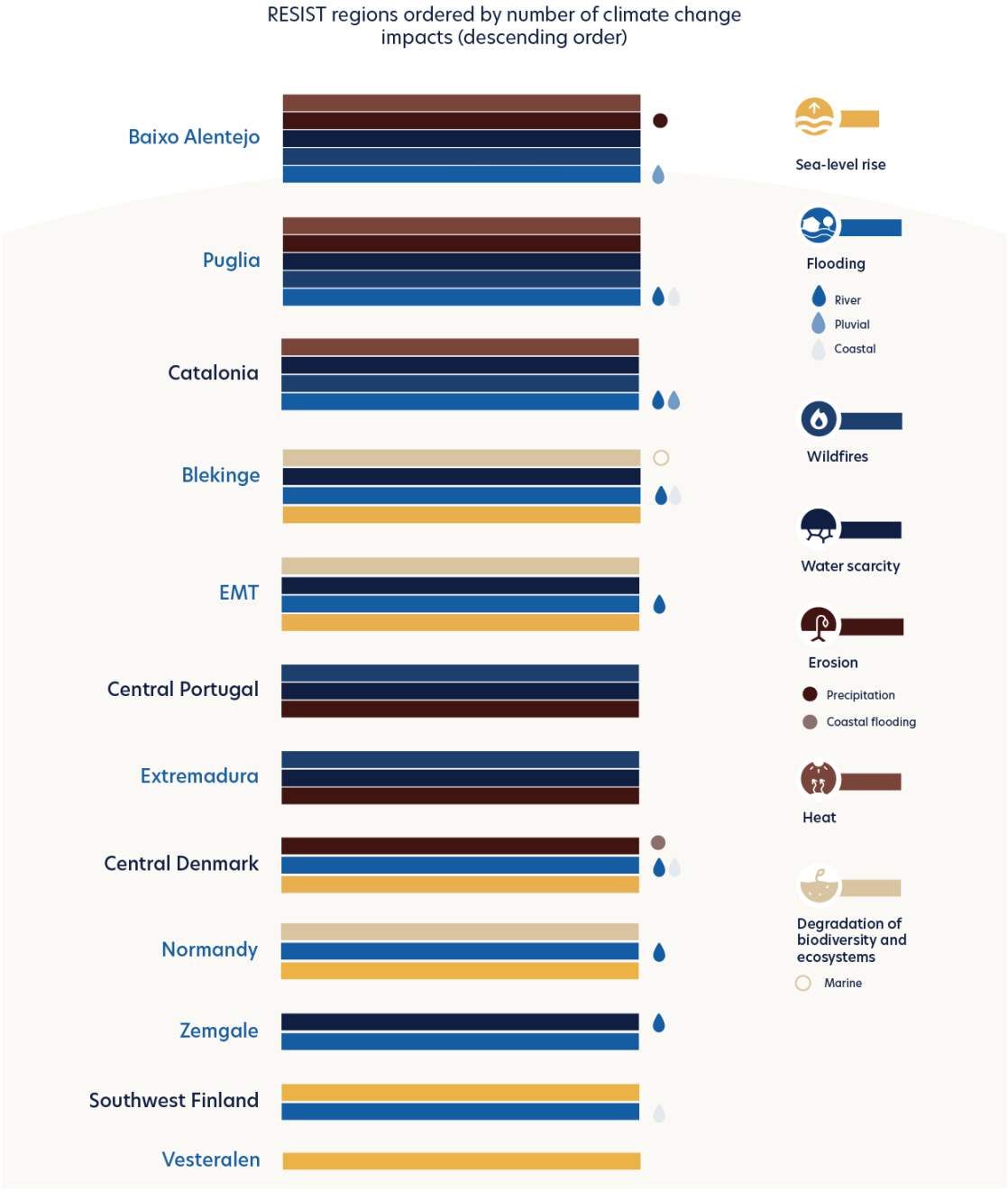

Figure 22: Common climate change impacts addressed within RESIST (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

Besides the above-mentioned impacts, the regions are affected by **further climate change consequences** that are not explicitly addressed within the RESIST project but should be pointed out to be considered in further adaptation actions: In EMT, major impacts further include heat stress

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and forest fires. Normandy's littoral is highly affected by erosion, landslides and coastal submersion. Central Denmark is affected by heatwaves and drought, but does not tackle these within the RESIST project. Blekinge is confronted with but does not address heatwaves, erosion or wildfires within RESIST. Zemgale faces heatwaves, erosion, heavy precipitation and hailstorms, which are not addressed in the project. Centro Portugal and Extremadura additionally face heat as a main climate risk as well as flash floods. Vesterålen is also concerned by impacts of rising ocean temperatures and ocean acidification. Additionally, (flash)floods and erosion are climate risks in Vesterålen that will not be tackled within the RESIST scope. However, even if the regions are not specifically planning to tackle a certain hazard, it may well be that planned measures alleviate this hazard as a positive side-effect. Many adaptation solutions often offer co-benefits addressing several climate change impacts.

Table 58: Common climate change impacts addressed within RESIST.

Impact	Region affected	Description
Sea-level rise (SLR)	Blekinge	Projected SLR rise under RCP8.5 scenario: year 2100 +0.5 m, year 2150 +1.1 m, year 2300 possibly +3.1 m (taking into account a combination of SLR, storm surges and waves as the worst possible scenario, is projected to add another +2.5 m to each of the SLR scenarios)
	Central Denmark	Due to proximity to the sea in all cardinal directions (esp. east and west coast), Central Denmark is particularly susceptible to increasing SLR and related coastal flooding and coastal erosion. The region's low altitude (flat region almost entirely at sea level) further exacerbates risks from SLR.
	Eastern Macedonia and Thrace	Similar to SW Finland, SLR is not expected to pose a great threat in the mid-term future. However, towards 2100, substantial increase in risk expected. Due to proximity to the sea, region particularly susceptible to SLR and associated coastal flooding.
	Normandy	SLR currently averaging 3 mm/year, resulting in a 20 cm rise in 100 years but could reach +1.8 m by 2100 under a 4 °C global warming scenario. SLR in coastal areas leads to salinisation and consequent reduction in availability of drinking water; and increases risk of coastal flooding and erosion. Inland consequences: flooding from storms and increasing water tables, blocking of river flows
	SW Finland	In the mid-term, increase in likelihood of high sea levels not expected in the Archipelago Sea. Towards 2100, projected SLR but estimates subject to considerable uncertainty. Together with increase in intensity and frequency of storms, SLR would increase risk of flooding in the region.
	Vesterålen	- Projected SLR under different emission scenarios: RCP4.5 up to 0.35 m, RCP8.5 up to 0.55 m - Together with ocean temperature rise and acidification threat to fishing industry and aquaculture - SLR is a threat to housing, industry and infrastructure along the coastline (SLR is approximately 1.9 mm per year)

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Flooding	Baixo Alentejo	- Impacts from flash floods, resulting from heavy precipitation events, are an important climate impact today, especially in locations where water accumulates (insufficient drainage / infiltration) - In the future, increases in frequency and intensity of heavy precipitation events have the potential to exacerbate associated risks
	Blekinge	- Coastal flooding due to high sea levels (esp. in low-lying coastal areas) and fluvial flooding along inland watercourses due to heavy rain, rapid snowmelt and spring floods. Two municipalities with very high risk of floods: Karlshamn and Karlskrona. - Significant material and financial damage already occurring now
	Catalonia	- Projections indicate that areas with significant increases in fluvial flood risk correspond to the large river basins of the region, affecting important urban centres such as Barcelona, Girona, Tarragona or Manresa - Changes in pluvial flood risk remain rather uncertain. Projected future precipitation presents a large interannual variability. Precipitation anomalies (annual and seasonal), both positive and negative, are projected to increase, leading to years with very significant increases but also years with significant reductions in precipitation. Despite the uncertainty, the trend seems to point towards a general decrease in average annual precipitation, particularly during summer.
	Central Denmark	- Coastal flooding occurs due to rising sea levels esp. at east and west coast of Central Denmark, causing coastal and soil erosion, damages of infrastructure, buildings and transport networks - Fluvial flooding along the intricate network of streams and lakes is caused by increasing storm surges, cloudbursts, heavy rain and high groundwater levels
	Eastern Macedonia and Thrace	- Substantial variability of precipitation generates risks of inland flooding and coastal erosion - Severe flooding in recent years in the prefectures of Evros, Rhodope and Xanthi, resulting in numerous economic losses to residential and agricultural areas
	Normandy	- More frequent and intense river flooding threatening water resources - Heavy rainfall and subsequent run-off and soil erosion increase turbidity and contamination of watercourses - SLR increases risk of coastal flooding and erosion which is already severe today
	Puglia	In every area the risk for flooding is constant or slightly increasing: high risk is forecasted for the Tavoliere plain in northern Puglia. Medium to high risks for flooding are around the Ofanto river, Central Puglia and in Salento delle Serre - (River) flooding causes hydrogeological instability - Reduction in the water availability for civil, urban and productive uses - Increased risks of erosion, failure of embankments and erosion at the base of bridges, thermal expansion of bridges / viaducts - Flooding of land transport infrastructures
	SW Finland	Impacted by inland watercourse, heavy rainfall associated and seawater flooding to different extents: - Currently moderate risk of inland watercourse flooding, not projected change by 2050. However, impact may vary by river basin. Main risk areas: Salo on the Uskelanjoki and Perniö along the Perniönjoki branch of the Kiskojoki - Flash floods already a relatively high risk due to high population density, high number of paved surfaces and topography. With increasing frequency and intensity of heavy rainfall, the risk expected to increase further - No significant SLR expected by 2050: seawater flood risk assumed to remain significant but not aggravating. Turku coastal region as major seawater flood risk area. Rare flooding events but affecting hard-to-evacuate sites, industry locations and sites subject to environmental permits

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	Zemgale	- Risks are limited to inland watercourse flooding - Current flooding affects urban areas and infrastructure, agriculture and economic sectors, population and ecosystems - Increased risk of flooding in Zemgale's dense network of (small) rivers and two largest river basins Daugava and Lielupe
Wildfires	Baixo Alentejo	- Risks from wildfires are already of high importance for the region today - Given projected rising annual temperatures and decreasing annual total precipitation, more arid climatic conditions are expected in the region for the end of the century, exacerbating wildfire risks
	Catalonia	- Forest fires are already today an important hazard in Catalonia - Risk of forest fires might increase in the future, due to projected increases in length of dry spells (the dry streak length index is generally projected to increase throughout the territory), although both positive and negative precipitation anomalies are projected to increase in the future.
	Centro Portugal	- Climate risk due to old-age dependency, emigration from rural areas, extensive fuel loads in forests - Meteorological fire risk projected to increase up to 41.3 days under RCP8.5
	Extremadura	- Climate risk due to low population density, population decline, unmanaged, dense and thick forests and shrubland with fuel built-up - 2% of forest area growth per year
	Puglia	Possible increase in the danger of forest fires and lengthening of the fire season; reduction of areas with conifers, broad-leaved trees, mixed and commercial forests, sclerophyllous vegetation
Water scarcity, drought	Baixo Alentejo	- Total annual precipitation is expected to decrease by the end of the century by 9% (RCP4.5) to 10% (RCP8.5) - Projected number of consecutive days with precipitation < 1 mm, however, not expected to change substantially: projections therefore do not suggest a sharp increase in the *duration* of dry spells in the future. - However, given projected rising annual temperatures and decreasing annual total precipitation, more arid climatic conditions might nevertheless be expected in the region for the end of the century. The region therefore acknowledges the risk of increases in the *frequency* and *severity* of droughts.
	Blekinge	Decreasing groundwater levels as a primary issue in the region; expected to further decrease due to climate change
	Catalonia	- Precipitation anomalies (annual and seasonal), both positive and negative, are projected to increase, leading to years with very significant increases but also years with significant reductions in precipitation. - The dry streak length index is generally projected to increase throughout the territory.
	Centro Portugal	- Droughts affect forested areas and agroforestry - 46.6% of Region Coimbra's territory area projected to be affected by very high and extreme water deficit under RCP8.5
	Eastern Macedonia and Thrace	- Trend of prolonged droughts: number of days with < 1 mm precipitation anticipated to rise from 10 to over 70 by 2100 in almost all parts of the region - Highly vulnerable agriculture sector, natural environment, wetlands and protected areas
	Extremadura	- Reduction in precipitation and more unequal distribution increase the risk for desertification - By 2041-2070, 70% of Extremadura will have desert characteristics (A2 scenario water deficits ranging from -275 to -250 mm for 2011-2040 and -500 to -475 mm for 2041-2070) which increases vulnerability to forest fires and for the agriculture sector

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	Puglia	- Reduction in water availability for civil, urban, and productive uses - Reduction in river water availability - Consequences: Erosion, Salinisation, Aridification, Loss of organic matter in soils - Risk is increasing in every region of Puglia, especially in the Tavoliere plain, central Puglia, Alta Murgia, Murgia dei Trulli, Arco Ionico Tarantino, Tavoliere Salentino are already showing a medium to high risk for drought
	Zemgale	- Risks from drought are projected to be more than moderate, affecting the primary sector (i.e. agriculture as a primary economic activity in Zemgale) - Observed trends of increasing temperatures and hotter summer days may further increase drought-related risks in the future
Erosion	Baixo Alentejo	- The projected increased frequency and intensity of heavy precipitation events has been identified as one of the climatic trends bearing important risks for the region. - These projected changes in heavy precipitation events have the potential to exacerbate erosion problems in the future.
Erosion	Blekinge	- Coastal erosion (and beach erosion) is already present in all coastal municipalities due to SLR and coastal floods - Erosion along inland watercourses is related to fluvial flood risk, resulting in loss of land, instability of slopes risk of landslides risks.
Erosion	Central Denmark	Risk of erosion due to coastal flooding along the entire coastline of Central Denmark
Erosion	Centro Portugal	Risk of erosion due to forest fires, specifically during heavy rainfall events
Erosion	Extremadura	- Rainfall-induced erosion is primary cause of fertile soil loss (contributes to desertification) - High risk because of geomorphological characteristics of steep slopes and narrow valleys (in RESIST regions, high-medium risk areas)
Erosion	Puglia	Coastal erosion: Clear retreat of most sandy beaches and significant portions of the regional coastal territory, characterised by low altitudes above mean sea level and depressed areas inland (e.g. the areas facing the gulfs of Manfredonia and Taranto) subject to frequent flooding, following even not particularly intense meteorological events.
Heat	Baixo Alentejo	- Both minimum and maximum temperature are projected to rise significantly in the region until the end of the century - by up to +3.2 °C (RCP8.5) for minimum temperatures, and up to +3.5 °C (RCP8.5) for maximum temperatures - An increase in in the number of hot days is further expected
Heat	Catalonia	- Average annual temperature will continue to increase across the region across all climate scenarios. - For a high emission scenario, the average temperature may increase by up to 3 ºC by 2050. Maximum temperature is projected to increase by up to 4 ºC, minimum temperature by up to 3 ºC. - Geographically, the largest increases are projected for the Pyrenees.
Heat	Puglia	- More frequent and intense heat waves, with increased mortality/morbidity - Water scarcity and decrease in water quality - Increase in peak summer energy demand, blackout risk. - Seaside tourism: change in the attractiveness of the destinations (e.g. explosion of the population of algae and jellyfish; decrease in the level of navigable lakes - Most regions are prognosed with a medium risk for heat waves in the future
Biodiversit y loss	Blekinge	Depletion of marine ecosystem, specifically near coastline, affecting coastal communities; however, currently lack of data and monitoring on cause-effect-relationships
Biodiversit y loss	Eastern Macedonia and Thrace	- Biodiversity, wetlands and protected areas with high to extreme vulnerability to warming, reduced precipitation, increased duration of seasons, and decreased water quality - Topic of priority in the RAAP

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Normandy	- Rising temperatures and SLR exerting pressure on terrestrial and marine biodiversity - Effects of climate change compounded by other factors linked to human activities, such as changes in land use and practices, pollution, habitat fragmentation and introduction of invasive species

To address these climate change impacts, the regions are developing adaptation solutions in the fields of stakeholder engagement concerning different target groups, nature-based solutions (NbS) for drought tolerance and flooding, early warning systems (EWS) and hydrological modelling, as well as identifying new economic opportunities for adapted land management and assessing the cost-benefit-effectiveness of measures (see Figure 23, Table 59).

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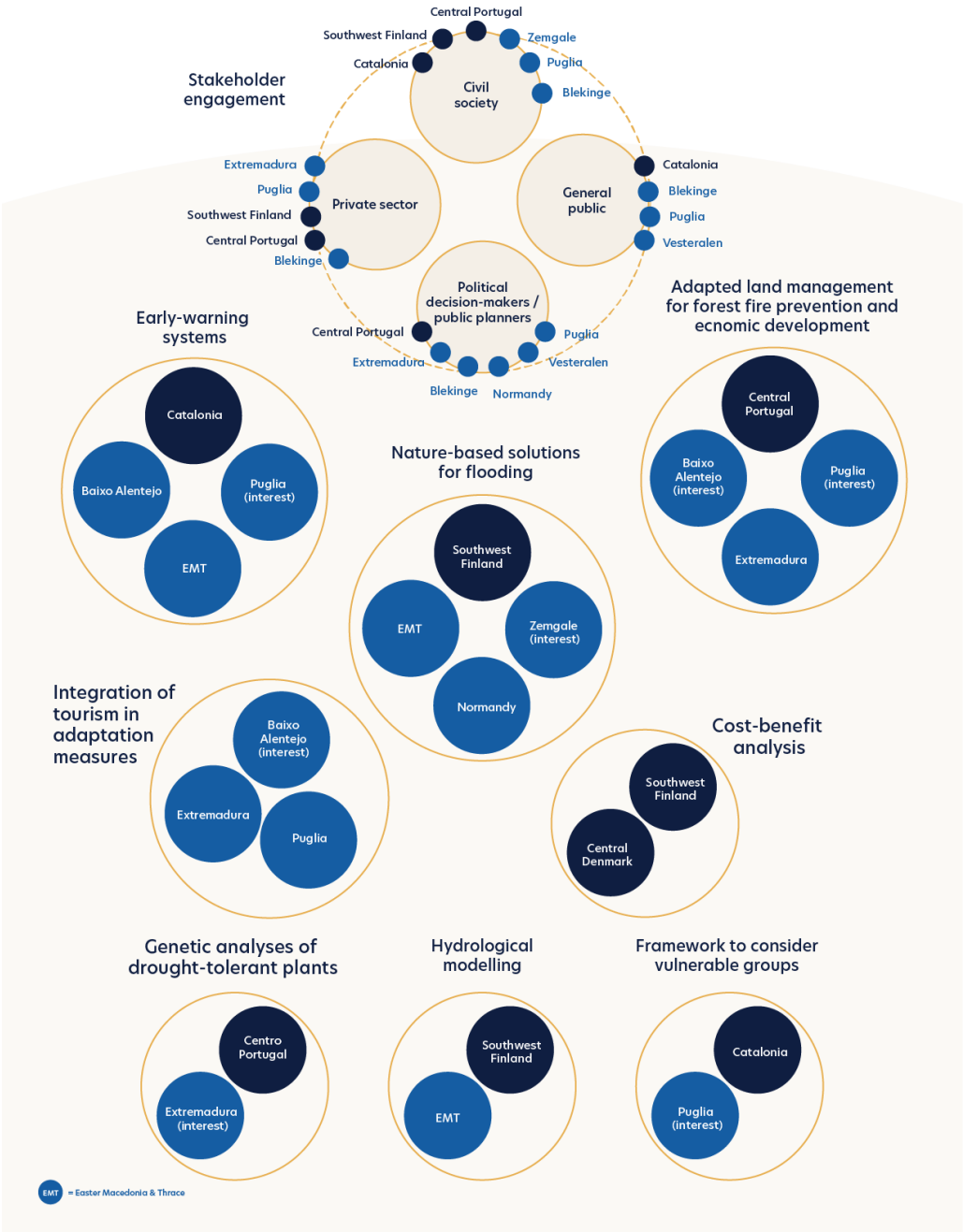

Figure 23: Common adaptation solutions developed within RESIST (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

NbS for flooding is a major activity in all regions of LSDT1, with additional cost-benefit-analysis (CBA) performed in SW Finland and forecasting and early-warning systems (EWS) innovation in EMT. Stakeholder engagement has been planned and started with different actors, such as private land

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owners, farmers, and engineers. Here, potential for further support through RESIST partners exists especially concerning civil society and citizens (see section 4.2). Flood risk management and respective improvement of data collection and monitoring systems is the major focus of all regions in LSDT2, with Central Denmark focusing on demo-houses for flood-resistant building techniques and Zemgale having a strong interest in blue-green NbS solutions for river flooding. The development and implementation of EWS, improving collaboration in the public protection sector, as well as identifying and addressing people in vulnerable situations are key focus topics of LSDT3, especially for Catalonia and Baixo Alentejo. Puglia aims at taking an approach concentrating more on the tourism sector and how its resilience to climate change impacts can be strengthened. Fire-adapted landscape management is the focus of Centro Portugal and Extremadura (LSDT4) which involves stakeholder engagement on various levels. Vesterålen is additionally focussing on modelling SLR and ocean acidification and temperature rise which is not part of the table as no other region is working on that specific topic.

Table 59: Common climate adaptation solutions within RESIST.

Adaptation activity	Region	Description
Stakeholder engagement – civil society	Centro Portugal	Engagement with civil society for implementing the AIGPs and village condominiums
	Puglia	For the animation activities a bottom-up approach will be pursued. Support is needed in the workshop design and again the consideration and involvement of vulnerable groups.
	SW Finland	On-site surveys and focus group discussions with vulnerable groups that cannot access surveys such as small children and elderly people
	Zemgale (interested)	Especially with civil society
Stakeholder engagement – private sector	Centro Portugal	Engagement with private farmers and forest owners for fuel management
	Extremadura	Engagement with private farmers and forest owners for implementation of FSL and with the tourism sector (restaurants, tour agencies etc.)
	Puglia	One of the main planned activities is the formulation of innovative guidelines or policies for the tourism sector. For this political and private sector stakeholder need to be involved and ways need to find to deal with scepticism. Also, the potential of the SRACC needs to be examined further
	SW Finland	Collaboration with local businesses discussing innovative measures: showcasing the benefits of NbS and co-creating solutions to convince businesses to expand activities and support implementation
Stakeholder engagement – political decision-makers/ public planners	Blekinge	Development of serious games to drive innovation and design decision-making including sustainability aspects Development of collaborative decision-making arenas ('decision theatre') where a number of stakeholders can be gathered and supported in their discussion
	Centro Portugal	Development of a new governance model for AIGPs and village condominiums

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	Extremadura	Engagement with regional/ local decision-makers for policy and legislation adaptation to create and manage FSL
	Normandy	Organising meetings between the environmental vice-president and elected representatives in the potential sites Aims to encourage deployment of NbS instead of current local development practices/encourage local authorities to use its solutions
	Puglia	One of the main planned activities is the formulation of innovative guidelines or policies for the tourism sector. For this political and private sector stakeholder need to be involved and ways need to find to deal with scepticism. Also, the potentials of the SRACC need to be examined further
	Vesterålen	Guideline / tools to support public planners in integrating climate change adaptation measures in planning process (local climate change governance)
Stakeholder engagement – general public	Catalonia	-Raising awareness and effectively communicating risks to communities, including designing targeted warning messages for SSWs -Identifying vulnerable areas and communities susceptible to specific or multiple hazards and implementing better EWSs, starting with the municipalities of Terrassa and Blanes
	Puglia	One of the main planned activities is the formulation of innovative guidelines or policies for the tourism sector. For this political and private sector stakeholder need to be involved and ways need to find to deal with scepticism. Also, the potentials of the SRACC need to be examined further
	Vesterålen	Engagement with general public through survey, projection mapping in the GAIA Vesterålen museum and through environmental contract
Framework to consider vulnerable groups	Catalonia	Developing an inclusive framework for prevention and emergency management at the local level to incorporate the needs, knowledge, and capacities of the most disadvantaged or marginalized groups
	Puglia (interested)	As stakeholder involvement is an essential part of the planned activities, it is important to consider vulnerable groups. There is already a gender agenda for Puglia, but so far, no link has been made to climate risks or adaptation.
Integration of tourism in adaptation measures	Extremadura	Tourism as part of the fire-smart landscape management for making (trails/ tours through FSL, sell products from FSL in restaurants/ shops, education activities)
	Puglia	Main focus of all the activities in the project is the tourism sector. The partners are still very open and to what to implement and there. Support needed in the identification of the measures
Analysis of drought-tolerant plants	Centro Portugal	Genetic map of best performance plant against hydrological stress: DNA analysis of drought-tolerant tree and shrub species
	Extremadura (interested)	High interest in analysis results
Hydrological modelling	Eastern Macedonia and Thrace	Regional-scale flood modelling based on free HEC software to assess implementation of sustainable urban drainage system
	SW Finland	- Modelling to investigate and demonstrate opportunities of NbS in water retention in agricultural catchment (Savijoki): benefits of reducing nutrient loads and increasing water regulation/retention. - Results to be used in supporting local land owners in their water management decisions

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Nature-based solutions for flooding	Eastern Macedonia and Thrace	NbS for minimizing flood events and surface water pollution
	Normandy	Renaturation, stream clearing, nature-based rainwater handling and quality management of discharged water
	SW Finland	- NbS for stormwater quality and quantity management - Drainage-basin specific multi-beneficial water retention plans
	Zemgale (interested)	Blue-green solutions for addressing river flooding and groundwater levels
Adapted land management for forest fire prevention and development of new economic opportunities	Baixo Alentejo (interest)	Baixo Alentejo has expertise in dealing with and managing forest fire risks, also in ensuring collaboration between the regional and municipal level. There might be interest to exchange on land management practices to reduce forest fire risks.
	Centro Portugal	Centro plans to implement “Integrated Areas of Landscape Management” and “village condominiums” (change in land management and valorisation of bioresources from forest residues) → technical, governance and legislation levels
	Extremadura	Fire Smart landscapes based on the mosaic approach (cost-effective productive fuel breaks managed by local farmers) in collaboration with fire suppression bodies → technical, governance and legislation levels
	Puglia (interest)	Not explicitly mentioned by the region, but as forest fire risk is a prominent risk in the rgion, it could be interesting to exchange
Early-warning systems	Baixo Alentejo	Transfer and deploy EWS tools from Catalonia to the Baixo Alentejo region
	Catalonia	- Multi-hazard EWS at the municipal level “Argos” to be further developed and implemented in additional municipalities - Evaluate the performance of implemented MH-EWS tools (Argos) during significant weather events - Install and expand site-specific warnings (SSWs) in different high-risk locations, able to trigger automatic protection protocols
	Eastern Macedonia and Thrace	Leveraging Python, Power BI, and advanced AI algorithms, for data visualization and predictive analytics/early warning
	Puglia (interest)	Interest in EWS, but nothing implemented or planned so far
Cost-benefit analysis	Central Denmark	BEST-adapt Tool: decision-support tool for municipal planners to be completed by 2026
	SW Finland	- CBA of ecosystem services concerning stormwater retention, biodiversity and recreation to improve knowledge on effectiveness of NbS and increase stakeholders’ motivation to design and invest in NbS - Assess cost-benefit-effectiveness of NbS in Rauvolanlahti catchment

4.2 Commonalities in challenges and support needs

In most twinning regions, planning of adaptation measures is still in its early stages. Nevertheless, some key challenges (see Figure 24, Table 60) and avenues for support (see Figure 27, Table 61) can already be identified that are emerging in several project regions.

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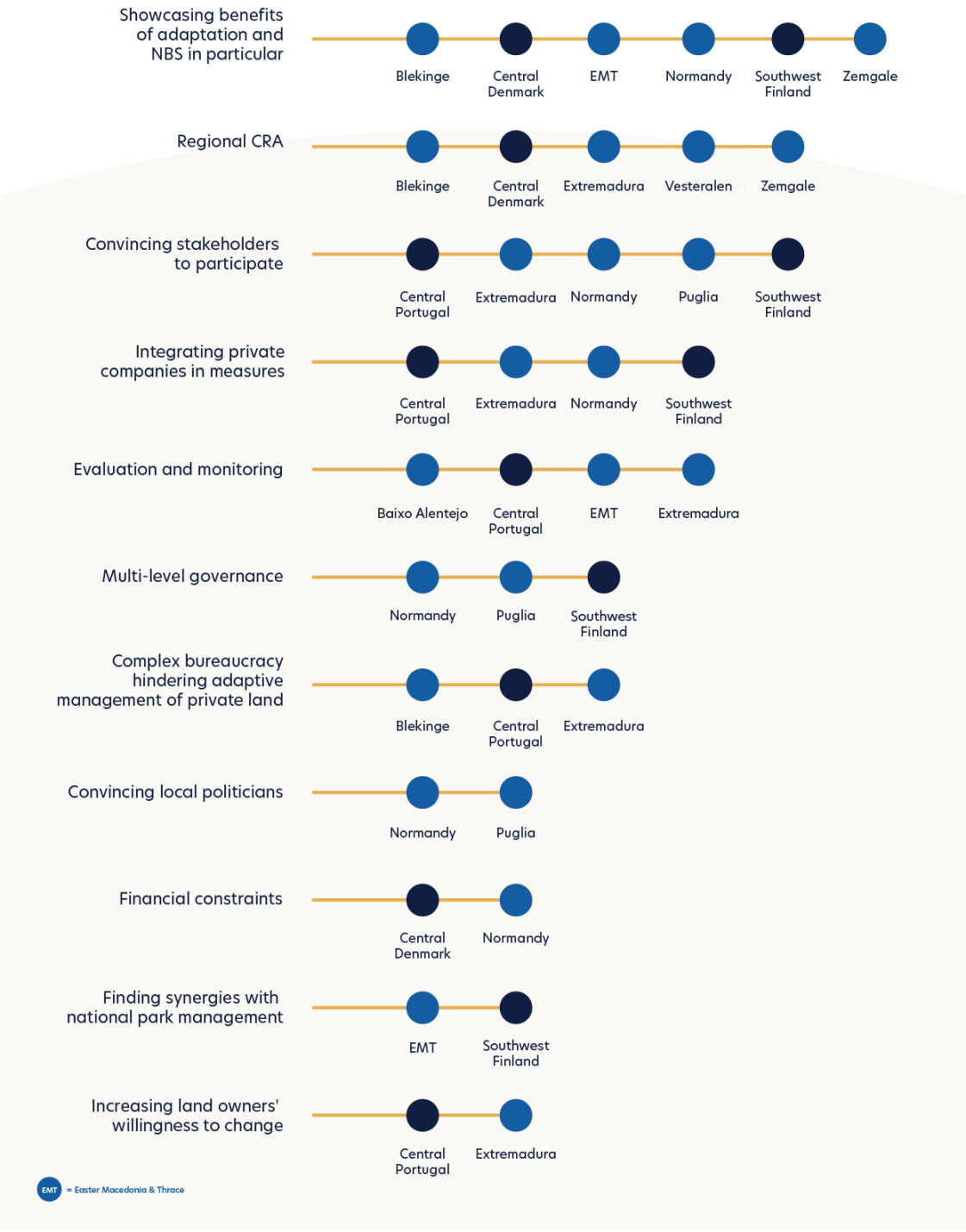

Figure 24: Common regional challenges and needs within RESIST (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

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Concerning challenges the regions are facing, common themes are issues of stakeholder engagement, financial and institutional capacity constraints as well as knowledge-sharing and capacity-building concerning NbS and CBA. Some regions do not yet have a climate risk assessment (CRA) or the currently available assessments were performed more than a decade ago and thus need an update. Additionally, convincing stakeholders to participate in adaptation actions, especially the private sector, land owners and local politicians, poses a major challenge for many regions. In this context, there is a high need to showcase the benefits of adaptation and to identify synergies in different fields. Financial and institutional capacity constraints in regions include the presence of varying and sometimes unclear or conflicting responsibilities on the national to local level, the lack of an adequate governance and policy background to enable transformative adaptation, and, in some regions, limited public and private funding. Finally, several regions have already expressed interest in evaluation and monitoring of project activities and beyond (see Figure 24, Table 60). Addressing these challenges at an early planning state creates great leeway for designing innovative solutions for climate resilience.

Table 60: Common regional challenges and needs within RESIST.

Challenge	Region	Description
Regional CRA	Blekinge	CRA out of date. There is a need to update regional risk assessment and adaptation action plan, including gender aspects and vulnerable groups. First step could be developing a proposal for adaptation planning (that would also integrate social dimensions and to find innovative ways forward)
	Central Denmark	- Absence of regional CRA hampers coordination and alignment of adaptation efforts in the region; disconnect to national level - Enhancing a comprehensive risk understanding (beyond flood focus)
	Extremadura	- The existing CRA is more than 10 years old and needs to be updated - Also, a more specific focus on forest should be taken up (e.g. through sectoral assessment)
	Vesterålen	No regional CRA exists but would be highly necessary to understand hazards, exposure and vulnerabilities at a regional level
	Zemgale	No regional CRA
Convincing stakeholders to participate	Centro Portugal	Integration of private forest owners/ private sector companies in adapted land management changes
	Extremadura	Integration of private forest owners/private sector companies in adapted land management changes
	Normandy	Without regional support for local financing of NbS within RESIST, need to convince essential stakeholders and the wider community of the necessity and benefits of adaptation solutions
	Puglia	Stakeholders need to be informed and convinced. There are different barriers: scepticism towards climate adaptation activities and language (not all stakeholders are speaking English)
	SW Finland	In Savijoki pilot site, challenge to convince private landowners to participate

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Convincing local politicians	Normandy	Site selection in cooperation with local politicians who might be sceptical towards adaptation and NbS
	Puglia	Involving local politicians when planning interventions in the pilot region
Integrating private companies in measures	Centro Portugal	Pulp and paper companies are so far not integrated in project but have an important role in forest management (owners of forest; economic importance in the region of the companies)
	Extremadura	Timber/biomass companies, carbon credit companies should be actively integrated in the implementation process of FSL
	Normandy	- To address financial constraints in the project - Potentially within pilot sites, depending on site selection
	SW Finland	In industrial area of Oriketo, challenge to convince companies to participate and potentially invest
Multi-level governance	Normandy	Limited coherence and effectiveness of adaptation policies conducted at national, regional and local levels: uneven distribution of institutional responsibilities; existing administrative boundaries not always sufficiently scaled to address climate-related issues effectively
	Puglia	One of the main planned activities is the formulation of innovative guidelines or policies for the tourism sector. For this political and private sector stakeholder need to be involved and ways need to find to deal with scepticism. Also, the potentials of the SRACC need to be examined further
	SW Finland	Unclear division of work between regional adaptation actors; underdeveloped cooperation between regions, sectors and relevant stakeholders as well as different perceptions of the role of regional councils and ELY centres
Complex bureaucracy hindering adaptive management of private land	Blekinge	Navigating complexities of regulations and legislation: challenges around property ownership; independence of municipalities
	Centro Portugal	Facilitation of legislation and governance mechanisms for private land owners
	Extremadura	Complex structures and facilitation of governance and legislation needed for the creation of fire-smart landscapes and the integration and valuation of private forest owners in practices
Financial constraints	Central Denmark	Support identification of financing options, including private sector actors
	Normandy	Region can provide limited local funding for pilot sites within RESIST
Showcasing benefits of adaptation and NbS in particular	Blekinge	- Interested in communication toolkit and products to showcase benefits of NbS for adaptation and beyond. This has to be carried out in close collaboration with Partnership for Regional Innovation (PRI) - Stakeholder exchange, helping to increase political relevance of adaptation and policy coherence
	Central Denmark	- Interested in exchange and collection of NbS on coastal and river flooding and can offer their best cases, combined with stakeholder engagement - Can offer connective negotiation as approach to stakeholder engagement
	Eastern Macedonia and Thrace	- Persisting misconception of NbS as less effective or more expensive than other adaptation solutions - Lack of knowledge and expertise regarding monetary and non-monetary benefits of NbS, lack of financial evaluation of these solutions

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	Normandy	Common misconceptions of NbS as inefficient or expensive and structural obstacles (lack of reference system, regulatory complexity, incompatibility with external technical standards)
	SW Finland	- Lack of awareness for climate change impacts and the necessity to adapt - General reservations against NbS: perceived as more expensive than traditional grey infrastructure, insufficient understanding of the multiple benefits and value of ecosystem services
	Zemgale	Interested in learning about NbS, especially blue-green solutions for flood management
Finding synergies with national park management	Eastern Macedonia and Thrace	Area under study of high environmental importance due to rich biodiversity, habitat coverage and transboundary rivers; includes five national parks and more than 20 Natura 2000 sites
	SW Finland	In Rauvolanlahti pilot site, discharge to a NATURA 2000 reserve
Increasing land owners' willingness to change	Centro Portugal	Economic (e.g. CBA) analysis of co-benefits for land owners to adapt land management, increasing their willingness to change
	Extramadura	Economic (e.g. CBA) analysis of co-benefits for land owners to adapt land management, increasing their willingness to change
Evaluation and monitoring	Baixo Alentejo	Interest in monitoring and evaluating success of activities
	Centro Portugal	Interest in monitoring success of project activities and beyond
	Eastern Macedonia and Thrace	High interest in modelling and data collection as potential for innovative monitoring
	Extremadura	Interest in monitoring success of project activities and beyond

Multi-level governance and misconceptions about NbS are hindrances in all regions of LSDT1. In Normandy financial constraints and political conviction also pose a challenge, as well as the integration of the private sector – a challenge shared with SW Finland. Using the existing and continuously growing data base for evaluation and monitoring presents a great opportunity in EMT. For all regions in LSDT2 a common challenge lies in the absence of an (up-to-date and in-depth) regional CRA and the need for establishing such a guiding document in order to enhance a comprehensive climate risk understanding and to improve effectiveness of adaptation measures in the respective region. In addition, all three regions face challenges with regard to showcasing benefits of NbS solutions, specifically related to flood management, and are keen on leveraging targeted NbS communication for improved stakeholder engagement. In LSDT3, due to its specific focus on EWS and the public protection sector, the regions of Catalonia and Baixo Alentejo do have quite specific challenges they do not share with the other regions. Catalonia faces challenges related to developing a user friendly, targeted EWS, as well as developing formats to effectively raise awareness and communicate climate-related risks to communities. Baixo Alentejo shares these challenges, but is still at an earlier stage of EWS deployment. The region needs to upskill their regional workforce and improve coordination in the civil protection sector. Additionally, Baixo Alentejo faces the challenge of deploying adaptation action in small, rural and dispersed villages. Puglia's main concerns regard stakeholder engagement and multi-level governance, as one of the main

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planned activities is the formulation of innovative guidelines or policies for climate adaptation in the tourism sector. Stakeholder engagement and more specifically engaging forest owners in adapted land management is a major challenge in Extremadura and Centro Portugal. Additionally, revising legislation is needed to ease and incentivise adapted land management. For Vesterålen, the engagement of the general public is a challenge together with the development of a regional CRA and the engagement of stakeholders.

To tackle these challenges, adelphi has identified several common avenues for support (see Figure 25, Table 61). Main activities revolve around designing and coordinating stakeholder engagement processes in an inclusive and collaborative way, identifying innovative financing solutions and developing strategies to engage the private sector as well as enhancing strategic planning, building capacity concerning CBA and monitoring of adaptation measures.

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Figure 25: Common support activities within RESIST (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

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In all regions of LSDT1 there is support needed for inclusive stakeholder engagement integrating social equity and gender dimensions as well as advancing integrated strategic planning. Innovative finance is an important lever to address Normandy's financial constraints within RESIST but is also interesting for further adaptation action in SW Finland. Monitoring does not present the largest need in EMT but comes with high potential. Baixo Alentejo would further be interested in support and exchanges on how to support adaptation actions in small, rural and dispersed villages, focussing on water management (risk of water shortages), forest management (risk of forest fires) and energy (risk of reduced production of hydro power).

Table 61: Common support activities within RESIST.

Support activity	Regions	Description
Stakeholder communication	All regions	Develop communication toolkit for different stakeholders
Integrate needs of vulnerable groups	All regions	Perform vulnerability assessment Mapping of needs and interests of stakeholders Provide guidelines for inclusive stakeholder engagement
Avoiding maladaptation	All regions	Assistance to use self-assessment REGILIENCE tool / Workshop on screening for maladaptation
Regional CRA	Baixo Alentejo	Update CRA to better integrate socio-economic aspects of risks, and generally further investigate and integrate vulnerability aspects
	Central Denmark	Update of current CRA based on current standard with a focus on vulnerable groups and gender
	Extremadura	Update of current CRA based on current standards and a dedicated chapter/ sectoral analysis of the forest sector
	Puglia	The SRACC was launched in August and the partners need support to see the full potential and strengths of this framework for the work within RESIST.
	Vesterålen	No regional CRA exists but would be highly necessary to understand hazards, exposure and vulnerabilities
	Zemgale	Conduct CRA and educate local experts
Stakeholder engagement	Baixo Alentejo	Co-develop innovative ways to engage stakeholders and the communities, develop overall stakeholder engagement concept
	Blekinge	Stakeholder engagement is ongoing. However, the region is interested in mapping all stakeholders and in learning more innovative practices for engaging decision-makers and private sector
	Catalonia	- Support with innovative stakeholder engagement concepts, proofing of existing formats - Examples of workshops to engage communities and vulnerable groups
	Central Denmark	Stakeholder engagement is ongoing. However, the region is interested in learning more innovative practices for engaging decision-makers and private sector

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	Centro Portugal	General engagement with stakeholders ongoing however further support to engage forest owners and private companies and general citizens in project needed (integration of vulnerable groups and gender dimensions); e.g. Brochure/ guideline/ formats for citizen
	Eastern Macedonia and Thrace	Processes with certain stakeholders planned and carried out, but potential support for inclusive stakeholder engagement integrating social equity and gender dimensions
	Extremadura	General engagement with stakeholders ongoing however further support to engage forest owners and private companies and general citizens in project needed (integration of vulnerable groups and gender dimensions); e.g. Brochure/ guideline/ formats for citizen
	Normandy	Guidelines and support with designing and implementing inclusive and collaborative stakeholder engagement processes
	Puglia	Guidelines and support with designing and implementing inclusive and collaborative stakeholder engagement processes
	SW Finland	Processes with certain stakeholders planned and carried out, but potential support for inclusive stakeholder engagement integrating social equity and gender dimensions
	Vesterålen	Support for the further engagement with stakeholders such as regional planners, general citizens (integration of vulnerable groups and gender dimensions); e.g. Brochure/ guideline/ formats for citizens
	Zemgale	Support with innovative stakeholder engagement concepts, especially for civil society engagement
Additional funding and innovative financing	Baixo Alentejo	Interest in innovative financing solutions for climate adaptation, especially coupled with the tourism sector, support set up of finance strategy
	Blekinge	Overview of and support for identifying further climate adaptation financing options
	Central Denmark	Support in identification of further financing options for projects and specific solutions, including private sector actors
	Centro Portugal	Attraction of new investments based on new economic model (bioeconomy)
	Extremadura	Financing for expanding FSL beyond RESIST is of interest/ general interest in adaptation finance
	Normandy	Provide overview of financing options: - Map and endorse private investment opportunities (together with FASTTRACK) - Facilitate exchange on private investments in other EU regions (together with SERN)
	SW Finland	General interest in innovative adaptation finance
	Vesterålen	General interest in innovative adaptation finance
	Centro Portugal	Involvement of private companies (pulp and paper industry, 12% of GVA in Coimbra) in the forestry sector in project

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Involvement of private sector in adaptation	Extremadura	Involvement of private companies (timber/ biomass companies & carbon credit companies) in the forestry sector in project
	Normandy	Depending on the final pilot sites, this can be very relevant for the region
	SW Finland	Attraction and integration of private sector (finance); co-creation of adaptation solutions
Toolkit/ capacity building for regional/ local planners	Vesterålen	Vesterålen interested in training concept with local planners on how to integrate adaptation in local planning measures
	Zemgale	Interested in engaging civil society stakeholders
Strategic planning	Baixo Alentejo	Support strategic planning for adaptation measures
	Eastern Macedonia and Thrace	Linking individual measures through integrative planning to create synergies and additional benefits beyond planned adaptation objectives, e.g. social co-benefits
	Normandy	Strengthening coherence and impact of adaptation policies across scales and sectors, including screening processes and ex-ante assessments of adaptation actions
	Puglia	Helping to set a scope for interventions and give a good overview of best practices to support the decision making in this process
	SW Finland	To address challenge of multi-level governance, support integrated planning across local and regional authority boundaries and with the view of achieving defined, long-term, objectives
Assessment of economic benefits of adapted land management	Centro Portugal	Assessing of economic benefits of adapted land management practices & analysis of co-benefits for increasing the willingness to adapt land management for land owners (incentives)
	Extremadura	Assessing of economic benefits of adapted land management practices & analysis of co-benefits for increasing the willingness to adapt land management for land owners (incentives)
Concept for monitoring success of activities	Baixo Alentejo	Support with the creation of processes for monitoring success of activities / initiatives, introduction to monitoring concepts
	Centro Portugal	Support in developing a monitoring approach/ framework
	Eastern Macedonia and Thrace	Support in developing a monitoring approach/ framework based on existing comprehensive data base
	Extremadura	Support in developing a monitoring approach/ framework

4.3 Regional expertise and opportunities for transfer

The twelve RESIST regions have diverse and broad expertise in various fields relevant to climate change adaptation (see Figure 26). The project thrives on this knowledge and the regions' openness to pass it on and transfer it to other contexts. Adding to the support that can be provided by adelphi and other horizontal partners, RESIST can draw on this wealth of knowledge to implement and up-scale innovative adaptation solutions.

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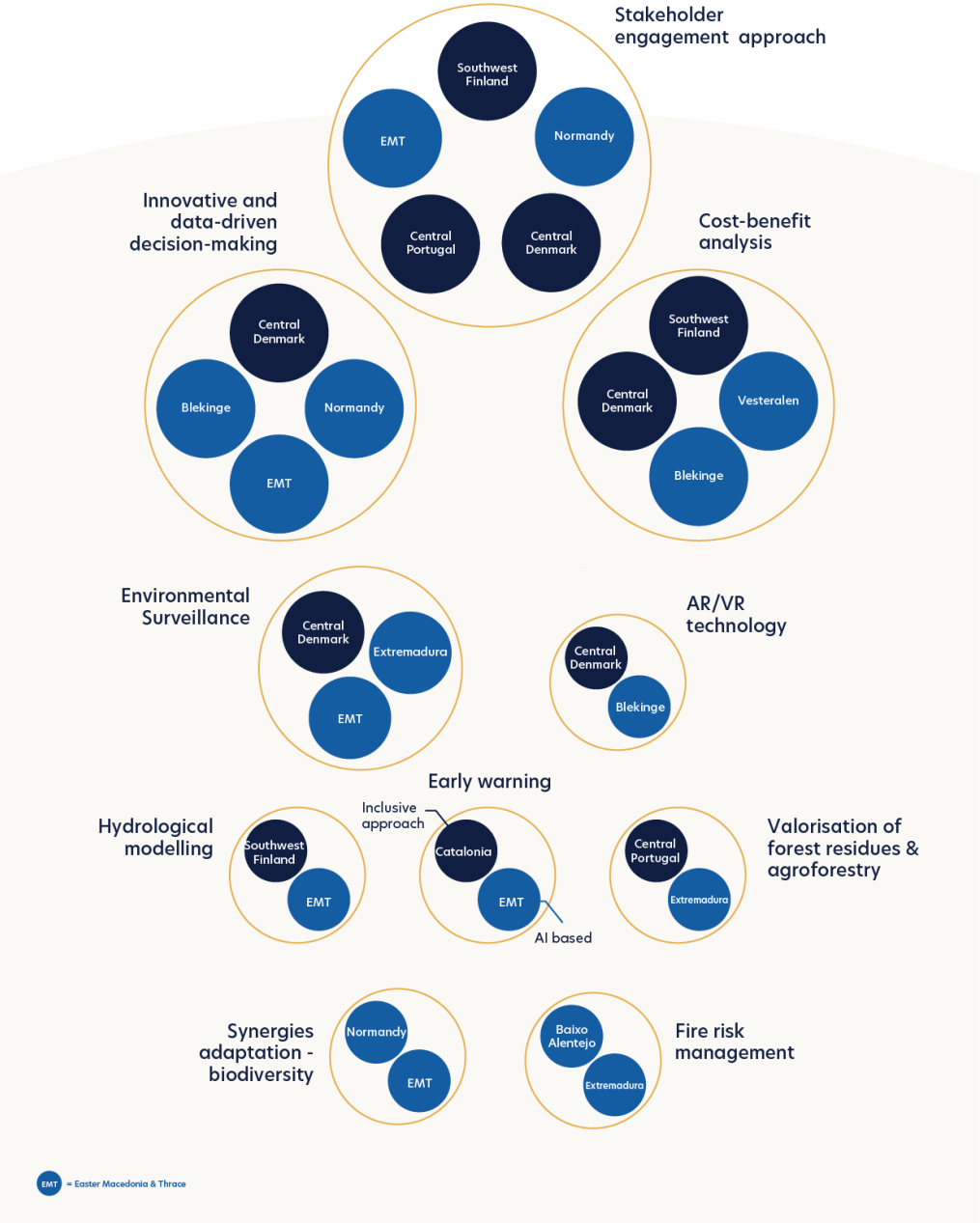

Figure 26: Strengths and expertise of RESIST regions (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

All regions can benefit from the transfer of adaptation solutions within RESIST in terms of knowledge sharing and peer-to-peer learning in concrete practical questions, such as exploring the variety of potential NbS, performing CBA and convincing opposed stakeholders (see Figure 28 and Figure 29, Table 62). Exchange and co-creation are also vital to realise the full potential of digital tools and

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technologies (Figure 27). Going beyond RESIST, regions can benefit from exchanging ideas and strategies on how to overcome structural barriers to transformative adaptation and create more systemic and innovative solutions.

Figure 27: Digital tools and technologies developed within RESIST (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

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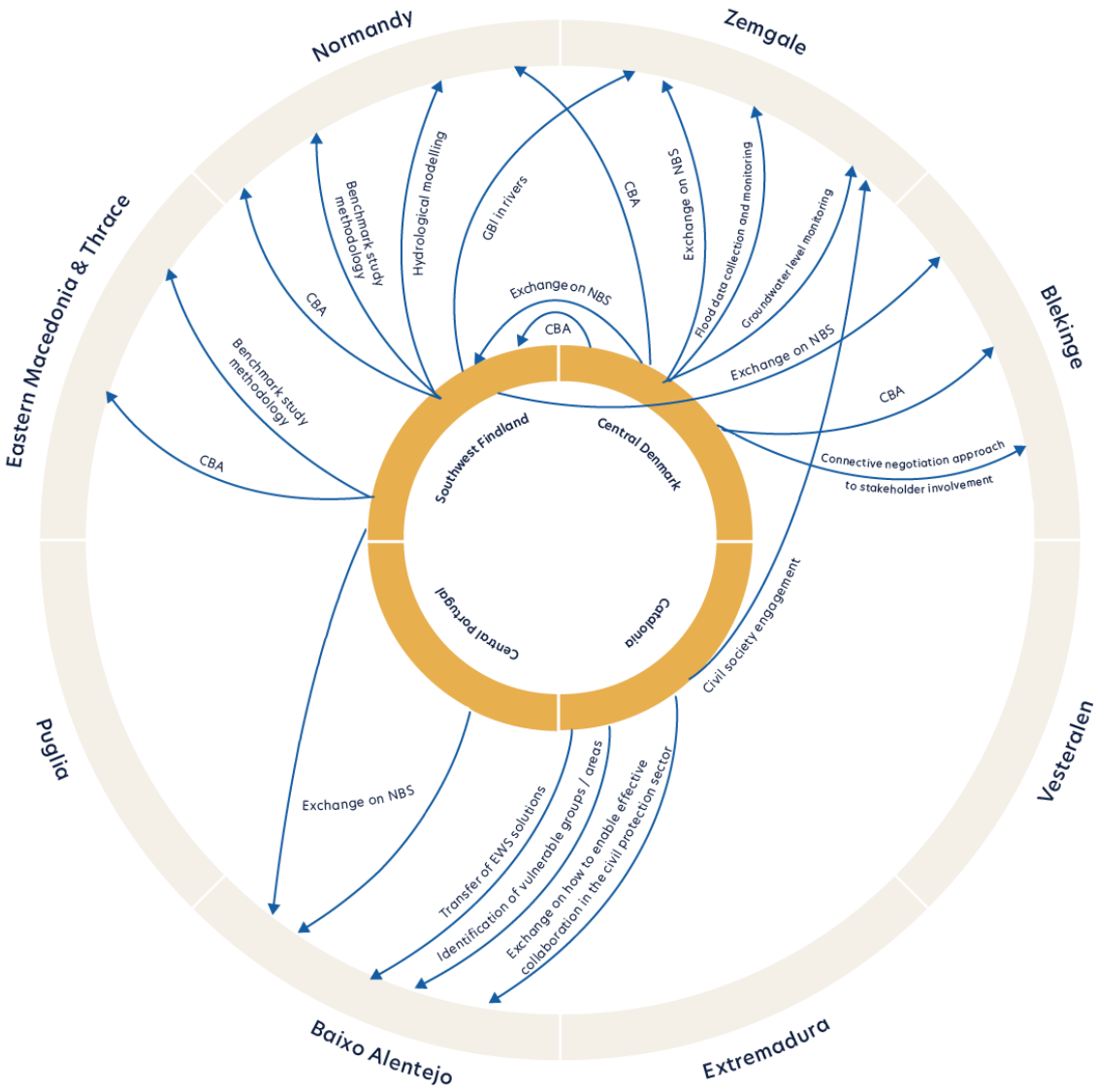

Figure 28: Transfer potentials from LSDs (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

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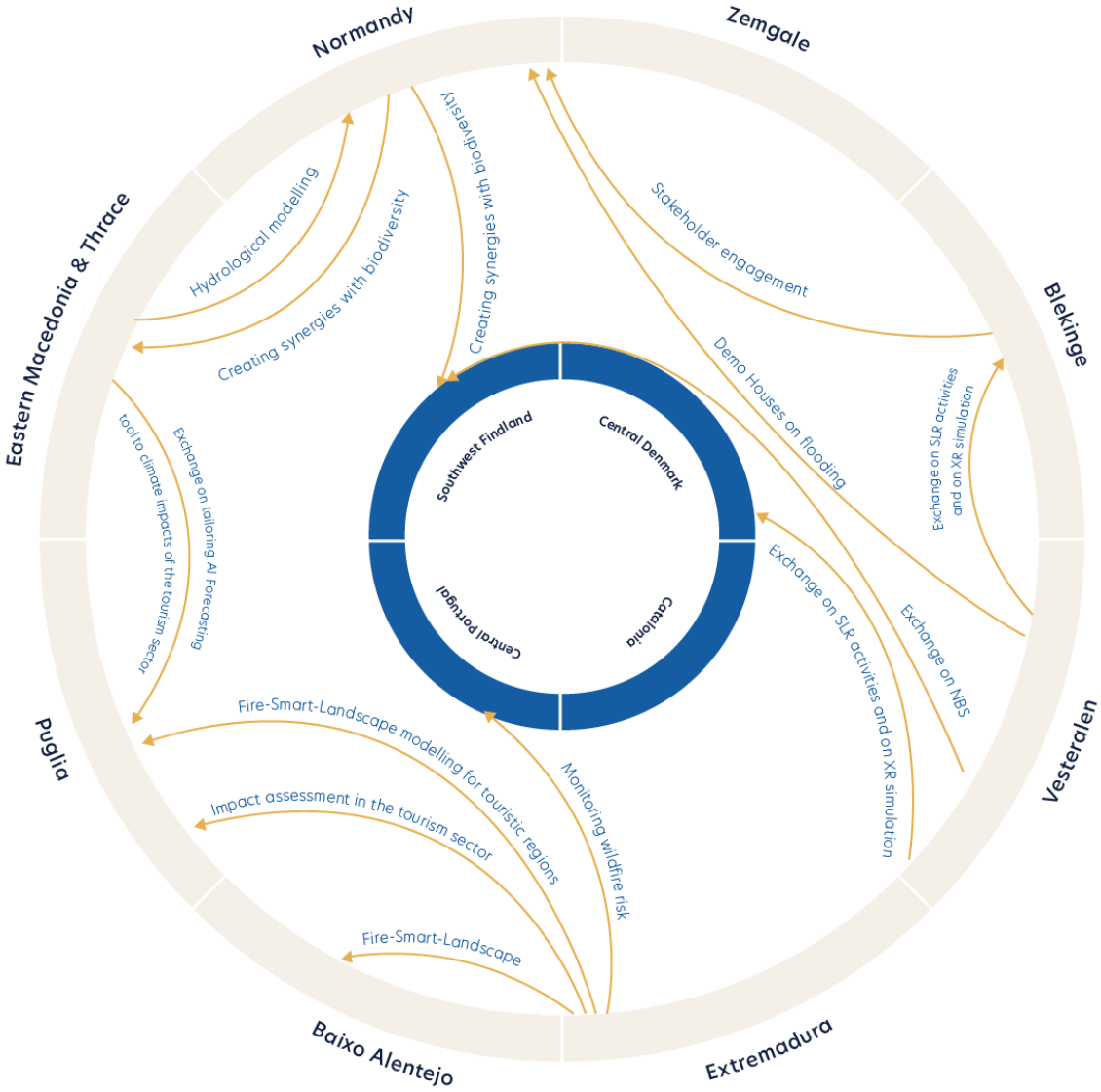

Figure 29: Transfer potentials from twinning regions (graphic created by REVOLVE). LSDs in dark blue, twinning regions in light blue.

Potentials for transfer between regions lie in the following fields: planning, policy-society interaction, nature-based adaptation, assessment, evaluation and monitoring, numerical modelling and data collection, and digital innovative solutions (Table 62).

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Table 62: Transfer potentials between RESIST regions.

Strengths, expertise		Supplier region	Recipient region	Comments, further information
Planning	Identifying vulnerable groups and areas	Catalonia	Baixo Alentejo, Puglia	Vulnerability lens for planning of activities
	Benchmark study methodology	SW Finland	Normandy, Eastern Macedonia and Thrace	Analysis of innovative regulatory measures for adaptation and NbS
	Focus on tourism sector	Extremadura	Puglia	Integration of tourism sector through fire-smart landscape approach
	Creating synergies with biodiversity	Normandy	Eastern Macedonia and Thrace, SW Finland, Centro Portugal	Nature conservation / NATURA 2000 reserve areas
	Exchange on tourism inclusion in forest fire management	Extremadura	Baixo Alentejo, Puglia	Extremadura can share how tourism is integrated to support adapted land management (fire-smart landscapes as tourist attraction)
	Genetic map of best performance plant against hydric stress	Centro Portugal	Extremadura	Drought-resistant tree and shrub species identification
Policy-society nexus	Stakeholder engagement	Blekinge	Normandy	Serious games development for decision-makers to drive innovation and sustainability. Designing collaborative decision-making arenas for stakeholders.
		Centro Portugal, Extremadura	Puglia	Specific focus on how to engage with forest owners for adapted land management
	Best practices on engaging with the public and considering the needs of vulnerable groups in the civil protection sector	Catalonia	Zemgale, Vesterålen, Baixo Alentejo	Exchange in a workshop on Catalonia's inclusive framework for prevention and emergency management at the local level to incorporate the needs, knowledge, and capacities of the most disadvantaged or marginalized groups
	Connective negotiation approach to stakeholder engagement	Central Denmark	Blekinge	Exchange on connective negotiation approach and vice versa on Blekinge's experience with stakeholder engagement: (a) serious games development for decision-makers to drive innovation and sustainability; (b) designing collaborative decision-making arenas for stakeholders.
Nature-bas	Exchange on NbS	SW Finland	Blekinge	Exchange on NbS that help target flooding and coastal degradation. Exchange on Blue-Green solutions.

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		Central Denmark	SW Finland	Exchange on Blue-Green solutions from existing projects at NIRAS, and AU. Implemented cases on NbS for climate adaptation.
	… for water management / to combat water scarcity	Eastern Macedonia and Thrace, Normandy, SW Finland	Baixo Alentejo	Exchange on both water quantity and water quality management
	… for blue-green solutions in rivers	SW Finland	Zemgale	Experience with blue-green infrastructure, especially in urban areas
	Forest fire management exchange	Centro Portugal, Extremadura	Baixo Alentejo	Forest management options for reducing the risks of wildfires; exchange on drought-resistant trees/shrubs
	Collaboration in the civil protection sector	Catalonia	Baixo Alentejo	Improve collaboration in the civil protection sector, also considering regional-municipal collaboration
Assessment, evaluation and monitoring	Cost-Benefit Analysis	SW Finland	Normandy, Eastern Macedonia and Thrace, Vesterålen	Economic valuation of NbS
		Central Denmark	SW Finland, Normandy, Blekinge	
	(Impact assessment in tourism sector)	Puglia	Extremadura	Puglia will have a focus on this topic throughout its activities, so the expertise will grow over time and could only be transferred in the later stages of the project.
Numerical modelling and data collection	EWS Solutions	Catalonia	Baixo Alentejo (and other interested regions)	Deployment of municipal-level multi-hazard EWS (Argos) and piloting site-specific warnings.
	Modelling, mapping and monitoring wildfire risk	Extremadura	Centro Portugal	Exchange on forest fire models and maps developed by the University of Extremadura
	Hydrological numerical Modelling	SW Finland, Eastern Macedonia and Thrace	Normandy	Investigate and demonstrate opportunities of NbS in water retention, e.g. in an agricultural catchment
	Flood data collection, monitoring of flood and groundwater levels	Central Denmark	Zemgale	Expertise to Zemgale in defining where to start with data collection and monitoring
Digital innova tive	Tailoring AI forecasting tool to climate impacts in tourism sector	Eastern Macedonia and Thrace	Puglia Potentially Extremadura	Transfer AI based forecasting methodology

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	Tools for digital twins	Blekinge	Interested regions/ Horizontal Partners	PAPER1, PAPER2, PAPER3
	Development of serious games	Blekinge	Interested regions/ Horizontal Partners	First exchange on stakeholder engagement within LSDT2, followed with exchange with all interested regions

4.4 Looking ahead

The needs assessments for the twelve regions give a comprehensive overview of the challenges these regions are facing in realising effective climate change adaptation activities as well as of the expertise they are bringing into the project to overcome these challenges. The analysis has shown that the regions, on the one hand, differ in specific needs and individual support activities but that, on the other hand, many challenges encountered are shared among regions and so numerous paths for transfer and knowledge exchange exist.

The further process within Task 1.1 will thus follow three approaches simultaneously: address individual challenges with individual support activities, tailor shared support needs to the regional contexts, and facilitate transfer of solutions and knowledge between the regions. The activities will focus on the needs that are most pressing to address within the RESIST project in order to enable regional partners to achieve their goals and implement their planned projects against the background of developing innovative solutions for climate change adaptation. Identified needs and challenges are prioritised in collaboration with regional partners. A first workshop to determine which challenges or needs have the biggest influence on the work of the regional partners or which are the biggest barriers to successful adaptation took place in November. Building on this, a workplan of support activities will be developed that also considers temporal dimensions, from immediate to longer-term support, as well as scope, from ad-hoc to larger, more extensive endeavours that can go beyond the immediate activities planned by the regions. A particular focus is on supporting the regions in developing and implementing social and technological innovation to increase resilience, i.a. realising the full potential that lies in digital tools such as the GDT. To coherently address this, adelphi will work in close collaboration with the horizontal partners and assist the interdisciplinary implementation of adaptation measures.

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Annex A: Questionnaire for needs assessment

WP1: Needs assessment and status quo analysis.

A COLLABORATIVE NEEDS ASSESSMENT TO SUPPORT THE REGIONS

The Questionnaire below is part of the needs assessment and status quo analysis, which forms the basis for RESIST transversal project partners, to tailor their services and support in developing innovative solutions with your Region.

The Questionnaire has been co-created by WP1 task-leaders in very close relation with WP3 leader ERRIN, to ensure that you, as an LSD or Twinning Region, are asked for information in a coordinated and efficient manner.

A series of interviews will be held in May and co-organized with your LSD leads and coordinators, ensuring that we have collected the key information and references from the right contacts, informing us of a clear picture of your needs; the goal is to provide you with the best qualitative support and services.

HOW TO WORK WITH THE NEEDS ASSESSMENT:

First of all, we encourage the regional ecosystem to **collaborate and to prepare their answer together**.

This is an initial questionnaire, to share the information available in your region. Not all questions are mandatory but based on the availability of information. Regional authorities are a good starting point for information gathering, if not, they can point in the right direction of the person responsible.

It is not necessary to process and edit all information, please share the documents with their source. Please share all documents, including those that may have been shared previous, such as the climate risk assessments or existing adaptation plans and strategies. Any additional and detailed information you can give us will be much appreciated.

Documentation does not have to be in English, feel free to add it and we will use a digital tool for translation.

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Once we have the information, the different partners in WP1 will process it to determine the baseline and status quo of regions' climate change adaptation activities. We will analyse how planned adaptation measures that effectively address climate risks have already been implemented. Based on an initial analysis we will prepare bilateral dialogues with each region to discuss findings.

We thank you in advance for the hard work and your effort into this process 😊

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QUESTIONNAIRE

POLICY, PLANS & IMPLEMENTATION

- Documentation and results of **performed climate risk assessments** (frontrunner regions should have completed CRAs);
  - with information on the most pressing climate impacts; hotspot areas; critical infrastructure
  - Who are the groups/actors that are particularly vulnerable to the impacts of climate change in the region?

- Key documents describing strategy, policy and measures already implemented on adaptation for the region*
  - adaptation strategies, adaptation plans, etc. - ideally with a level of detail which includes descriptions of whether it is politically approved/legally binding; on planned measures, key actors, whether finance has already been secured/approved, and timelines
  - Monitoring reports or evaluations of adaptation actions at the regional or municipal level
  - Existing or planned political commitments related to climate adaptation, including through membership to dedicated agreements/covenant networks
  - Existing NbS**

- Information about planned adaptation measures at the regional level (both within and outside of the RESIST project)
  - What is planned?
  - Who is involved?
  - What are the main obstacles/ challenges? What are the key opportunities/levels in the hand of the region? e.g. Competency for spatial planning regulation, Cohesion Fund managing authority, etc.
  - What is the NbS** that are planned?

- If available: overview of regional, national, or any other relevant:
  - Regulations /laws
  - Subsidy or incentive programs
  - Plans and strategies that impact the respective region with regard to CC adaptation

Feel free to emphasize where the transversal partners could support on policy, plan and implementation.

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DATA, KNOWLEDGE MANAGEMENT and TOOLS

- Overview of **existing digital tools / services to evaluate CC risks and potential adaptation measures**. Please include a brief description of your experience and level of satisfaction with these tools.
  - Examples are, but not limited to:
    - Software tools (e.g. Remote Sensing tools),
    - Modelling tools (e.g. to map flood risks),
    - Data analytics tools,
    - Algorithms (e.g. for AI/ML/DL), etc.
  - Tools developed at the national / European level or by international organizations, as long as they are known and used by the regions
- Overview of available knowledge, process, and method resources used to make decisions with CCA.
  - either used by the region authorities themselves,
  - or publicly available resources targeting actors from specific sectors or the general public
- Please **describe and share examples of the existing data** connected to CCA, adding any links, screenshots or any other means to describe the data
  - Examples are, but not limited to:
    - geospatial data (Digital Terrain Model);
    - water courses,
    - hydrographic network,
    - underground water table;
    - statistical data; population data (numbers, distribution);
    - meteorological information,
    - location of Nature-based Solutions; etc.
- Describe how the data are collected, stored, processed and presented

Feel free to emphasize where the transversal partners could support on data, knowledge management and tools

COMMUNITY ENGAGEMENT

- Information about important stakeholders:
  - Stakeholders that are involved in existing or planned adaptation activities
  - Stakeholders that are very knowledgeable about the regional CC challenges
  - Policy/government/agency actors on all levels that shape the context of the regional CC adaptation

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- NGOs (or other initiatives) which are active in the field of CC in the region
- Other key actors that play an important (positive or negative) role in the regional context

Organization name	Type***	Website	Location	Short description	Involvement/Importance for RESIST	Contact
Example Stakeholder	*Academia*	*www.example.com*	*City in your region (or beyond)*	*Innovative SME that has done research on NBS in the context of our regional challenge*	*To be involved in the pilot for … OR Not directly involved but still important because...*	*Name of the project partner who can help establish a contact*

***Type:** Selection of fixed Categories: 1) Academia, universities, higher education system, 2) Industry, firms, economic system, 3) State, government, political system, 4) media and cultural NGOs and civil society 5) Environment/natural protection NGOs and civil society.

Feel free to emphasize where the transversal partners could support on community engagement.

FUNDING and FINANCING

- Information on **funding options / financing strategies** for adaptation measures
  - How were past adaptation measures financed?
  - How are planned adaptation measures financed?
  - If possible: Overview of available financial resources for further adaptation measures
  - Have innovative / blended finance strategies (e.g. with the private sector) explored?

Feel free to emphasize where the transversal partners could support on funding and financing

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GENDER FRAMEWORK

Please note that every organization have to fill-up the gender framework information individually.

You have declared in the Form A at proposal preparation stage whether you have a Gender Equality Plan (GEP). Has this changed since? Provide answers in yes or no.

If you have a GEP (either declared at proposal stage or prepared since), please provide the link to it. If it is an intranet link, please share the document.

If you do not have a GEP, do you have any diversity / inclusion-related policy/certification in place at your organization? Please specify the name (in English) if a certification. Or, provide a summary of the policy or the document.

Feel free to emphasize where the transversal partners could support on genders framework

OTHER

Feel free to share any other inputs, questions or remarks that you feel are necessary to support this process

Note:

**For the steps already taken by the Region in terms of adaptation policy, A reference can be the urban adaptation support tool that will be adapted to Regions through the Mission platform:*
1 Preparing the ground for adaptation
2 Assessing climate change risks and vulnerabilities
3 Identifying adaptation options
4 Assessing and selecting adaptation options
5 Implementing adaptation
6 Monitoring and evaluating adaptation

*** Please use EC definition of NbS: Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions."*

Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services.

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Annex B: Information about virtual interview sessions

Overview of most important information

- Virtual meeting with the main partners of the LSD regions
- One session is scheduled for each LSD, lasting two hours
- The sessions will be organized and led by adelphi
- Each session will be recorded
- Interested partners are welcome to join

Purpose of these sessions

- One session is scheduled for each LSD, lasting two hours
- Clarify questions that adelphi and KU Leuven have after reviewing the material for the needs assessment and status quo analysis
- Collect more detailed information regarding the questions from the needs assessment
- Collect opinions and estimation of the regional partners on identified issues, challenges, gaps and needs
- Gather supplementary information that cannot be derived from documents → expert opinions

Tentative agenda

- Welcome and brief introduction of purpose of the meeting (5 min)
- Explain purpose of needs assessments and status quo analysis (5 min)
- Presentation of work done by adelphi and KU Leuven as part of Task 1.1 and 1.3 (10 min)
- Presentation of initial results of analysis until now (15 min)
- Discussion of interim results, following guiding questions (30 min)
- Discussion based on guiding questions (60 min)

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Initial list of guiding questions

- According to your expertise, which issues, needs and gaps that we identified so far (according to interim results) are valid? Do you see further adaptation needs and gaps in your region? How would you prioritize the identified needs?
- What are the anticipated effects of the adaptation actions planned within RESIST? i.e. What do you hope to achieve with what has been planned / What are your goals? To which extent can these goals be achieved with what has been planned in RESIST?
- What obstacles to further, more systemic action can be identified (funding, qualified personnel, institutional inertia, lack of awareness for the need for adaptation)? Systemic action here is (but not only) an approach that involves many streams of data, tools and technologies, a diversity of stakeholders, a clearly defined and adjustable strategy as well as regular communication.
- Do you see any major data or information gap to be able to implement, monitor and evaluate CCA measures / solutions? If so, what data / information is currently missing?
- Who are the main stakeholders opposing adaptation measures? What are their interests? Which of their interests could be used to convince them?
- Who are relevant stakeholders that could support the process as partners?
- Are gender aspects being considered in the design of adaptation measures? If yes, what are those aspects? How are vulnerable population groups considered?
- Are you aware of initiatives taken in other regions in your country or in other countries? If yes, are you in contact with them and should we involve them in the RESIST project? Which regions are you thinking about?
- Based on the information about the main challenges you are facing, how could adelphi and KU Leuven support the design and implementation of adaptation measures? What type of support are you hoping for, for which steps in your process and when will this support be useful?

Examples of support adelphi can provide:

- Integrating the consideration of gender aspects in the design of adaptation measures
- Integrating the consideration of particularly vulnerable population groups and their needs
- Integrating the consideration of cross-border and cascading risks, cross-sectoral interactions, complex and compound risks
- Ensuring the design of solutions in a way that avoids maladaptation
- Identifying possible funding opportunities or value-capture mechanisms
- Communicating with and convincing stakeholders that might be opposed

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Examples of support KU Leuven can provide:

- Identifying similar practices and initiatives in other regions of Europe
- Providing a mechanism to compare CCA initiatives in different regions in Europe
- Provide a platform to access all relevant information on CCA actions, the data and tools used through an easy to use interface

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RESIST

Annex C: ESPON-CLIMATE: Data sources

Impact chain	Indicators (hazards)	Data Source	Data calculation
Heat stress on population	Annual mean temperature (°C)	Copernicus Climate Data Store	**Mean value of daily mean temperature over 10 days;** aggregated at annual level by averaging all 10-day periods. Second, these annual values were averaged for the baseline (1981-2010) and future periods (2071-2100)
Droughts on primary sector	Annual mean precipitation (mm)	Copernicus Climate Data Store	**Sum value of daily precipitation sum over 10 days**; 10-day accumulated precipitations were summed annually and then aver-aged for the baseline and future period, resulting in four annual mean precipitations values per NUTS3 region
Droughts on primary sector	Consecutive dry days (days/year)	Copernicus Climate Data Store	**Longest period of consecutive days when daily precipitation sum < 1 mm in each trimester**; maximum number of consecutive dry days among the four trimesters that belong to each specific year was selected. Then, these annual maxima were averaged for the baseline and future period, resulting in four annual maximum consecutive dry days values per NUTS3 region
Flash Floods on cultural centres	Very heavy rainfall days (days/year)	Copernicus Climate Data Store	**Number of days per 10 days when daily precipitation sum > 20 mm**; Annual number of very heavy precipitation days was obtained by summing all 10-day periods. Then, these annual values were averaged for the baseline and future period; the higher the number of very heavy rainfall days, the higher the hazard;

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Heat stress on population	Summer days (days/year)	Copernicus Climate Data Store	**Number of days per 10 days when the daily maximum temperature > X°C.** X refers to the different thresholds that are provided by the agroclimatic indicators dataset: 20ºC, 25ºC, 30ºC, and 35ºC; annual number of summer days was obtained by summing all 10-day periods. Then, these annual values were averaged for the baseline and future period, resulting in four annual summer days values per NUTS3 region
Heat stress on population	Tropical nights (days/year)	Copernicus Climate Data Store	**Number of days per 10 days that have a daily minimum temperature > 20°C,** it is accounted as a tropical night; for aggregation: annual ∑ of 10 day periods; then that value was averaged for the baseline and future periods
River flood on population River flood on infrastructure, industry and service sector	River flooding frequency (return period in years)	PESETA IV River floods	**Changes in frequency of the current 100 years river flood event** under different climate change scenarios; PESETA IV Model indicator was the change in frequency of the 100-year return period event of the reference period, weighted average of a grid cell (5x5km) was aggregated for NUTS3 , the weight was set by the proportion of flooded areas inside each grid cell;
Coastal flood on infrastructure, industry and service sectors	Coastal flooding frequency (return period in years)	PESETA IV Coastal floods	**Extreme Sea Levels** (ESL) for coastlines, baseline is 100-year return period; future return periods based on ESL values of (5-,10-,20-,50-,100-,200-,500-,4000- year return period)

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Wildfire on environment	Days with fire danger (days/year)	Copernicus Climate Data Store	Based on **Canadian Fire Weather Index System**: combination of responses of soil moisture to atmospheric forcing at different soil depths; input on a daily basis is air temperature, relative humidity, wind speed and daily accumulated precipitation data (from EU Cordex; downscaled GCMs); fire danger index is classified in moderate, high, very high

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Annex D: ESPON-CLIMATE: Framework of Impact Chains

Indicators / Impact chain	Hazard Indicators	Exposure Indicators	Vulnerability	
			Sensitivity	**Adaptive Capacity**
Heat stress on population	• Annual mean temperature (°C) • Number of Summer days, Number of Tropical Nights	• Population	• Age dependency	• Social capacity • investment in education • persons with tertiary education • risk perception • social capital • gender equality index • Infrastructure capacity • medical doctors • hospital beds • settlement compactness • Technological capacity • research staff
Droughts on primary sector	• Annual mean precipitation (mm) • Consecutive dry days (days/year)	• Agricultural area • forested area • mixed area	• Primary sector employment • primary sector GVA • share of irrigable and irrigated areas in utilised agricultural area	

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Flash Floods on cultural centres	• Very heavy rainfall days (days/year)	• Museums • world heritage sites	• Touristic arrivals	• patent applications • research and development investments • Economic capacity • employment rate • risk of poverty • regional GDP • national GDP • Institutional capacity • national adaptation strategies • regional quality of gov. Index • municipalities signatories of the covenant of mayors
River flood on population	• River flooding frequency (return period in years)	• population	• Young-age dependency • old-age dependency • disabled with need for assistance	
River flood on infrastructure, industry and service sector	• River flooding frequency (return period in years)	• Roads • Railways • Railway station • Airports • Harbours • Settlements • industrial areas • thermal power plants • Refineries • educational facilities	• Industrial service sector employment • Industrial service sector GVA	

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Coastal flood on infrastructure, industry and service sectors	• Coastal flooding frequency (return period in years)	• Roads • Railways • Railway station • Airports • Harbours • Settlements • Industrial areas • Thermal power plants • Refineries	• Industrial service sector employment • Industrial service sector GVA
Wildfire on environment	• Days with fire danger (days/year)	• Protected areas • Forested area	

For calculating climate risk, the following formula is used:

$$Risk_t = Hazard_t^{\frac{1}{3}} \cdot Exposure_t^{\frac{1}{3}} \cdot Vulnerability_t^{\frac{1}{3}}$$

An example for such an impact chain and its composition is shown below for “Heat on population”:

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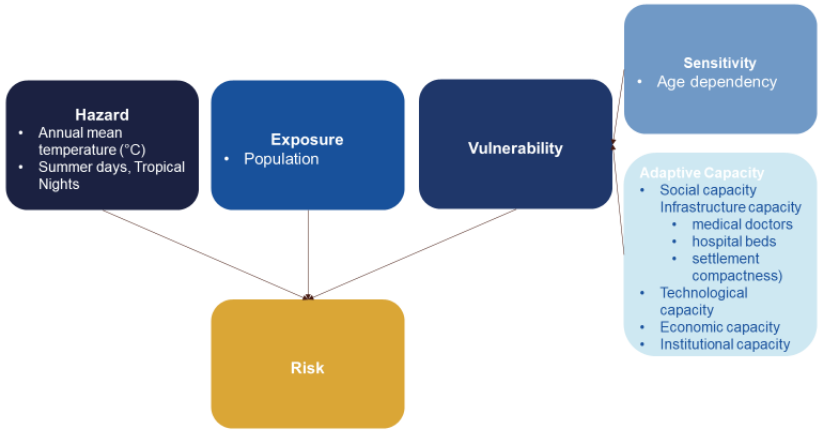

Figure 30: Impact Chain for "Heat on population" based on (Navarro et al. 2022).

The hazard is composed of the annual mean temperature and the number of summer days and the number of tropical nights. It is then combined with the exposed population in the region. The vulnerability component considers the sensitivity of the population, which is described by age dependency, as well as the adaptive capacity, which includes various capacities to adapt to the hazard. As an example, the infrastructure capacity includes indicators such as the number of medical doctors, the number of hospital beds, and settlement compactness.

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