# NEVERMORE

**N**ew **E**nabling **V**isions and Tools for **E**nd-use**R**s and stakeholders thanks to a common **MO**deling app**R**oach towards a Climat**E** neutral and resilient society

## D2.7 Report on socio-technological requirements

May 2023

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## Abbreviations and acronyms

| Acronym | Description |
|---|---|
| ICT | Information and Communication technologies |
| SDGs | Sustainable Development Goals |
| IAM | Integrated Assessment Model |
| WILIAM | "Within limits" Integrated Assessment Model |
| PESTLE (analysis) | Political, Economic, Social, Technological, Legal, and Environmental (analysis) |
| SECAP | Sustainable Energy and Climate Action Plan |
| A&M | Adaptation and Mitigation |
| PA | Public Administration |
| PaM | Policies and Measures |
| RCP | Representative Concentration Pathway |
| NBS | Nature-based solutions |
| EEA | European Environment Agency |

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## Executive summary

This Deliverable provides an initial **overview of the high-level technical and non-technical aspects** that should be carefully considered in developing the NEVERMORE services and ICT tools. The Deliverable targets NEVERMORE consortium members and is the output of Task 2.5 (M4-M12), which was meant to provide a first list of high-level socio-technological requirements for developing the NEVERMORE ICT (Information and Communication Technology) Toolkit combining the user's needs and desiderata with the opportunities offered by ICT solutions. To this end, user-centred design principles have been applied to obtain tailored recommendations from each user group and identify user requirements. The output of these activities includes a set of system recommendations that enhance the domain and user needs specific to the actors involved. The inputs elicited from users and other stakeholders in this task will be used to re-design or adapt existing components and tools that will be integrated into the NEVERMORE ICT Toolkit to provide valuable functionalities.

A detailed understanding of user requirements considering different perspectives is needed to develop a user-oriented portal that supports decision-making processes. Hence, our work in the present document integrates: i) socio-technical requirements empirically elicited through users' involvement, ii) requirements related to the principles and guidelines found through literature review and desk research, and iii) technical requirements and constraints related to the implementation of the NEVERMORE ICT solutions.

This document includes the description of the process followed to acquire the socio-technical requirements, which was conducted in synergy with other WPs (Work Packages), namely:

- WP4 to understand the sectoral impacts of climate change;
- WP5 for the policies of mitigation and adaptation at different scales;
- WP6 to understand the sectoral data of case studies.

The description of the requirements will be further detailed and refined as the research work progresses and will be additionally documented in other following deliverables, in particular:

- **D7.1** "ICT Toolkit design and architecture" **by CARTIF at M18**. For this deliverable, D2.7 provides grounding privacy and security requirements and system architecture interoperability, extensibility, and independence requirements.
- **D7.2** "Report on the data storage design and development", **by CARTIF at M36**, for which D2.7 provides a list of requirements for the data management related to the local and EU/global scale policies catalogue and the policy action scenarios.
- **D7.3** "Report on the ICT toolkit development", **by SIMAVI at M42**, for which D2.7 provides a list of tailored requirements for each tool composing the NEVERMORE ICT Toolkit.

# 1 Introduction

This deliverable describes the socio-technical requirements for the NEVERMORE ICT solutions' design, re-design, and development. One of the main ambitions of NEVERMORE is to foster the practical usability of theoretical models in policy making and creating mitigation and adaptation strategies. To this end, the **NEVERMORE ICT toolkit** will be tailored to users' needs and consider their perspectives in relation to the four tools that will be developed in WP7, namely: i) the A&M policy catalogue, ii) the EU-scale tool, iii) the local scale tool, and iv) the gamification tool.

The development of the ICT toolkit pursues two main goals: i) provide user-friendly tools to support policy-makers in their **decision-making** to tackle climate change and ii) **promote the necessary societal transformations** among stakeholders and users (e.g., citizens, policy-makers, investors, consultancies, associations, NGOs, renewable energy companies, land-owners, and farmers) to **make policymakers' decisions widespread and effective** by increasing their knowledge and attention on climate change, its effects and possible future scenarios.

This deliverable is among the first ones of the project. It aims to provide an initial overarching view of the socio-technical requirements for implementing the ICT toolkit based on a holistic approach that **integrates top-down perspectives** (literature reviews, best practices and expert recommendations) **with bottom-up perspectives** elicited through the stakeholders' engagement in defining the socio-technical requirements.

## 1.1 NEVERMORE ICT toolkit

NEVERMORE aims to develop an open-science and user-friendly ICT toolkit operating on multiple scales to conduct ex-ante evaluations of the combined effects of climate change and adaptation and mitigation policies. The toolkit will serve to assess climate change impacts and risks as well as understand better the interactions between mitigation and adaptation strategies at local, EU (European Union), and global scales. The NEVERMORE ICT tools will jointly consider and evaluate adaptation and mitigation measures, considering their drivers, barriers, co-benefits and trade-offs at local, EU and global scales. These tools will allow stakeholders and the public to access, visualise, and analyse data and evaluate and compare different combinations of measures and policies for supporting the creation of strategies following a multi-sectoral approach.

At the end, NEVERMORE will develop four interactive tools, and this Deliverable provides recommendations for the development of each of them, which will be done in WP7:

### A&M catalogue tool

An interactive tool to find the most suitable adaptation and mitigation measures (at the local and regional scales) and policies (at the EU and global scales), including specific information such as synergies, co-benefits, and trade-offs with other measures, multi-sectoral effects, and negative or positive effects on SDGs. This tool relies on the catalogue of policies developed in WP5. It includes a review of measures already implemented, potential solutions from literature research, and scenarios co-created with the Local Councils of Stakeholders.

### Global-EU-national scale tool

A web-based tool to visualise future impacts of climate change and select, evaluate, and compare (via KPIs) adaptation and mitigation policies towards a climate-neutral and resilient society. It will be built upon WP4 activities and will include policy recommendations to achieve adaptation and mitigation objectives.

### Case study tool

A web-based tool to visualise risks and impacts of different scenarios and create, evaluate, and compare (via KPIs) suitable adaptation and mitigation measures in the case studies. It will be built upon WP6 activities and include recommendations for each case study based on the challenges and the baseline.

### Gamification tool

A simulation game to learn and raise awareness about climate change, which can be used for education, climate change and sustainability roundtables, or role-playing games.

For these tools to be useful and functional, their development will follow an iterative refinement process. Starting from the requirements elaborated within T2.5 and listed in this deliverable, SIMAVI and the other project partners involved in WP7 will produce incremental versions of the tools, which will be tested with stakeholders and users, thus progressively refining both user requirements and product features.

## 1.2 Stakeholders and users of NEVERMORE solutions

The terms “user” and “stakeholder” are often confused in project management and co-design. For the sake of this document, we propose to use the word “stakeholder” to denote “anyone who could impact or be impacted by the project” (following the PMBok® Guide, 2021). On the other hand, in this project, we use the term “users” to refer to specific types of stakeholders defined by their relations to the system that is going to be designed: primary users are those who use the ICT solutions regularly; secondary users are those who may occasionally use the system or who use it through an intermediary; and Tertiary users refer to individuals or groups who are not directly involved in using the system but are impacted by its usage or have decision-making authority regarding its acquisition. (Abras et al., 2004). Stakeholders' and users’ perspectives should be considered for the NEVERMORE ICT Toolkit's design and development. As suggested by Stwart et al. (2017), the early definition of the user of such services is crucial to design useful and acceptable climate services.

In NEVERMORE, different categories of stakeholders should be considered in relation to the different tools that will be developed to identify their needs and motivations as well as barriers in using ICT tools. The primary target audience of NEVERMORE is decision-makers. This category includes policymakers, managers, planners, and practitioners ranging from individuals to public and private organisations and institutions (Jones et al., 2014). The enlargement of the decision-making process around climate change to various actors dates to the early years of this century (Orlove et al., 2020). These include private firms and organisations representing different sectors of the economy, civil

society organisations, researchers, and professional organisations that influence the decisions and who make decisions on their own.

Below is a list where potential categories of climate services users are associated with the tools developed in NEVERMORE that could potentially interest them.

**Table 1. Potential categories of climate services users associated with the tools developed in NEVERMORE**

| TYPE OF STAKEHOLDER | NEVERMORE tools |
|---|---|
| **Local government institutions (city councils, county/province administrative boards, municipalities, etc.)** | Catalogue of policies and measures<br>Local case study tool |
| **Climate scientists and researchers** | Catalogue of policies and measures<br>EU case study tool |
| **European government organisations** | EU case study tool |
| **Private businesses and non-profit organisations** | Catalogue of policies and measures<br>Local case study tool |
| **Civil society and communities** | Local case study tool<br>Gamification tool |

## 1.3 Schema for ICT recommendations and desiderata description

This deliverable reports the socio-technical requirements as emerged through a top-down and bottom-up perspective (described in Section 2) and provides a list of recommendations and desiderata (defined in Section 5). For a detailed description of each requirement, a table with the following fields has been included:

- *ID*: a unique identifier that can be used to refer to the recommendation quickly;
- *Name*: a title that concisely describes what the recommendation is about;
- *Description*: a detailed explanation of what is required, plus the rationale behind it;
- *Source*: where the information emerges from (e.g., stakeholders, experts, literature review).

**Table 2. Schema for ICT recommendations**

| ID | NAME |
|---|---|
| **Description** | … |
| **Source** | …. |

## 1.4 Document structure

This document is organised into two main parts: **the first one** (sections 1, 2, 3, 4) **describes the context and the rationale for the high-level requirements** for the NEVERMORE ICT solutions; **the second part** (sections 5 and 6) presents the actual **list of socio-technical requirement descriptions in the form of tables.**

More specifically, the report's first part describes the requirements elicitation process performed during the first six months of the project development. This process considered different perspectives and types of requirements: top-down, bottom-up, transversal user, and transversal technical

requirements. For top-down requirements, the report summarises literature and web search of relevant ICT tools and insights gathered through semi-structured interviews with partner experts. For bottom-up requirements, the deliverable reports about the implications emerged from the analysis of the technology-related needs of the five case studies. For transversal user requirements, consolidated standards and recommendations for usability, acceptability and usefulness, trust and privacy are reviewed and translated into practical implications for the NEVERMORE ICT Toolkit development. For transversal technological requirements, the deliverable reviews common characteristics of Climate Portals architectures that have emerged from previous studies and projects on Climate services and Climate data visualisation tools.

The second part of the deliverable comprises a technical inventory to be used as a reference guide by project partners to inform development decisions and perform regular evaluation measurements of the ICT tools prototypes.

## 2 Methodological Approach

A requirement can be defined as a demand or need related to what the system should do. The requirements elicitation process should start with the understanding and documentation of the stakeholders' wishes and the flow of user processes (Khan et al., 2014). The elicitation of the NEVERMORE socio-technical requirements integrated perspectives and inputs coming from different sources, namely:

- Literature and best practices.
- Consultations in the form of online focus groups with the five case study leaders.
- Individual interviews with people operating in the leading institutions of the five case studies.
- Individual interviews with project partners representatives with responsibilities of the back-end development of one of the four NEVERMORE tools, namely RINA-C for the Local case study tool, CMCC for the Catalogue of Policies and Measures, CARTIF for the EU scale and the gamified tools.

The complete list of the interviewees can be found in Annex 2 “List of participants in the semi-structured interviews to collect socio-technical requirements”.

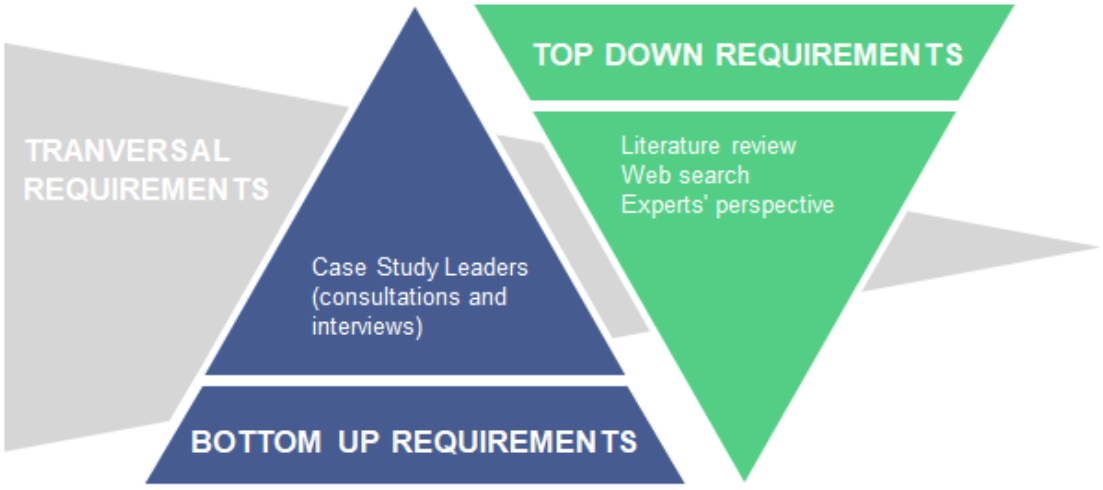


**Figure 1. The elicitation of NEVERMORE requirements integrated perspectives and inputs coming from different Tasks and WPs**

## 2.1 Top-down requirements

Top-down requirements refer to principles and guidelines of the NEVERMORE ICT tools gathered through literature analysis and best practices identified by analysing existing tools and solutions. This analysis has been enriched with recommendations from NEVERMORE technical partners with experience developing digital solutions for climate change. Several interviews have been conducted with technical partners to collect their expertise in developing ICT tools to support decision-makers in addressing climate change issues or fostering climate awareness among civil society.

### 2.1.1 Literature, web search and analysis of existing solutions

Searching and analysing examples from the literature and the web is crucial to developing innovative solutions. In NEVERMORE, an effort has been dedicated to searching for examples of tools that could offer interesting features for the project. This research process required consulting various sources of information, including scientific articles, technical documentation and user reviews. This systematic approach enabled the team to identify tools offering desired functionalities and features. By analysing these tools, the team deeply understood their performance and limitations and used this information to select the best examples to inspire the NEVERMORE project. Furthermore, some of these tools were also evaluated by experts to identify valuable features for the NEVERMORE tools.

### 2.1.2 Semi structured interviews with expert partners

Partners with longstanding expertise in developing one of the tools of the NEVERMORE Toolkit were interviewed to elicit their knowledge and lessons learnt from previous projects on topics related to NEVERMORE. To this end, partners with tasks related to the back-end development of the NEVERMORE tools were interviewed:

- **CMCC,** as the leader of WP5 on "Climate change adaptation and mitigation policies". Furthermore, CMCC is a partner in related projects such as the H2020 Rethink-Action (https://rethinkaction.eu/) which aims to develop a cross-sectoral decision-making platform.
- **CARTIF,** as the project scientific and technical coordinator, and in particular, leader of T3.1 on "Analysis improvements and new features integration in the IAM climate module"; T4.2 on "Methodology for climate change assessment including risks and impacts". CARTIF is also the coordinator of RethinkAction project (https://rethinkaction.eu/) leading the platform development. Furthermore, CARTIF is leading the tools development in LOCOMOTION H2020 project (https://www.locomotion-h2020.eu/), which aims to design a new IAM (Integrated Assessment Model) and tools to provide policymakers and relevant stakeholders with a reliable and practical modelling system to assess the feasibility, effectiveness, costs and ramifications of different sustainability policy options.
- **RINA-C,** as the leader of T6.5 "Modelling mitigation and adaptation policies/measures focus on the case studies".

Interviews lasted 1 hour on average and investigated the critical aspects of the development of each specific tool.

## 2.2 Bottom-Up Requirements

One of the main goals of NEVERMORE is to develop usable and useful ICT tools to support decision-making on climate data and models. The elicitation of bottom-up requirements has been conducted to incorporate the needs and expectations of the five areas representing the case studies in the design and development of the NEVERMORE ICT toolkit in WP7.

An iterative process has been followed to refine the understanding of the case studies' specificities and needs to elicit the specific requirements of the five case studies. Stakeholders' perspectives have been empirically elicited through the involvement of the leaders of the NEVERMORE Case Studies, namely CS1 - Sitia, CS2 - Trentino, CS3 - Norrbotten, CS4 - Murcia, and CS5 - Tulcea. Additionally, we aimed to explore the obstacles and difficulties associated with using models at both the local and global levels by decision-makers. Previous research has indicated that incorporating stakeholders' viewpoints into developing integrated assessment models (IAMs) has been limited (van Vliet et al., 2010). This distance between models and policymakers has resulted in scepticism toward the outcomes of modelling, frequently due to an insufficient understanding of the presumptions underlying intricate models.

Stakeholders of the NEVERMORE project have been involved in the definition of the socio-technical requirements since the very beginning of the project. A first round of insights was gathered during the first consultation with Local Case Studies (M6 - December 2022). Then, the analysis was refined with focused interviews (starting at M10 and finishing at M12). We describe the approach adopted and the results collected in the following paragraphs.

### 2.2.1 Consultations with Local Case Study Leaders

On December 5th, 2022, a first consultation was organised with Case Study Leaders. The goals were mainly to collect input for Task 5.1 and T6.1 and to elicit the first desiderata and requirements for the ICT toolkit. The participatory workshop was conducted online and organised as follows (See the Agenda in Annex 1; the detailed description of participatory activities will be reported in deliverable D2.4).

During the consultations, the ICT dimensions explored were:

- Case studies' activities and decision-making affected by climate change.
- What information and data might be helpful for them to take better decisions.
- Tools already used to inform the decisions.
- Interests and expectations about the usefulness of the ICT tools that will be developed in NEVERMORE. To this purpose, the four tools were first introduced, and then feedback on them was collected from stakeholders.

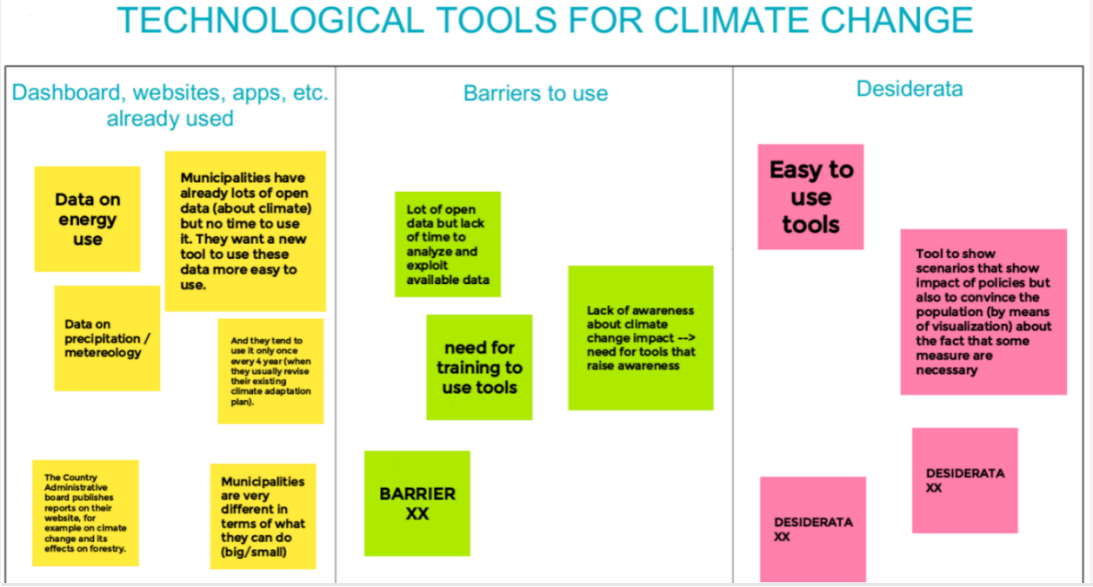


Figure 2. A snapshot of the Jamboard used to collect feedback from stakeholders on the ICT toolkit

### 2.2.2 Semi-Structured Interviews with Local Case studies

To refine our understanding of the opportunities offered to support decision-making processes, semi-structured interviews were performed from March to May 2023. The target of interviews were the representatives of the Case Studies, as representatives of the category of decision-makers, and other actors who use or would be interested in using ICT data, models, and tools for the definition and evaluation of local and global policies for adaptation and mitigation of climate change.

Here is a summary of the dimensions that have been investigated through the interviews (for a detailed description of the investigation protocol, see Annex 2):

Table 3. Summary of dimensions investigated through the interviews

| DIMENSIONS | DESCRIPTION |
|---|---|
| **Professional role** | The professional role, work experience, and relevance of climate change in relation to one's role. |
| **Data and climate change** | Use of data on climate change (e.g., types of data, digital tools used, gaps, etc.) and the **role of data in decision-making processes** (depending on the interviewee's professional role). |
| **Exploration of the four digital tools that will be developed in NEVERMORE** | **Climate models (both at the global and local levels)**: previous knowledge and experience with climate change models; perception of the usefulness and accessibility of models, challenges, reflection on gaps, and possible improvements. |
| | **Policy catalogue**: an exploration of an example of a policy catalogue, discussion on opportunities and desired characteristics of the NEVERMORE policy catalogue. |

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| | **Gamification and digital solutions to raise awareness** in civil society about climate change: opportunities and possible application scenarios related to local challenges. |

Interviews lasted about 1 hour; they were audio-recorded and summarised to be shared among the team that performed the data analysis. Overall, 7 semi-structured interviews were conducted (see Annex 2). To encourage participants to reflect on the digital tools that will be developed in NEVERMORE, we showed examples of digital solutions and evaluated the pros and cons with them. The use of these so-called "technological probes" (Hutchinson et al., 2023) was aimed to focus the conversation on digital solutions and helped interviewees express their needs and desiderata about NEVERMORE tools.

## 2.3 Transversal User Requirements

Transversal requirements refer to the general and fundamental characteristics a digital solution should satisfy to be useful, acceptable, and accessible by users, considering different types of users, such as PAs, private entities, and citizens.

Various factors influence the adoption of new technology, including usability, accuracy, price, physical appearance, security, function, interoperability, and robustness. For the design and development of the NEVERMORE Toolkit, designers should consider various criteria, including usability, usefulness, acceptability, trust, credibility, and privacy, based on the diverse needs of users such as public administrations, private entities, and citizens.

# 3 Overview of the Case Studies: Priorities and Current Use of Data for Decision-Making

This section provides general information about the context of the 5 Case Studies involved in NEVERMORE. A detailed analysis of case study characterisation will be provided in D6.1. "Report on NEVERMORE case studies characterisation" at M15, the list of priorities for each Case Study is described in Annex II of D5.1 "Report on review of policies, measures and initiatives".

D6.1 will summarise the results of the activities conducted in T6.1. to make a socio-economic and environmental characterisation of each case study, combining the analysis of the geographical landscape and historical climatic conditions, the most relevant weather/climate change factors in the area and a preliminary evaluation of critical vulnerable sectors and infrastructures that could lead to socio-economic tipping points to be identified among agricultural, energy, tourism/transport and local industry), with a PESTLE analysis to understand which are political, social, technological, regulatory, economic, environmental drivers of the local ecosystem and economy.

In this deliverable, we provide high-level information on case studies that can contextualise and clarify the desiderata and needs of Case Study Leaders toward the ICT tools that will be developed in NEVERMORE. Information about each case study has been collected through Consultations with Case study leaders and semi-structured interviews. For each case study, we briefly summarise priorities, main sectors addressed, tools and data already used to make decisions on climate change, attitudes and familiarity with climate change models.

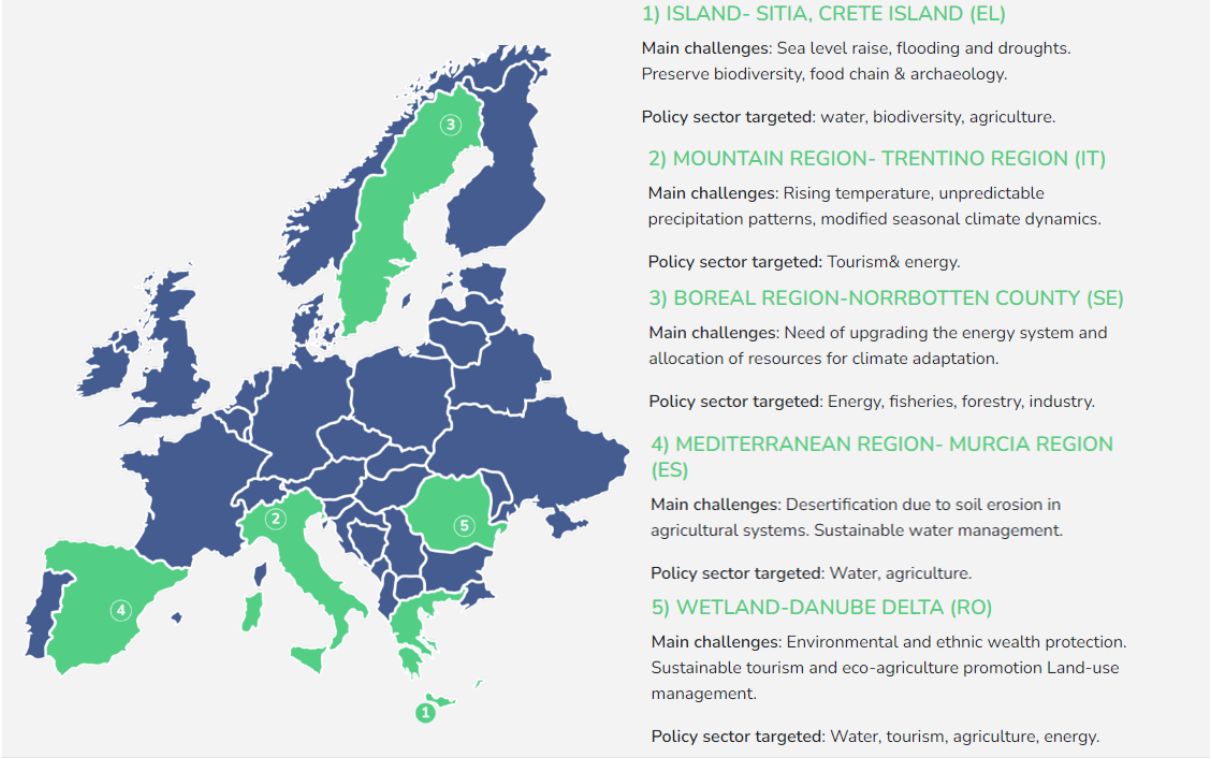


**Figure 3. A schematic representation of the context and specificities of each case study**

## 3.1 CS1 - Sitia - Crete Island (EL)

| | |
|---|---|
| CASE STUDY LEADER | Municipality of Sitia. Department of firefighter |
| SECTORS | Agriculture, forestry and fishing; Water and waste; Biodiversity and natural heritage; Tourism. |
| PRIORITIES | Protect people (citizens and tourists) against extreme events such as floods, fires, and earthquakes; protect the economy (agriculture, tourism, freshwater). It is important to have policies in place, known and active.<br>The attention and concern are on how to tackle extreme events in real time. |
| DATA & TOOLS USED AND PERCEIVED BARRIERS | • Tool to know weather conditions (every day from weather centres)<br>• Tracking system to track firefighters and civil protection staff, and trucks<br>• Real-time alert systems about earthquakes and tsunamis<br>• Windmills have sensors able to collect data about wind and energy generation continuously.<br>Barriers:<br>• The only way to get information from windmills is to call them one by one by phone<br>• There is a limited number of weather centres in Sitia; more would be needed to act and react more effectively. Also, because Sitia has very small-scale weather patterns, there is a need for high-resolution data.<br>• In general, municipalities lack time to go through all data. |

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| DESIDERATA ABOUT ICT TOOLS | The ideal tool for Sitia would be a real-time presentation about the weather effects and the development of fires, rain, and wind. Also, a system to inform people to evacuate and how to track in real-time firefighters, civil protection staff, and citizens and tourists who might not know about the local terrain would be very needed.<br>The municipality's goal is to prevent human loss, so a warning system to evacuate is considered necessary.<br>Besides these tools needed during extreme events, tools to use after extreme events would also be considered interesting: in particular, a tool to scan the terrain for different kinds of uses, for example, for a windmill or, after a bushfire, to find differences in the land. Moreover, it would be interesting to have a tool to suggest actions to prevent flooding, land erosion, etc. |
| ATTITUDE AND FAMILIARITY TOWARD MODELS | Expertise in physical models of the evolution of natural hazards (in particular fires but also floods). There is the feeling that creating an accurate, useful, and complete model for the local reality can be very difficult. |

## 3.2 CS2 - Trentino Region - Mountain Region (IT)

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|---|---|
| CASE STUDY LEADER | The Autonomous Province of Trento (PAT) offices involved in the NEVERMORE are two, and they deal with different aspects of tourism in the Trentino region: one is dedicated to the tourist promotion of the area, while the other focuses on the maintenance of the mountain assets. |
| SECTORS | Tourism, Energy |
| PRIORITIES | The most impacted areas by climate change are the mountains in terms of tourism and mountain heritage valorisation (e.g., shelters and trails, winter tourism). Concerning natural and energy resources consumption, priorities are:<br>• Manage tourists' flow all year round<br>• Ensure energy efficiency, sustainability, and safety<br>• Water management across various sectors (drinking, snow, energy, agriculture)<br>• Have actionable data to support the sustainable management of the territory |
| DATA & TOOLS USED AND PERCEIVED BARRIERS | At present, the Tourism Promotion Office does not utilise any climate change data. Although they can access information from other offices, such as the Environmental Protection Office and the Meteorological Offices, as well as national reports for snow tourism management (such as 'Nevediversa' from Legambiente[1]), this is scarcely integrated into their decision-making process. Nevertheless, they acknowledge that incorporating such data would be beneficial for the territory's strategic development.<br>The office relies on data about tourists' consumption behaviours. PAT is developing the "Trentino Guest Platform" to inform tourists about the activities on the territory and will soon allow the purchase of experiences. Besides being a service, this platform will allow the collection of data about tourists' consumption behaviours. |

[1] https://www.legambiente.it/comunicati-stampa/nevediversa-2023-i-dati-del-nuovo-report/

| | |
|---|---|
| | The office dedicated to mountain assets relies on environmental data, including rainfall, snow conditions, and extreme events like storms, to make decisions regarding financing and contributions to both public and private organisations. Currently, data used to make informed decisions are the following:<br>• *Mobility data*, which may be helpful to make decisions, for example, on ski lifts since they are used not only for winter sports but also as a means of transportation in the summertime.<br>• *Snow coverage* (e.g., to make decisions about sports facilities such as toboggan run and ski lifts).<br>• *Rainfalls* (e.g., useful to distribute contributions to refreshments for shelters due to lack of rainfall)<br>• *Heavy meteorological episodes* (e.g., falling trees for practicability of paths). |
| DESIDERATA ABOUT ICT TOOLS | Informed decision-making cannot rely solely on statistical data. Desiderata about data and tools are:<br>• The integration of different data sources and data-driven analysis to support the decision-making process<br>• Climate change data to define the territory's strategic plans.<br>• Improve the dialogue with local stakeholders, capacity building, generate awareness in citizens about climate change<br>• Data visualisation/web GIS on the local level<br>• Evaluation of actions/policies for decision making → Development of scenarios that consider climate impact<br>• Quantitative trend of water resources in the mountain, both at the micro-level (the area surrounding an alpine refuge) and macro-level (provincial level). For example, to<br>  • Finance alpine shelters: knowing if water comes from an upstream source or glacier is enough. What are the forecasts?<br>  • Make political choices at the provincial level related to water resources - mountain water resources trend for provincial policies. |
| ATTITUDE AND FAMILIARITY TOWARD MODELS | Representatives of PAT have different levels of familiarity with models depending on their background: some have never dealt with models before, while others have even contributed to developing them. Representatives with a technical background in models know the limits of complex models and need more information to understand the reliability of models and what is behind them.<br><br>Currently, the Tourism Department is starting an internal project to collect all the available data and integrate all the datasets the Autonomous Province of Trento has so that this data can become predictive information that helps them make decisions or define strategies. The Department aims to achieve a standard definition and framework for data and how to use it to inform decisions, including climate change data. |

## 3.3 CS3 - Norrbotten county - Boreal region (SE)

| | |
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| CASE STUDY LEADER | The Energikontor Norr AB (North Sweden Energy Agency, also called Eknorr) is a small organisation of 12 people. It is owned by 14 municipalities and the county council and provides them with consultancy about energy efficiency in companies |

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| | and households. Originally, Eknorr's main domain areas were buildings and transportation (e.g., car electrification and renewable energy sources). Recently, there has been an increasing demand by municipalities for support in reducing carbon footprints in many sectors, for example, public procurement, which can be about food for preschool, etc., leading to a shift in focus towards resource management.<br>Although the organisation has 20 years of energy efficiency experience, climate change is relatively new to them. Now, they need to understand how climate change affects companies and municipalities and adjust training approaches accordingly.<br>They suggest and support municipalities to make new policies. Therefore, they must keep track of the new European and national policies to get new projects and know what we should focus on. For example, in Sweden, a law mandates each municipality to have an action plan for climate change adaptation, but not all cities have developed one. Those working on climate adaptation refer to this law. |
| SECTORS | Energy; Agriculture, fisheries, reindeer husbandry; Forestry; Mining-industry; Transport; Tourism |
| PRIORITIES | For the Norrbotten area, challenges are various but interconnected:<br>There is a problem with land use because of many competing interests. For example, air force training camps limit land use for wind power. Energy production, mining and tourism take land from reindeer. The problem of land use is not only an issue of the amount of land dedicated to a specific sector but also a land organisation issue. Reindeer husbandry needs connected lands so animals can move. The land should not be fragmented.<br>There is a problem of increasing energy demand. Being energy production mainly based on mining, an increasing demand for land for mining is rising. On the other hand, soon, energy from hydropower could be more challenging because snow melts earlier.<br>The increased temperature could lead to boreal diversity loss, such as a shift from cold to warm fish species, thus, damaging the fisheries sector. Biodiversity cannot be measured through the number of animals but by the variety of species (number of species) and which are the original ones and the newcomers. Temperature increase also affects reindeer's nutrition: by melting and refreezing, snow becomes a frost layer that prevents reindeer from finding nutrients underneath.<br>Increased risk of foster fires and wind could damage forestry, and the need for more pests and fertilisers could damage agriculture.<br>The main priorities are:<br>• Protect reindeer husbandry, as it is a peculiarity of the territory;<br>• Prevent local biodiversity loss, both directly caused by climate change and indirectly by other sectors;<br>• Increase energy production from renewable sources, possibly avoiding trade-offs with other sectors;<br>• Maintain the sustainable forestry industry. |
| DATA & TOOLS USED AND PERCEIVED BARRIERS | EKNorr is more interested in data about energy use, sources, and potential in the region. They provide data and use it to get an overview of the challenges and understand how to tackle them. For example, they could use that data to see that a city's emissions are high in the transport sector and then find a project that |

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| | matches those challenges and have a leading role in that project. Also, they look at trends in other countries or Sweden at the national level to see the possibilities [for new projects]. Even if the idea is that municipalities should use data themselves, they often help cities use data.<br><br>Some of the perceived barriers are<br>• Lack of time to consult data: One of the problems is that municipalities have a lot of data about many things but lack time to consult all of them. Cities use data from the Swedish Meteorological and Hydrogeological Institute. From there, they can see the temperature changes, precipitations, etc. That website is relatively easy to use and helps understand what they need. Still, there are several other authorities and scenarios tools, but municipalities only use those easy to access and from which they can get a quick view of what you need.<br>• Lack of ambition: Some municipalities are tiny and are not interested in making adaptation plans, while others are big and more ambitious. There is a vast difference between what they can, want, and need to do. |
| DESIDERATA ABOUT ICT TOOLS | While discussing tools currently used, Eknorr representative stated that the Swedish Meteorological and Hydrogeological Institute is relatively easy to use. Still, there are several other authorities and scenarios tools, and municipalities will only use those that are easy to access and from which they can get a quick view of what they need to do. Nobody has time to get training to use the tools. Municipalities may use them only to define their climate change adaptation action plan, which needs to be updated every three years. So, they need something to access and quickly get the data they need.<br>A tool to know what goals national and EU-level policies set would help persuade municipalities to undertake sustainability and innovation processes. National or EU-level policies can be taken as an example and point of reference for the goals that local municipalities should achieve.<br>Originality. In Sweden, authorities have access to a vast amount of data, including open-access data. The municipalities that work with EKNorr have inquired whether a project can offer them something new that they do not have readily available or do not have sufficient time to consult.<br>Various tools are required for different audiences. While technical documents like action plans can be suitable for some users, persuasive tools could be more helpful for municipalities to convince citizens to accept a new policy. |
| ATTITUDE AND FAMILIARITY TOWARD MODELS | Norrbotten municipalities have access to a scenario tool developed by the Swedish Meteorological and Hydrogeological Institute, which shows the effects of the different Representative Concentration Pathway (RCP) scenarios in small areas. This tool is based on a map and allows zooming. However, people in general, including political leaders on climate aspects, often do not know what RCP scenarios are and what their numbers mean. |

## 3.4 CS4 - Murcia region - Mediterranean region (SE)

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| CASE STUDY LEADER | Instituto de Fomento de la Región de Murcia (INFO) is the economic development agency of the Autonomous Community of the Region of Murcia, Spani, that is entrusted with promoting and developing the business fabric, stimulating the competitiveness, innovation and productivity of regional companies, especially SMEs, to generate quality and stable employment. |

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| | With regard to NEVERMORE, it is especially relevant the role of INFO as regional coordinator of the Covenant of Mayors (a European Union initiative launched by the European Commission): INFO provides the participating municipalities with support by promoting the Covenant of Mayors, providing technical and financial support for developing and implementing Sustainable Energy and Climate Action Plans (SECAP) and holding networking events for the pact's participants. |
| SECTORS | Agriculture; Water |
| PRIORITIES | Murcia is interested in climate change, whose most visible effect is desertification due to soil erosion in agricultural systems. A priority is to address this issue. Another related priority is sustainable water management.<br>INFO Murcia is the case study leader for the Murcia region and oversees Murcia's business and regional economic development. In the context of NEVERMORE, the primary role of INFO is to be the technical coordinator of the covenant of mayors in the region, which currently consists of 45 municipalities.<br>The Covenant of Mayors' initiative aims to engage and support cities and towns to commit to reaching the EU climate mitigation and adaptation targets. Signatory cities pledge action to support the implementation of the EU 40% greenhouse gas reduction target by 2030 and the adoption of a joint approach to tackling mitigation and adaptation to climate change.<br>The region of Murcia coordinates its own Covenant of Mayors (Pacto de Alcades, in Spanish) through a dedicated website[2].<br>The objective of INFO is to promote active engagement by municipalities in climate change adaptation and mitigation efforts. However, some municipalities require varying levels of persuasion and motivation to act on climate change. This can be done by exploiting sound arguments and creating a working atmosphere, so municipalities are invited to work on adaptation and mitigation. To do so, INFO needs to develop specific strategies and methods with municipalities.<br>INFO Murcia has coordinated a past project, LIFE ADAPTATE[3], whose goal was to develop Sustainable Energy and Climate Action Plans (SECAP) in 6 municipalities in 3 different countries (Latvia, Portugal and Spain). Life Adaptate allowed 3 cities of the Murcia region to craft a SECAP: Lorca, Aguillas, and Cartagena. Now the goal of Murcia is to build on this successful experience and the procedure developed and extend it to more municipalities.<br>Summarising, Murcia's case study is interested in involving more municipalities in the covenant of the region's mayors and having them draft and approve their own SECAPs. |
| DATA & TOOLS USED AND PERCEIVED BARRIERS | There is no lack of data: there is data about climate change, its causes and effects, and policies to address it. What is missing is the commitment from each municipality and mayor to take care of it and create and approve a SECAP. This is mainly due to time constraints and difficulty understanding the bureaucratic language describing the process.<br>Some examples of data available:<br>• Information about climate change from the national authority competent on the environment.<br>• Data for every energy source (gas, petrol, etc.) used in industry and agriculture. Interestingly, in the past, Info Murcia used to share precise |

[2] https://www.pactoalcaldesregmurcia.es/
[3] https://lifeadaptate.eu/

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| | and complete reports with statistics and numerical data about energy consumption within each municipality. But, because cities would not use these reports, they need to ask for them actively if they are interested in consulting them.<br>• Data about policies, plans, and how to write SECAPs are available in different portals (www.adaptecca.es, www.lifeadaptate.eu, https://mycovenant.eumayors.eu/site/landing). These portals will be described later in the "Catalogue of Policies" section.<br><br>The barrier to the use of these already available data and tools are:<br>• Lack of commitment of municipalities: working on climate change adaptation and mitigation is not perceived as the daily priority<br>• Related to this, there is a lack of time, and the quantity of information is too much<br>• Often the language used is too complex and technical, and there is no expertise in the municipality able to work with that.<br>• Often documents and procedures are in English, and people working in the municipality are not confident with English. For example, the document "Guide for the Elaboration of Sustainable Energy and Climate Action Plans (SECAP)" is only available in English.<br><br>With respect to industry, INFO Murcia can use economic incentives for specific industries to help them calculate their Co2 and water footprint. There is also the availability of a sustainability voucher, i.e., an external service to calculate and get the ISO certificate. |
| DESIDERATA ABOUT ICT TOOLS | The desiderata go directly in the direction of overcoming the previously mentioned barriers:<br>• Create websites with information that is shorter and more focused so that less time is needed;<br>• Make information directly actionable so it is possible to action sooner instead of having to read many documents and data;<br>• Simplify the language;<br>• Provide documents and procedures in Spanish;<br>• Suppose the tool can become very persuasive for citizens. In that case, it might be able to change the behaviour and attitudes of citizens, which will then put pressure on the major to work more on climate change and prioritise it. |
| ATTITUDE AND FAMILIARITY TOWARD MODELS | The case study leader has never dealt with models before. They are more interested in procedures that municipalities can use to create practical plans, such as SECAPs. |

## 3.5 CS5 - Tulcea - Wetland Danube Delta (RO)

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| CASE STUDY LEADER | INSTITUTIA PREFECTULUI JUDETUL TULCEA<br>Public Institution Coordination and European Affairs |

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| SECTORS | Agriculture; Forestry; Fisheries; Transport; Tourism; Heavy Industry; Water as a resource |
| PRIORITIES | • Improve water management to prevent floods and droughts<br>• Sustainable fisheries<br>• Promote sustainable tourism |
| DATA & TOOLS USED AND PERCEIVED BARRIERS | The Public Administration of Tulcea does not produce data but relies on data provided by other offices, local administration, and universities. In particular, they exploit data from the Meteorological Institute, the Department of Agriculture or the Statistic Institute, and they mainly rely on meteorological forecasts and statistical data about weather. They are the first to be informed about damages and rely on a joint evaluation team. They count on the same ICT tools to manage damages and issues related to climate change:<br>• The RO Alert App RO alert app[4], developed by the Ministry's emergency office, provides information to the population in case of extreme events;<br>• 112 first aid number;<br>• maps updated in real-time by the meteorology institute and water management system.<br>Some barriers exist to using and exploiting data and ICT tools, such as the restriction to implement apps that need formal approval from the Ministry of Internal Affairs because of cyber-security concerns. |
| DESIDERATA ABOUT ICT TOOLS | Desiderata related to new ICT tools are:<br>• A tool accessible to the large public (hence with few specialised competencies) and by all partners in the decision process<br>• A map with the fish species most affected by climate change, the extremes (highest and lowest number) of fish species<br>• A map with the spread of animal diseases with layers for the different animals<br>• A map with blocked roads when there are heavy snows |
| ATTITUDE AND FAMILIARITY TOWARD MODELS | They do not have experience and familiarity with models or simulations of policies. |

# 4 Recommendations & Requirements for the NEVERMORE ICT Toolkit

One of the main goals of NEVERMORE is to transform climate data and models into useful information guiding the decision-making process. Climate services are meant to support understanding current and future climate change and related impacts on different policy sectors at local and global scales by exploiting user-oriented products. Climate services provide climate information to support understanding of climate impacts and decision-making.

[4] https://ro-alert.ro/

In this section, we summarise the main output of the research on the different ICT tools that will be developed in NEVERMORE, considering best practices and recommendations coming from previous studies and available web tools, suggestions from experts and feedback and insights from case studies. The section will be divided in five parts, one for each of the five tools (Catalogue of climate change policies, EU-scale tool, Local-scale tool, Gamification and serious game) and a final one collecting requirements about the more general climate change portals and visualisation tools.

## 4.1 Catalogue of policies: best practices and recommendations

In NEVERMORE, an interactive policy catalogue will be developed as part of WP5 activities to evaluate Adaptation and Mitigation (A&M) policies and measures consistent across scales (local, national, EU and global) and understand co-benefits, synergies, and trade-offs between the different measures. This catalogue aims to enhance understanding of the interaction, complementarities, and trade-offs between adaptation and mitigation strategies.

The policies in the catalogue will be modelled and included in the multi-sectoral evaluation method to detect and better understand their synergies, conflicts, and trade-offs at different scales (e.g., structural causes). The main targets of this tool are local policymakers to obtain better informed decisions and local stakeholders to be aware of the possible outcomes and trade-offs of the different choices.

### 4.1.1 Existing tools and examples

A few catalogues of policies have been developed so far to support decision-makers in sharing and becoming aware of the different climate change-related policies. We present the most interesting for the NEVERMORE project in the following tables.

**European Environment Agency database on greenhouse gas policies and measures in Europe**

| | |
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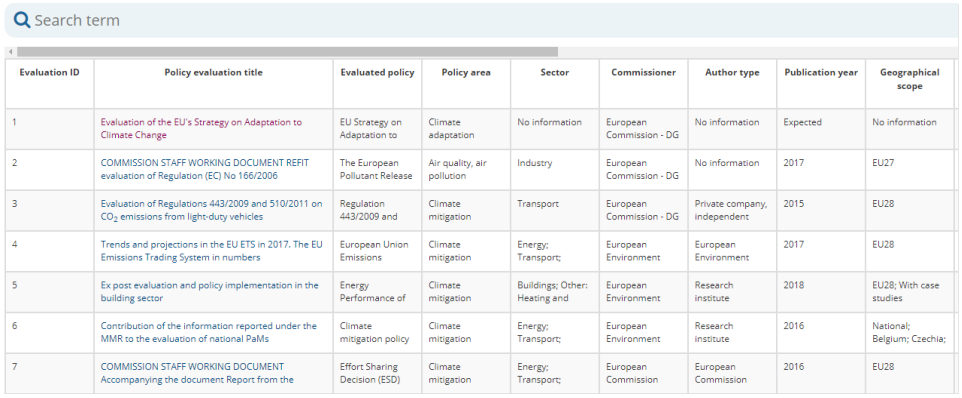
| European Environment Agency | This database contains policies and measures (PaM) implemented, adopted, or planned by European countries to reduce greenhouse gas (GHG) emissions. These PaMs were reported by European countries under the Governance of the Energy Union and Climate Action Regulation in 2021, and two countries (Germany and Iceland) updated their submissions in 2022. It is maintained by the European Environment Agency.<br>A few features of this database could be relevant for NEVERMORE:<br>• The search engine gives access to detailed information for each of the PaMs (or groups of PaMs).<br>• Countries report the main characteristics of the PaMs, such as their description, objective, type, status, sectors affected, related Union Policy, entities responsible for their implementation, implementation period, etc.<br>• Where available, quantitative information on the GHG emissions savings achieved by PaMs (or groups of PaMs), both ex-post (retrospectively) and ex-ante (anticipated savings), as well as the projected and realised costs and benefits of the reported PaMs, are reported.<br>• The data shown can be filtered by different parameters using the right-hand drop-down options.<br>• The database can be downloaded as a CSV file. |
| **Website** | Link to the catalogue |

| | |
|---|---|
| **Screenshots** |  |

Search term

| Evaluation ID | Policy evaluation title | Evaluated policy | Policy area | Sector | Commissioner | Author type | Publication year | Geographical scope |
|---|---|---|---|---|---|---|---|---|
| 1 | Evaluation of the EU's Strategy on Adaptation to Climate Change | EU Strategy on Adaptation to | Climate adaptation | No information | European Commission - DG | No information | Expected | No information |
| 2 | COMMISSION STAFF WORKING DOCUMENT REFIT evaluation of Regulation (EC) No 166/2006 | The European Pollutant Release | Air quality, air pollution | Industry | European Commission - DG | No information | 2017 | EU27 |
| 3 | Evaluation of Regulations 443/2009 and 510/2011 on $CO_2$ emissions from light-duty vehicles | Regulation 443/2009 and | Climate mitigation | Transport | European Commission - DG | Private company, independent | 2015 | EU28 |
| 4 | Trends and projections in the EU ETS in 2017. The EU Emissions Trading System in numbers | European Union Emissions | Climate mitigation | Energy; Transport; | European Environment | European Environment | 2017 | EU28 |
| 5 | Ex post evaluation and policy implementation in the building sector | Energy Performance of | Climate mitigation | Buildings; Other: Heating and | European Environment | Research institute | 2018 | EU28; With case studies |
| 6 | Contribution of the information reported under the MMR to the evaluation of national PaMs | Climate mitigation policy | Climate mitigation | Energy; Transport; | European Environment | Research institute | 2016 | National; Belgium; Czechia; |
| 7 | COMMISSION STAFF WORKING DOCUMENT Accompanying the document Report from the | Effort Sharing Decision (ESD) | Climate mitigation | Energy; Transport; | European Commission | European Commission | 2016 | EU28 |

## European Environment Agency database of environment and climate policy evaluations

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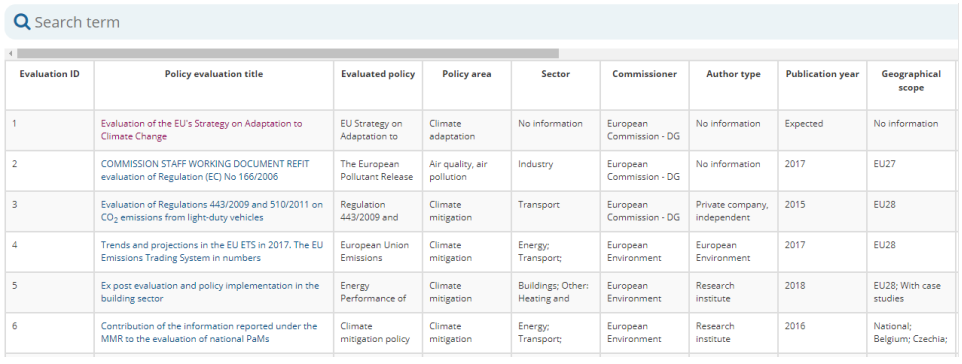
| European Environment Agency | The European Environment Agency (EEA) Catalogue of policy evaluations in the field of environment and climate policies is a database containing extensive information on almost 600 policy evaluations. The catalogue aims to provide easy access to the available assessments and obtain an overview of European policy evaluation practices in the areas of environment and climate policy.<br>Interesting features for NEVERMORE:<br>• The policy evaluations included in the database have been documented according to a series of features to obtain an overview of policy evaluation practices.<br>• The main feature categories include basic information on the evaluation, policy areas and economic sectors covered, information on the geographic and timely scope, information on authors and commissioners, evaluation criteria used, evaluation methods and techniques applied, data used and evaluation results. |
| **Website** | Link to the catalogue<br>Link to the final report |
| **Screenshots** |  |

Search term

| Evaluation ID | Policy evaluation title | Evaluated policy | Policy area | Sector | Commissioner | Author type | Publication year | Geographical scope |
|---|---|---|---|---|---|---|---|---|
| 1 | Evaluation of the EU's Strategy on Adaptation to Climate Change | EU Strategy on Adaptation to | Climate adaptation | No information | European Commission - DG | No information | Expected | No information |
| 2 | COMMISSION STAFF WORKING DOCUMENT REFIT evaluation of Regulation (EC) No 166/2006 | The European Pollutant Release | Air quality, air pollution | Industry | European Commission - DG | No information | 2017 | EU27 |
| 3 | Evaluation of Regulations 443/2009 and 510/2011 on $CO_2$ emissions from light-duty vehicles | Regulation 443/2009 and | Climate mitigation | Transport | European Commission - DG | Private company, independent | 2015 | EU28 |
| 4 | Trends and projections in the EU ETS in 2017. The EU Emissions Trading System in numbers | European Union Emissions | Climate mitigation | Energy; Transport; | European Environment | European Environment | 2017 | EU28 |
| 5 | Ex post evaluation and policy implementation in the building sector | Energy Performance of | Climate mitigation | Buildings; Other: Heating and | European Environment | Research institute | 2018 | EU28; With case studies |
| 6 | Contribution of the information reported under the MMR to the evaluation of national PaMs | Climate mitigation policy | Climate mitigation | Energy; Transport; | European Environment | Research institute | 2016 | National; Belgium; Czechia; |

## Nature4cities explorer

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| NATURE 4 CITIES | The Nature Based Solutions (NBS) Explorer is an interactive tool allowing users to search for urban solutions and challenges. The NBS are classified according to the following hierarchy: i) Category; ii) Subcategory; iii) Type; iv) Solution. The platform visualises data through a radial layout that allows the user to navigate the NBS hierarchy and display links to urban challenges. It has been created in the context of the Horizon 2020 EU-funded Nature4Cities project which see as partners also CARTIF and RINA-C among others. |
| **Website** | Link to the tool |

| | |
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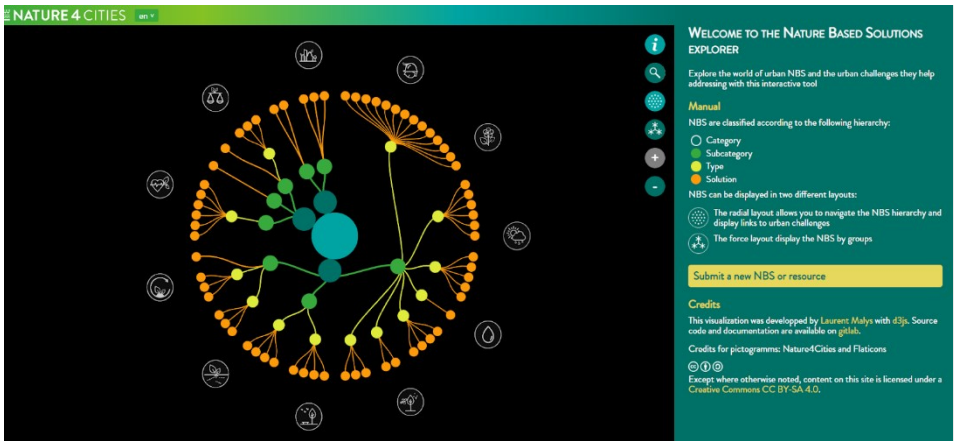
| **Screenshots** |  |

### CLIMATE adaptation app

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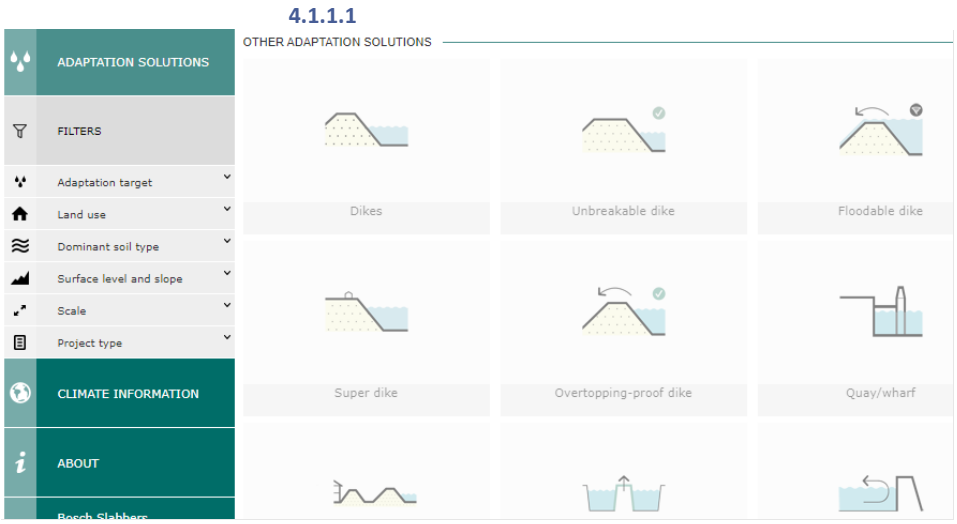
| ADAPTATION SOLUTIONS | The climate adaptation app gives urban designers, engineers or others insight into feasible measures for a project with a specific climate adaptation goal. The app will select feasible climate adaptation measures in less than a minute. If, for instance, an urban development in a flood plain is to be prepared for river flooding, the app will rank feasible measures based on the local conditions and the user's input. |
| **Website** | Link to the tool |
| **Screenshots** |  |

## 4.1.2 The expert perspective

To collect an expert perspective on the interactive catalogue of policies, researchers at CMCC have been interviewed since it is the partner responsible for WP5. During the interview with experts (CMCC), the four catalogues presented above were discussed and evaluated. In the Table below, we summarise the main themes that emerged.

Table 4. Main themes emerged from interview with CMCC about the catalogue of policies.

| Tool evaluated | Experts' Considerations |
|---|---|
| **EEA database on European greenhouse gas policies and measures** | The interview found the EEA database interesting because some of the fields considered could be relevant to the policies evaluation in NEVERMORE. However, in NEVERMORE, the focus is on policy recommendations, not policy evaluation. |
| **EEA database of environment and climate policy evaluations** | Interesting aspects that may be re-used for NEVERMORE:<br>• The quantification that could guide the simulation of the policy;<br>• Perhaps interesting to show also to those involved in modelling;<br>• A more helpful tool for those dealing with policy than for the user;<br>• Not very usable for the user, more synthetic data are needed;<br>Need for a new, more general policy framework - in addition to what already exists- that considers various elements and synergies. |
| **Nature4Cities Explorer** | User-friendly navigation: the navigation starts from general categories, which are similar to the NEVERMORE's challenges:<br>• It may be interesting to connect general challenges to policies and solutions;<br>• A difference between the NEVERMORE catalogue of policies and this tool is that Nature4Cities provides practical solutions (measures) on specific topics (urban NBS), while NEVERMORE address high-level cross-sectors policies;<br>• Another difference is that Nature4Cities collected relatively few solutions. In NEVERMORE, the policies could be more (>100).<br>The FACTSHEET that can be downloaded for each measure could also be very useful. Still, to structure the NEVERMORE content, the structure of the EEA catalogue of policy evaluations would be helpful (here an example of FACT SHEET) |
| **Climate Adaptation app** | • Interesting catalogue, even if only adaptation solutions related to soil and flood are considered.<br>• It provides very practical solutions (measures) on a specific topic (land use), while, in NEVERMORE, we have high-level policies and not necessarily practical solutions.<br>• Interesting aspect: the portal provides a percentage of how much the solution contributes to the target but lacks transparency about how it is calculated.<br>• In NEVERMORE, the measures will be simulated. However, in WILIAM ("Within limits" Integrated Assessment Model), the measures will remain at a more general level; the model will not be able to simulate the effects of such concrete measures.<br>It comprises information about co-benefits among measures. |

#### 4.1.2.1 Expert recommendations for the Catalogue of Policies

Besides the evaluation of existing tools, CMCC experts also provided other recommendations for the development of the NEVERMORE catalogue of policies:

- *Consider and integrate **cross-sectoral challenges and measures and synergies and trade-offs between measures** into the catalogue.*
- *Include the "**scale**" dimension in the catalogue: both the local and the global scales should be included.*

- *Include the **quantification** of measures. Such information could guide a policy simulation and be useful for decision-makers to understand the impact of specific measures.*
- ***Connect the** general c**hallenges experienced by the five territories** to policies and measures.*
    - The catalogue navigation could start with the challenges related to specific policies and solutions (like the Nature4Cities tool).
- *Consider the **large number of policies** that will be included in the catalogue.*
    - NEVERMORE catalogue will consider policies and measures across sectors at the local and global levels. This represents a challenge for the interactive tool, which should be designed to support the user in navigating this large amount of information.

### 4.1.3 The case studies perspective on the NEVERMORE catalogue of policies

#### 4.1.3.1 CS1 - Sitia

When asked for feedback about the EEA environment and climate policy evaluation database, the local case study leader found it challenging to use due to the overwhelming number of policies included. ("Wow, that's a lot of results") and reviewing all the information required a lot of time. The stakeholder could use it to find something specific ("It's like searching in Google"), and they deemed it more of a tool for an academic researcher on policy-making that can be used for writing a paper.

For them to use it, it would be recommendable that policies and interfaces are in the local language, in this case in Greek, and not in English.

Interestingly, the case study leader of Sitia has been asked to share policies for managing emergencies related to fires, floods and other natural hazards by the other provinces and municipalities of Greece. This case study is one of the regions most affected by them and has the most experience dealing with them. From this perspective, the case study leader expressed a lot of interest in sharing best practices on how to create a catalogue of policies and becoming an active user and creator of the content inside it, even if in a slightly different sector of interest, i.e., emergency management, and directly in Greek.

The Sitia case study leader also offered another perspective for the catalogue of policies: he suggested it could also be addressed to the local citizens and tourists. In this case, it could be an easy-to-use website where, in case of emergencies, they can find information about how to act if/when fires, floods, or other natural hazards happen quickly and in advance. As already pointed out previously, for this specific case study, there is an evident overlapping between policies and emergency plans.

#### 4.1.3.2 CS2 - Trentino

During the evaluation of the EEA database several input for the development of the NEVERMORE catalogue emerged:

*Useful for exchanging best practices*: in general, a catalogue of policies may help decision-makers take inspiration from other initiatives, learn from different experiences, and open their minds to solutions to common problems. It can indicate possible measures that must be implemented in one's territory regarding governance, etc.

*Support participatory processes of policy design and development.* A central challenge for local administrations is to develop shared territorial policies. For the development of policies (e.g., water resources management), it is mandatory to collaborate with other regions and stakeholders. Working

in synergy with other territories is essential for adaptation policies (e.g., emergency management). However, it is crucial for mitigation policies, where at least the national and European levels should be involved: “It would help to have a database of policies with an evaluation of their effectiveness to create a common ground for comparison between stakeholders and collective reflection”.

*Include an evaluation of the effectiveness of policies.* Each policy should relate to a measure related to its efficacy, supported by qualitative and quantitative data. Clear information about which indicators have been used to evaluate it should be used. Then, the catalogue could be used as a benchmark for policies' impact.

*Include information and recommendation about how policies can be implemented, incentivised, and adapted to a specific territorial area.* A challenge for PA is to understand how policies can be applied and which incentives may be used to make the policy effective (e.g., policy on the use of electric cars: which is the impact on CO2? What is the financial cost of changing the whole fleet of cars?). Moreover, for each policy, include recommendations and information on contextualising and applying a policy to a specific territorial context (e.g., using waste sorting is different in Trentino than in southern Italy).

*Support progressive refinement and deepening of information and data.* The tool should provide users with the possibility to go through the information with different granularities according to their needs: from initial high-level information to fine-grained data (e.g., the publication of the academic paper is helpful, but for the PAs, more usable, synthetic, and immediate in-depth data are needed).

*Connect the catalogue and the global/local tool.* From the user perspective, it would be helpful to connect the catalogue with the global tool with the following logical steps: click policy, read specifications, see impacts on the interactive tool, and find information on how to enter a specific territory.

*Enrich searchability by adding a filter about the geographical and climatic areas of application of the policies.* For example, in Trentino, they might be more interested in policies about mountain tourism or applied to mountain areas rather than generic ones. Therefore, a policy developed on the Pyrenees can be interesting for Trentino.

*For a catalogue to be used, the search must be immediate.* In the EEA Catalogue of European Environment and Climate Policy Evaluations, research through keywords and filters works well.

#### 4.1.3.3 CS3 - Norrbotten

*The catalogue of policies could be used to persuade municipalities to adopt a policy based on its success.* Norrbotten County's administrative board currently has a list of policies and a catalogue of adaptation measures to climate change, but both lack the evaluation part. This feature has been appreciated in the EEA database of environment and climate policy evaluations and found helpful in convincing municipalities to adopt the most successful ones ("Suppose we try to get one municipality to implement one policy. In that case, it is much easier if they can see that this policy has worked very well in Southern Sweden or a municipality of a similar size, sector, or area").

*Allow visualising the effect of combining multiple policies.* By selecting multiple filters simultaneously, it is possible to see the effects of combinations of policies and thus evaluate potential synergies or trade-offs: "Excellent that I can select more than one filter at once!"

*To be comparable and adoptable by other PAs, policies must be classified meaningfully.* The comparability of policies and measures depends on municipality size and geographical similarity. It is not easy to compare a policy's outcome at a national level with the area of a municipality. Many factors may affect the applicability of a policy in one place or another. Understanding what elements define the comparability of actions will also determine the columns of our catalogue of policies. "If I could choose, I would select the kind of policy, sector, and location with a colder habitat and a sparsely populated rural area. Then, I could compare. For example, one thing we often get to deal with is the electrification of cars. In central and southern Sweden, it is much easier [to implement these policies] because they are densely populated areas. Still, here we have a lot of rural areas, and you cannot have the economy to work with this kind of infrastructure".

#### 4.1.3.4 CS4 - Murcia

The complexity of the website "EEA Catalogue of European Environment and Climate Policy Evaluations" was identified as a major concern by the stakeholder, who believes that municipalities are unlikely to utilise it. The interface has been evaluated scarcely usable: the interviewee tried to browse policies evaluated for the region of Murcia by using the filters, but under “Geographical scope”, even searching for Spain does not return any value. In addition, the website contains an overwhelming amount of information that would take weeks to sift through, which is a luxury that municipalities cannot afford. The stakeholder suggests that the tools should be available in Spanish and should be user-friendly, without the use of technical jargon.

Another stakeholder from INFO Murcia with a more technical background shared similar concerns and considered the policies included there too high level for what INFO Murcia communicates and discusses with municipalities. Interestingly, as already hinted in a previous section, the INFO Murcia case study leader claims that there are already catalogues of policies at the local level. In the following, we write the examples which were suggested.

The Covenant of Mayors European website features a section[5] dedicated to "Local plans and actions" which provides a platform for mayors of European cities to share their best practices and implemented plans. This enables other mayors to learn from successful local initiatives and implement them in their own cities. Moreover, this website has very practical filters: for example, it is possible to search for Spain (under ‘Country’) and Murcia (under ‘Region’) and see the list of 36 Murcia municipalities enrolled in the Covenant of Mayors program and check their status. There is information about Population, Commitments, Adhesion date and Approval date. By clicking on the municipality's name, it is possible to go to the details page[6], such as for Cartagena, and read more information. While the Covenant of Mayors European website provides a useful section on "Local plans and actions" for sharing best practices and implemented plans by European mayors, it is not possible to access the actual SECAP document. This limits the potential for mayors, especially those in neighbouring cities such as Cartagena, to review and consider policies that could be adapted for their own SECAP. Providing access to the actual SECAP document would enhance the website's usefulness for sharing best practices and encouraging the implementation of effective climate policies. The entire website Covenant of Mayors Europe is available in many different European languages, including Spanish,

[5] https://eu-mayors.ec.europa.eu/en/action_plan_list
[6] https://eu-mayors.ec.europa.eu/en/signatory/14856

which is considered very important by the Murcia case study leader. A similar website[7] is accessible by mayors ("MyCovenant, the private space of the European Covenant of Mayors Community") in which more detailed information is available.

Another example suggested by Murcia as an already available catalogue of policies is Adapteca[8] which is "the platform for exchanging and consulting information on adaptation to climate change". It is an initiative of the Spanish Climate Change Office and the Biodiversity Foundation, which, together with the responsible Units on adaptation to climate change of the Autonomous Communities, identified the need for a tool for information exchange and communication among all experts, organisations, institutions and active agents in this field, at all levels. It has a specific section about Policies, Plans, and Programs in which it is possible to see policies and plans of other Spanish cities and regions and learn from them.

The last example is from the project LIFE ADAPTATE[9], which we commented on earlier in the previous section describing the case study. It also allows checking on Spanish municipalities' pilot actions and plans and learning from them.

In summary, it can be said that for Spain and the Murcia region, there are already numerous web tools available for exchanging information and consulting policies implemented by other municipalities. However, what is lacking are:

- Websites with shorter and more focused information so that less time to consult them is needed.
- Make information directly actionable so that it is possible to act sooner rather than reading many documents and data. For example, accessing SECAPs by neighbouring municipalities would allow adapting existing policies, and thus, it could be a quick way to start drafting a SECAP.
- The language should be simplified and, for some of them, translated into Spanish.

#### 4.1.3.5 CS5 - Tulcea

Tulcea County, as Public Administration (PA), applies public policies related to climate change at the European and national levels but is also involved in addressing specific local challenges through the development of local policies. Example: the Danube Delta has special regulations to raise horses (domesticated vs wild). The PA initiated a new approach to develop a statute for wild horses in the Danube Delta to protect them.

The catalogue of policies is considered relevant at different levels to:

- Analyse and document policies to apply the legislation, interested in having a catalogue;
- Have an interdisciplinary perspective on policies that goes beyond specific sectors;
- Have an overview of policies and how they are at the different levels: national, regional and local levels to find synergies between different policies;
- Have access to European funding;
- Useful at the local level to develop new local development strategies based on public policies.

[7] https://mycovenant.eumayors.eu/
[8] https://adaptecca.es/administracion-local/administracion-local
[9] https://lifeadaptate.eu/en/observatory/ and http://lifeadaptate.irradiare.com/#/country/4

## 4.2 EU-scale ICT tool: best practices and recommendations

The EU-scale ICT tool will work at the EU level to evaluate sectoral impacts based on the damage functions (WP4 - UVa) and identify adaptation and mitigation pathways based on the modelled policies selected from the catalogue (developed in WP5 - CMCC). From a practical point of view, the user will be able to select and customise some of the policies of the catalogue and observe the effects these policies will have on different indicators on time (up to 2100): these effects will come from the Integrated Assessment Model (IAM, precisely WILIAM, WithIn-Limits IAM) and will be pre-computed, i.e. the data shown are not computed in real time but pre-computed in order to have an interface able to provide instantaneous results.

The policies will be at European level while it will be possible to see some of their effects and impact also at the level of a specific EU nation.

The main targets of the EU-scale tool are EU policy advisors and decision makers, national and regional decisions-makers. Besides, the tool might benefit scientists interested in model exploration.

### 4.2.1 Existing tools and examples

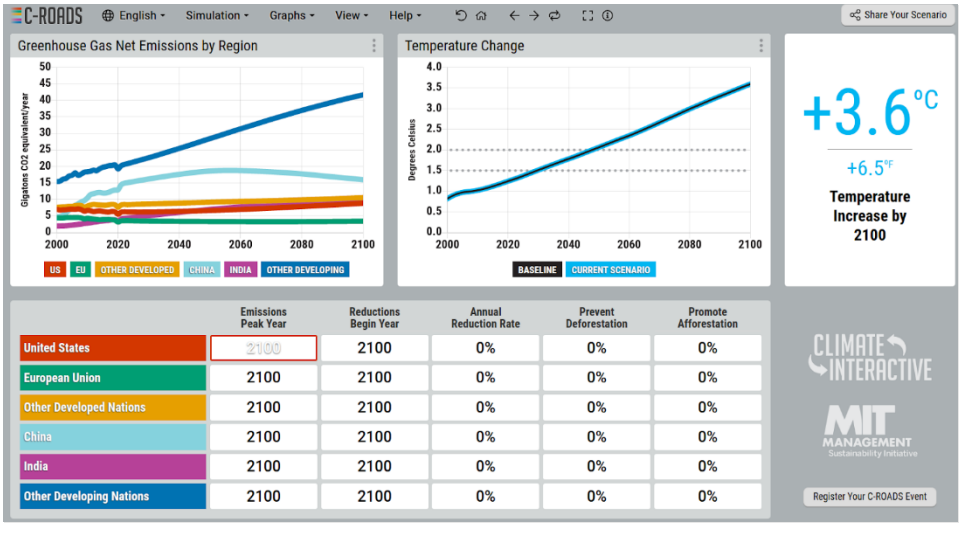
We present in this section a selection of modelling tools that may be relevant for NEVERMORE. Some of them have also been evaluated with both experts and stakeholders to collect their impressions (see Section 4.3.3). The selection of modelling tools has then been enriched with suggestions from experts (Section 4.3.2.)

#### En-ROADS Climate Solutions Simulator

| | |
|---|---|
| EN-ROADS | En-ROADS Climate Solutions Simulator is a freely available online simulator that provides policymakers, educators, businesses, the media, and the public with the ability to test and explore cross-sector climate solutions.<br>The En-ROADS simulator focuses on different global climate actions across several sectors, mainly energy, land, and industry. It covers interventions like carbon pricing, electric transport, land use, and technological carbon removal. In fact, in the bottom part of the interface, the user can change many indicators from the status quo (business as usual scenario) to options friendly with the environment. In this way, the user is implicitly testing scenarios, i.e., a set of policies or better changes in indicators. Everything (indicators, impacts, etc.) is computed at the global level, e., what happens to the entire world on average. For more details, it is possible to use C-roads (see the following tool).<br>Features:<br>• Two graphs are shown as default, but it is possible to change the shown graphs using the menu above or even to change how many scenarios are visualised.<br>• It is possible to share the scenario the user created.<br>• Usable with the persons in presence (like a town hall with a moderator) or remote. Usable alone or in groups.<br>• It is translated in many different languages |
| **Website** | Link to the tool |

| | |
|---|---|
| **Screenshots** |  |

## C-ROADS Climate Solutions Simulator

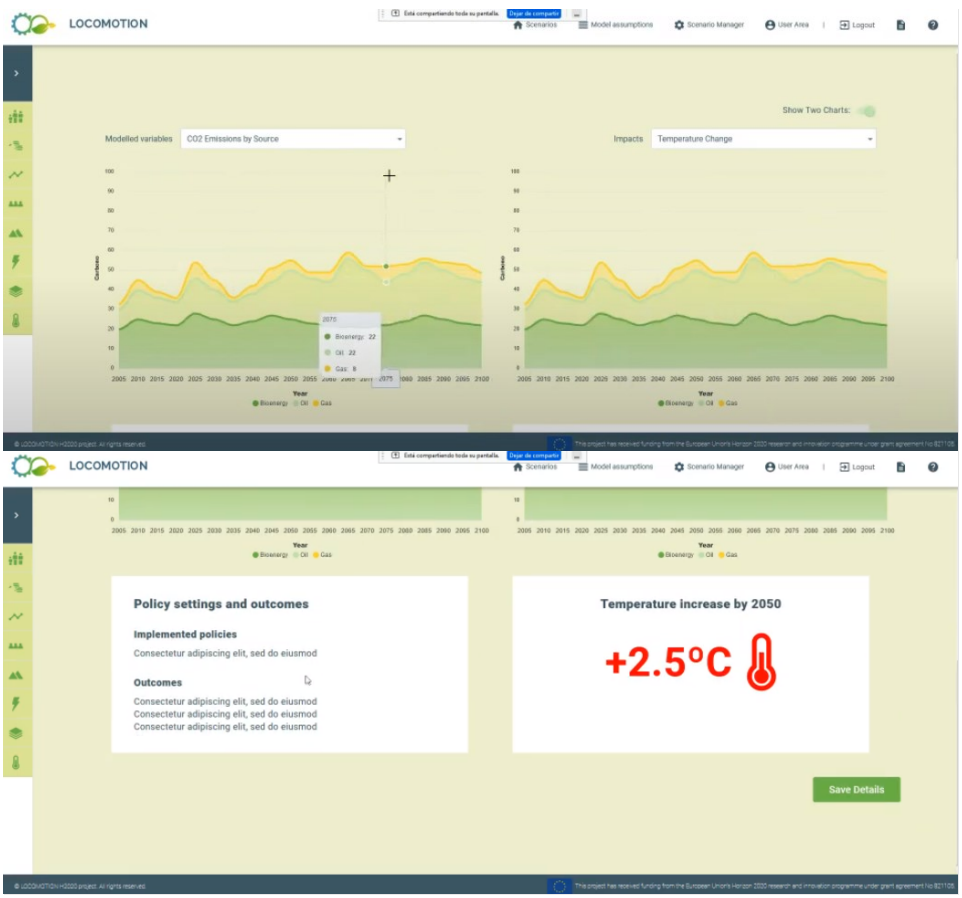
| | |
|---|---|
| C-ROADS | While En-ROADS is global in its explorations, the C-ROADS simulator focuses on specific emission reduction pledges from different countries and world regions (e.g., to meet the goals of the Paris Agreement). In C-ROADS it is possible to test actions like "What if China's carbon emissions don't peak until 2040?" or "What if the European Union reduces its emissions 5% per year starting today?". So, in this sense, both policies and impacts can be customised at the level of six macro blocks: United States, European Union, other developed nations, China, India, and other developing nations.<br>Differently from En-ROADS, policies and impacts can be defined at the level of macro blocks. However, fewer policies are modellable. |
| **Website** | Link to the tool |
| **Screenshots** |  |

### 4.2.2 The experts' perspective

To provide recommendations on the EU-scale tool, experts from CARTIF have been interviewed and suggested the following tools be considered for the design and development of the NEVERMORE project. These tools have been developed in past European projects such as LOCOMOTION. We list

them in the following tables and provide the experts' evaluation in the last part of the table, “Interesting features for NEVERMORE”.

### LOCOMOTION Model Explorer

| | |
|---|---|
| | The “LOCOMOTION Model Explorer” is an easy-to-use web-based application that allows users to explore different scenarios. The user can create different scenarios setting different parameters, and the results, computed employing the WILIAM model, are visualised to the user. WILIAM is an IAM (Integrated Assessment Model) that will also be used in NEVERMORE. As such, the LOCOMOTION Model Explorer is an important tool to consider. The application is primarily targeted at civil society. It aims to empower it to actively participate in an evidence-based public debate on pathways towards a carbon-neutral society. It allows users to explore the complex links between energy production and consumption, climate change, land use, economy and other social dimensions. This will help raise awareness of the impact of behaviour patterns on the systems we rely on and vice-versa. It has been developed in the context of the European project LOCOMOTION (2019-2023) by CARTIF. |
| **Website** | Link to the tool |
| **Screenshots** |  |
| **Interesting features for NEVERMORE** | • The web interface shows precompiled data computed by using the WILIAM model. Currently, the model needs 12 gigabytes of RAM for running the simulation. To have a responsive interface, it is suggested that all computations by the model are run in advance, cached and saved on a database and shown in real-time to the user when they interact with the interface. |

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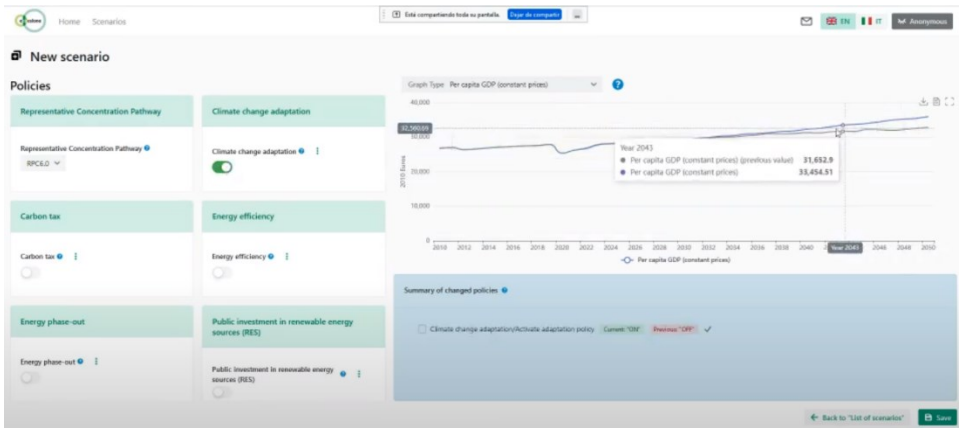
| | • If creating a new account, configurations can be saved from one session to the other. Users can develop scenarios by setting different parameters and saving them for the next access.<br>• Part of the interface is dedicated to explaining the module assumptions and pre-defined policies. Users cannot change them, but the model ensures its transparency by showing them.<br>• Policies are included at the global level. However, the values computed by the model are available at the regional level (35 regions with EU at national level). By doing so, it is possible to see the effect of global policies on specific areas.<br>• The system is similar to En-ROADS and C-Roads due to the use of a system dynamic model.<br>• No maps are needed in such a tool. |

## Ecoesione simulator

| | |
|---|---|
| | Ecoesione Simulator is very close to LOCOMOTION Model Explorer and has been developed by CARTIF and the University of Pisa, Italy.<br>Users can create their scenarios by switching on or off different policies, such as "Climate change adaptation" or "Public investment in renewable energy sources", which are already inserted in the tool. It is possible to:<br>• Explore in detail every single policy and the assumptions behind it and change them evaluating the results in real time.<br>• Compare the "business as usual" scenario and the chosen scenario.<br>• Save a scenario and open it again at the next login.<br>• Visualise scenarios from other users and share your developed scenarios.<br><br>Technologically, the main difference is that, in Ecoesione, the model runs in real-time in the browser. |
| **Website** | Link to the tool |
| **Screenshots** |  |
| **Interesting features for NEVERMORE** | • Interestingly, creating a scenario is straightforward because it requires switching on some already introduced policies.<br>• It is possible to explore every policy in detail, the assumptions behind it, and change them.<br>• There is an interesting design choice: the interface allows users to explore only one indicator at a time (see the central part of the interface). On the one hand, |

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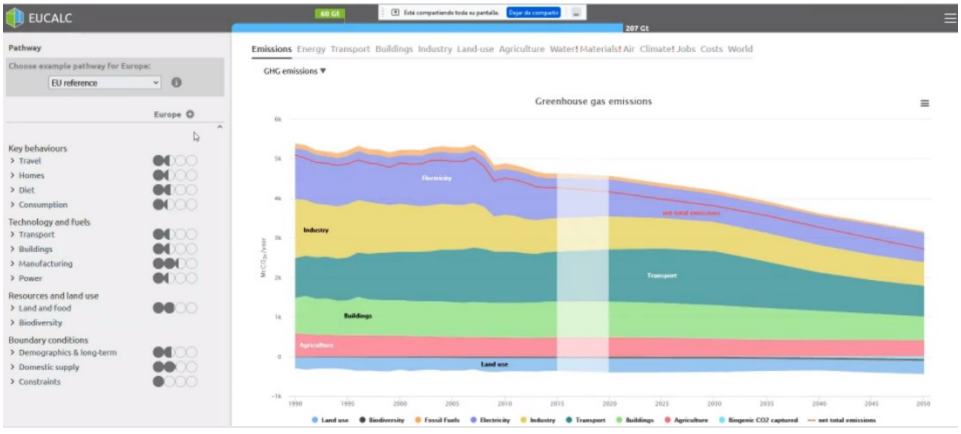
| | this solution prevents users from getting confused, but on the other hand, exploring many indicators takes time.<br>• It is possible to compare the "business as usual" scenario with the chosen scenario and download the simulation results (as a CSV file).<br>• Registered users can also:<br>  • Save a scenario to open it again at the next login.<br>  • Make their scenarios public.<br>  • Rate their scenarios with stars, which allows, for example, explicitly stating which scenario they think is better. This functionality is conceived to support peer learning and make the tool more participatory. As testing activities, the University of Pisa runs a context among scenarios: those rated more highly by other users will win the context.<br>• The costs of policies are not included in the model. The same is true also for LOCOMOTION Model Explorer. It could be interesting to integrate this part about the costs of policies (and the fact that there are limited financial resources) in NEVERMORE.<br>• Technologically, the main difference with respect to LOCOMOTION Model Analyzer is that the model runs in real-time in the browser. The model does not run within the Vensim software but has been ported to Webassembly and, to produce results in a few milliseconds with the limited resources of a browser, the model has been significantly simplified. |

### European Calculator

| | |
|---|---|
| EUCALC | This tool is the product of another European project, EUCALC, and it is based on a model which originated from the DECC 2050 calculators. The model runs on a server, but not all the results are available in real time.<br>There is a part about behaviour change, which may be relevant to NEVERMORE. For example, the user can choose among travel modes (e.g., "reduced use of private cars" or "reduced average distance people will travel in one year"), ways of living in the houses (e.g., "cooling and heating" or "use of appliances"), or diet or consumption. |
| **Website** | Link to the tool |
| **Screenshots** |  |
| **Interesting features for NEVERMORE** | Interesting functionalities:<br>The user can choose among travel modes (e.g., "reduced use of private cars" or "reduced average distance people will travel in one year"), ways of living in the houses (e.g., "cooling and heating" or "use of appliances"), or diet or consumption. |

| | |
|---|---|
| | Flaws:<br>This tool does not provide a real-time interface. When you change parameters, a pop-up window says, “Data for this pathway needs to be calculated first, which can take up to two minutes. Hit 'Calculate' to start”. We believe it is better to precompute calculations of indicators up to 2050 and cache them to show them in real-time as soon as the user changes any setting. |

### 4.2.3 The case studies’ perspective on the EU-scale tool

To collect input about the EU-scale tool, the interactive tool EN-ROADS was shown and discussed with the interviewees to encourage reflection at the interface level.

#### 4.2.3.1 CS1 - Sitia

EN-ROADS is considered interesting, and the stakeholder was positively surprised by it, especially when the stakeholder realised that many different graphs are shown for each indicator.

The stakeholder works as a firefighter and has experience with models that can model how fire evolves. He doubts how much models can model reality: “How can we trust the model?”

According to him, the Eu-scale tool is better suited for national policymakers. He would be more interested in using a tool at the local level, such as the case study tool.

#### 4.2.3.2 CS2 - Trentino

Attitudes and reflections from the Trentino case study on the interactive tool to navigate the EU-scale models and explore policy impact are diversified. The interviewed representatives of PAT exhibit varying degrees of familiarity with policy models, and each has distinct desiderata regarding policy modelling.

For one interviewee, global tools such as En-ROADS could be helpful only if they could integrate relevant sectors for the Case Study. For example, currently, En-ROADS does not include Tourism as a sector where policies can be expressed: "I find it hard to understand how tourism-related policies can enter here. Tourism is a complex practice: it includes aspects of mobility and consumption behaviours. Perhaps instead of 'Energy Supply', there should be "tourism" as a sector, and underneath many sliders for each activity defining tourism, e.g., mobility, consumption, tourists flow, degree of sustainability of accommodation facilities, etc.". Interestingly, the interviewee realised that, in a scenario, tourism could be either an input or an output. Tourism could be represented by a graph showing what impacts policies have on it (i.e., by moving sliders) and a collection of policies to change and see what effects they would have on the environment.

Another PAT representative, with a technical background in modelling, shared some concerns about using models for decision-making. They are aware of some of the limits of complex models with several parameters and ask for more information to understand the reliability of models, more transparency in the assumptions made in the model, and information about the temporal dimensions of a policy impact (e.g., how long it will take to achieve a result?). In addition to these considerations regarding En-ROADS as a decision-making tool, other usages and target users have been hypothesised. An interactive modelling tool may raise awareness and garner support for a particular policy. For instance,

to incentivise civil society and build consensus around a specific policy on sustainability (e.g., water consumption).

Although modelling policies is considered useful, interviewees also recognised the uncertainty of unforeseen variables that may affect the application and success of a policy. One interviewee stated, "In politics and administration, anything can happen between the decision-making stage and actual implementation, such as the war in Ukraine." This highlights policy-making's complex and unpredictable nature and the need to remain flexible and adaptable in the face of unforeseen circumstances.

For another PAT representative, features of this kind of tools are the possibility to link to the policy catalogue with the modelling tool and see the impact of a policy and the specific measures related to that policy at several levels: the global, national, and local levels (as an interviewee stated, “If I modify the parameter "deforestation", I would like to see the potential impacts and specific policies related to deforestation at the global, national, and local levels”). Here emerges the idea of connecting the global and local tools to allow users to customise the search and the exploration at the global or local level: “By inputting data specific to my region, I would like to obtain relevant outputs. This analysis can help assess a particular policy's economic, environmental, and social impacts and the potential timelines required to achieve these impacts. Furthermore, the option to input regional data would allow for a local analysis, which can be used to make informed decisions about which measures to adopt, their associated costs, and the trade-offs between different policy options”.

Comparing different policies would also be helpful: “Comparing policies that yield similar impacts but have different costs can provide valuable insight for decision-makers. Ultimately, this knowledge can help determine the sustainability and applicability of a policy, thus enabling more informed and effective decision-making”.

#### 4.2.3.3 CS3 - Norrbotten

Ease of use and understanding. The Interviewee from the Norrbotten case study had a positive impression of En-ROADS. They appreciated:

- The interaction with the sliders in the bottom part of the interface and the real-time visualisation of the effects through changes in the graphs in the upper part.
- The fact that the baseline (i.e., the effects of the 'business as usual' approach) is always shown in the graph, as it allows having an immediate idea of the improvement or worsening of the effects of our choices in the sliders.
- Seeing the effect of combinations of policies by moving two sliders simultaneously.

A legend to understand the graphs. Nevertheless, what the graphs represent was not clear. The interface allows changing what the graph represents by clicking on the title. Still, graph names are very technical ("I do not know what the charts mean, I would need a legend or something").

Probably Norrbotten municipalities would not be interested in using a tool like En-ROADS because it is at a very high level. If they were given a tool like this but representing their municipalities, meaning that if you change the sliders, you will see precisely what will happen in your municipality, then they might use it. Currently, the level is not close enough to their land. Conversely, a possible use envisioned for the EU-scale tool is to convince the population that a policy is in the right direction by visualising

its effects. Thanks to the power of visualisation, this tool could be used just for communication and raising awareness among citizens.

#### 4.2.3.4 CS4 - Murcia

Although claiming he is not an expert, the INFO Murcia case study leader does not find En-ROADS easy to use: the tool looks too sophisticated to be used by non-specialists. It must be considered that mayors and municipality employees are not experts and do not have time to learn the tool. Another person from INFO Murcia, with a more technical background, thinks En-ROADS is very interesting. He has been creating monitoring tools in Excel, but he thinks this is much more powerful and communicative. The overall feedback is that the tool must be in Spanish, easier to interact with and use a simple language.

#### 4.2.3.5 CS5 - Tulcea

There is a high interest in having data on the impact of policies. However, at the same time, some concerns may arise because of the novelty of these approaches and tools. A challenge is represented by the scarce familiarity with models and simulation, and models like those envisaged in NEVERMORE could be perceived by PA as highly innovative and complex.

Concerns are related to how these very innovative tools could be received by public employees unfamiliar with such complexity, especially people working at the local level. However, Tulcea County has strong institutionalised connections with several other PAs with whom a process of familiarisation with these new processes and tools can be developed to boost innovation and facilitate the integration of new ICT tools into public administrations.

Browsing En-ROADS, the interviewee is impressed by a model's potentialities. She found interesting:

- The possibility to see the details related to the policies, for instance, the possibility to add a period (start date - end date). She finds the representation usable.
- The interviewee raised some concerns about the usability of such a tool by non-expert: “This tool can be used only by the top management but not by local stakeholders and non-expert users”. This is because of the complexity of navigation, the tool's content, and the language (several PA representatives do not speak English).

## 4.3 Local-scale ICT tool: best practices and recommendations

The “local-scale tool” developed in the NEVERMORE project will be a software component that will integrate i) the methodological developments from WP6 (RINA-C), the climate datasets at the local scale (WP3 - NCSRD), and the sectoral data provided by WP6 (CARTIF). This tool will make possible the definition of climate change impacts and risks assessment for generating local adaptation and mitigation scenarios based on the user-selected measures from the catalogue (WP5) at the local scale. The tool aims to show the climate change impacts and risks for different adaptation or mitigation scenarios picked from the policy catalogue at a local level.

The main target of this tool is local decision-makers, such as public authorities, private businesses and non-profit organisations, but also research organisations and local stakeholders interested in better understanding possible outcomes and trade-offs of the different policies that might be adopted in the territory.

To elicit needs, desiderata, and envisioned concepts about the local-scale tool, we interviewed a RINA-C representative as the NEVERMORE partner in charge of developing the model behind the Case Study Tool and representatives of the case study leaders' partners. Because the tasks on the Local-scale tool still must begin and the discussion among the consortium partners is ongoing, many aspects, such as the role, function, and purpose, are still being defined. Since the core functionalities of the local-scale tool are not defined yet, and we did not find similar tools to be used as probes during the interviews (as it happened for the Catalogue of Policy, for instance), interviews with local stakeholders revolved around their experience with local data and climate information, and which tools they already work with at the local level.

### 4.3.1 The expert perspective

RINA-C is the NEVERMORE partner in charge of the development of the model behind the Case Study Tool (WP6 - T6.5, M18-M34), while SIIMAVI will develop the user interface (WP7 - T7.3, T7.4, M20-M42). For this reason, we have interviewed them to make their expertise and envision the concept of the case study emerge.

RINA-C has experience modelling risk and vulnerability curves related to extreme natural events like earthquakes, floods, and landslides. Risk is the combination of hazard, exposure, and vulnerability. They can estimate three types of damages due to extreme natural events: structural damage, economic damage, and service loss damage. Each damage is calculated in terms of financial loss. RINA-C reports are used to make a priority rate of the built structures and decide which ones to intervene in and can be used for insurance purposes. Furthermore, policies and laws can be changed when a hazard becomes frequent.

From the interview with them, the following vision and recommendations for the Case Study tool emerged:

- *Ensure integration and communication between the WILIAM model and the case-study tool model.*
    - One of the biggest challenges for the NEVERMORE project is understanding how to shift the impact calculations from the global model (developed by UVa and CARTIF) to the local one (developed by RINA-C).
    - Even if impact analysis is calculated by two different models, the tool to provide case studies should be one. Users from the case studies should be able to switch between the EU and the local scales of climate change impacts.
    - Given that WILIAM is a dynamic model, the impact model developed at the local level could use some of the trends shown by the WILIAM model to show a projection of how a localised vulnerability function could change over time. For example, in the case study tool, the population is a fixed datum, i.e., a snapshot of the number of people present in a specific context at a specific time. Since WILIAM can predict population growth in 2030, RINA-C could provide it would be useful to have an analysis with our models with that number - which for us is always fixed data but is updated based on another model.
- *Identify the tool's users and design visualisations, labels, and features according to their expertise.*

- If the users of the case study tool will not be technical experts, the interface must be easy to use. It is essential first to understand the user's identity and, based on that, define the degree of complexity, how far to go into the individual inputs, and what kind of choice to give the user.

- *Continuous data updates by certified users and tool sustainability in the long term*
  - Besides using the dataset to inform their decision-making processes, registered and certified users such as PAs could update data. Dataset enrichment by users could be achieved by providing different usage rights to the users, like when Dropbox users have the right to see only or to see and edit.
- *Allow users to select variables in the tool interface that inform an asset's fragility to a specific hazard*
  - Geographic area/region.
  - Sector and sub-sectors (if any) affected, e.g., energy or tourism sector.
  - Type of asset (e.g., roads, water networks, or single physical facility – hospital).
  - Asset attributes that describe and characterise it.
  - The socio-economic indicators (provided by ZSI) that tell us how much an asset is resilient/vulnerable to a specific hazard.
  - Type of hazards.
- *Represent data correlations through graphs or other visualisations.*
  - Typically, RINA-C shows Expected Annual Loss corresponding to the area under a curve. If the curve decreases, the area also decreases.
- *Base visualisations on geography: use of maps.*
  - Copernicus (or other similar databases) maps have grids. It would be helpful to use different colours to mark the intensity with which a hazard could hit a specific area on the grid for a specific type of asset. The input should be the type of asset, type of hazard and geographical coordinates for a certain area. It would be possible to identify the asset with a name unless it is universally recognisable such as the Colosseum.
- *Ensure integration and communication between the back-end and front-end development of the Case Study Tool.*
  - Coordination and agreement on the back-end and front-end programming languages are needed by the partners (RINA-C and SIMAVI).

### 4.3.2 The case studies perspective on the NEVERMORE case study tool

#### 4.3.2.1 CS1 - Sitia

The interviewee considered models at the local level much more interesting and useful than the EU-scale tool. He guesses that models at the local level might be even more challenging to build than global ones because they require collecting many local and specific data and understanding the relationships among them.

**Local models** are considered valuable because they **can guide local politicians and the population about what to do to have specific results in 10 or 15 years**. It would be extremely interesting if the tool could "simulate" policies, i.e., get a "tangible way to see what happens if we do or do not do something".

The primary target for the case study tool is **policymakers, using the tool to make decisions as well as to explain to the population why decisions are taken**. Furthermore, citizens could use it to suggest decisions and policies to politicians.

The need to connect the personal to the societal emerged, i.e., to **show how individual choices impact the local population at large and how society impacts individuals**.

#### 4.3.2.2 CS2 - Trentino

At the local level, the tool must be adapted to the territorial specificities. It would be useful to **tailor a global policy to the specific local context and analyse the impacts at the local level**, considering the territory's specificities and vulnerabilities. Therefore, in terms of interaction with a tool, it would be interesting to start from the policies for which a case study wants to see the effects (in the Trentino case, the energy and tourism sectors) and then reason on the local parameters to consider. The interviewees expressed concern about the feasibility of such specific models and the need to start from a careful analysis of the context and the territory's specificities. Furthermore, according to the case study leader's opinion, to make informed decisions based on them, **models should be transparent about their levels of reliability and robustness**.

Below are some examples of local tools used by the Trentino case study leader.

| **DOLOMITI PAGANELLA CALCULATOR** | |
|---|---|
| | https://www.dolomitipaganellafuturelab.it/<br>https://earthcheck.org/ |
| Dolomiti Paganella, with the Future Lab project and Terra Institute, the licensee of the "Earth Check" software, has created the Dolomiti Paganella Calculator. Earth Check (https://earthcheck.org/) is the world leader in sustainable tourism and provides easy-to-use software for hospitality operators. In the app, a facility can enter data about waste bills and water consumption, and the system compares the facility itself over time and with the average of operators with the same characteristics (stars, rooms, location). In this way, it is possible to acknowledge the gap concerning a facility's consumption compared with the average in its category. The system is global but customisable, and the Dolomiti Paganella team has calibrated it, considering the hotels, restaurants, schools, traders, and transport in their area. | |
| **TRENTINO HAZARD MAP (CAP)** | |
| | https://patn.maps.arcgis.com/apps/webappviewer/index.html?id=0bd213973cae4a3eb7ac72cbf040b7dc |
| The Hazard Maps (CaP) represent the dangers associated with hydrogeological phenomena, avalanches, floods, seismic events, forest fires, certain dangerous substances, suspended cables or other obstacles to air navigation and unexploded war devices in the Trentino Region. These maps result from the Trentino Civil Protection's forecasting activity, which involves identifying, delimiting, and classifying the hazards and risks present in the territory. They represent the basic tools for the Civil Protection's prevention activities (directed at the elimination or reduction of risks, both through prescriptive and binding measures for the proper use of the territory and through structural interventions) and protection activities (primarily planning, organisational, cultural and educational activities, and management interventions aimed at mitigating the harmful effects arising from risks that cannot be eliminated through prevention activities). | |

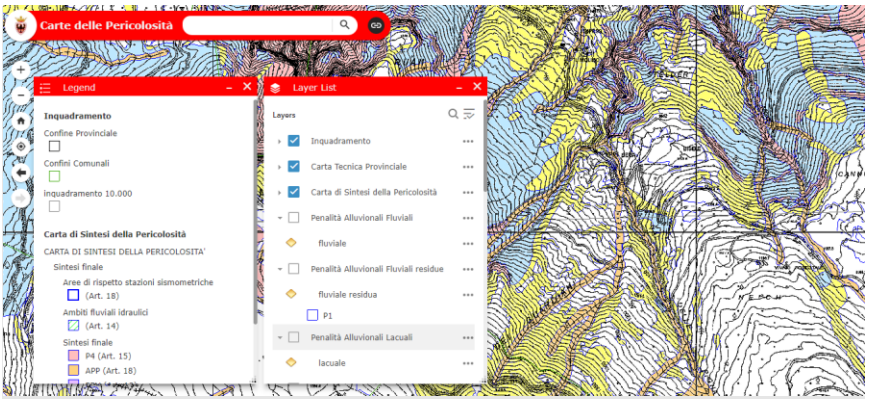



Figure 4. Trentino Hazard Map.

### 4.3.2.3 CS3 - Norrbotten

For Eknorr, the case study tool is the most important of the NEVERMORE ICT Toolkit because it would allow **knowing what the scenario will be if a particular measure is taken**. Such a tool would benefit municipalities, companies, and civil societies like nature conservation organisations.

Norrbotten municipalities that are members of the Local Council expect the case study tool to **show data connected with each city**. They would be happy to use it if it allows them to say: "We can reach this outcome if we stop using individual cars". Therefore, the case study tool cannot be for the whole region or the county; it will not convince them.

Many tools are available in Sweden, e.g., to see forecasts of precipitations and temperature, floodings connected to land use, etc. Still, they are not exploited at maximum because they are not easy to use or informative. The NEVERMORE project should aim to create interesting, useful, and easy-to-use tools.

| **REINDEER-GIS (NORRBOTTEN)** | |
|---|---|
|   | https://imfn.net/wp-content/uploads/2019/01/FactSheets_Eng_Vilhelmina.pdf<br>https://storymaps.arcgis.com/stories/b94c260e7667451b9d93c5ff9adb6009 |
| For reindeer husbandry, a Reindeer GIS is used. Uses of such tools have been reported in literature too. For example, Participatory GIS (pGIS) is a tool mapping indigenous ecological knowledge and other data sources on a geographic information system (GIS). The goal is to provide clear and understandable information about habitat use and reindeer movement across the landscape. PGIS allows land users to participate in planning processes more effectively by inputting their current practices and concerns on digital maps. The pGIS facilitates communication and conflict resolution and helps with negotiation processes (Sandström et al., 2012). | |

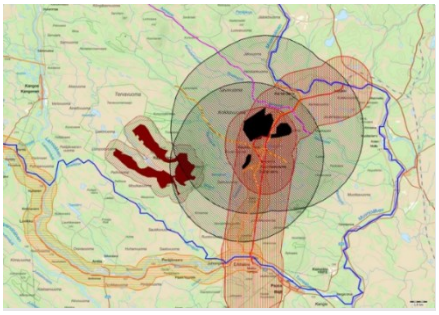


Figure 5. Reindeer-GIS (Norrbotten).

| LANDSLIDE RISK MAPPING (NORRBOTTEN) | |
|---|---|
| SWEDISH GEOTECHNICAL INSTITUTE | https://gis.swedgeo.se/skredriskkarteringar/ |
| The Swedish Geotechnical Institute has mapped the risk of landslides along Swedish rivers and water courses. They started mapping the risks related to the Göta älv River Valley in 2009-2012. The most important GIS application within the investigation of the Swedish Geotechnical Institute is the one known as "Viewer – Göta River". It contains almost one hundred layers and hundreds of thousands of geographic objects (for example, points, lines, and areas), with data provided by other authorities and results generated by the investigation. Then, based on the leading GIS platform, several other web-based GIS applications have been developed to manage and show the data collected easily. Moreover, in some GIS applications, it is also possible for the user to edit and revise the collected and displayed data. | |

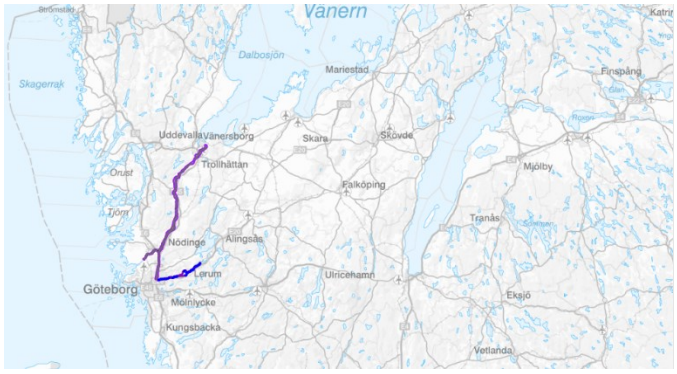



Figure 6. Landslide Risk Mapping (Norrbotten)

| SYMPHONY (SWEDEN) |
|---|
| Symphony is a model-based tool for ecosystem-based marine spatial planning. It is developed for Sweden but can be transferred to other countries. The model depicts how ecosystem components respond to human pressures through maps and other graphical representations (including a sensitivity matrix). The Symphony method provides valuable analyses for marine spatial planning in any context: it informs planners of the baseline conditions and cumulative impacts of various planning options in different areas. |

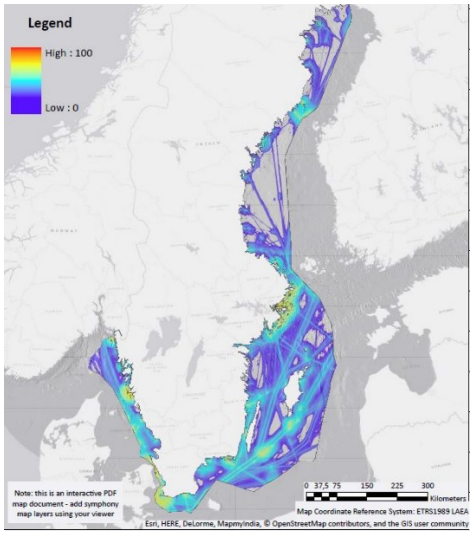



Figure 7. Symphony (Sweden)

| ADVANCED CLIMATE CHANGE SCENARIO SERVICE (SWEDEN) | |
|---|---|
| SMHI | https://www.smhi.se/en/climate/future-climate/basic-climate-change-scenario-service/sverige/medeltemperatur/rcp45/2071-2100 |
| The Swedish Meteorological and Hydrological Institute has developed this tool to show forecasts of climate processes and extreme weather events in the form of maps, diagrams, and downloadable data. This tool provides geographical maps where it is possible to look at each Swedish county and see what weather (temperature and precipitations) there will be here if policies applying the Paris Agreement guidelines, cutting emissions even more, or not cutting emissions are put in place. According to the Norrbotten case study leader, this tool is very good for understanding the effect in small areas, but it would be even better to combine it with this global model of policies. | |

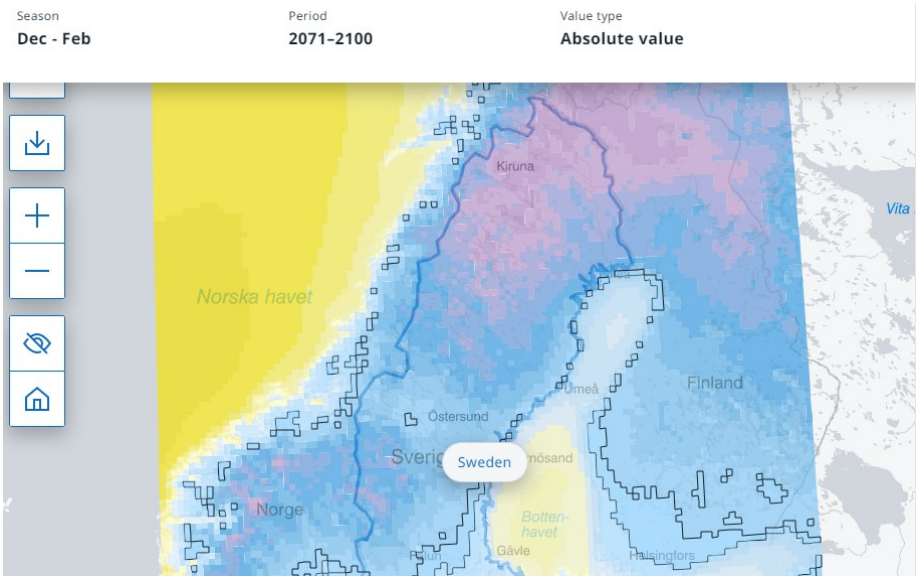



Figure 8. Advanced Climate Change Scenario Service (Sweden)

#### 4.3.2.4 CS4 - Murcia

Murcia's case study goal is to have mayors create and approve Sustainable Energy and Climate Action Plans (SECAP). Therefore, they would like tools that support this process, i.e., the writing, updating, and evaluating of SECAPs. On the other hand, a generic tool for the population (either at EU or local levels or gamified) would be helpful if capable of **making the local people change attitude and behaviour about climate change to trigger some form of pressure from the citizens on the municipalities so that they are pushed to make plans to adapt and mitigate climate change, i.e., create and approve SECAPs**.

As a general suggestion, all the digital tools should be in Spanish, straightforward to use, and without complex jargon and technical language: municipalities do not have time to learn complex tools.

Returning to tools that might help mayors create, update, and evaluate SECAPs, it is interesting to note their time horizon: SECAPs must have commitments within 2020 (which is already passed), 2030, and 2050 with concrete objectives. The objectives, defined by the EU, are the following: by 2020, a reduction of Co2 emission by 20%; by 2030, a decrease of 55%; and by 2050, climate neutrality, which is a 90% reduction. In this respect, **a tool showing possible future scenarios and how specific indicators will change if plans and policies are applied should have the following milestones: 2030**

**and 2050**. Probably, instead of a graph showing the evolution of each indicator year per year up to 2100 (as is typical in many of the tools we described), it could be enough to show the predicted values of the indicator only in 2030 and 2050: in this way, the interface might be simpler to understand and use. Regarding the types of policies, by 2020, only mitigation policies were required, while later, with the introduction of SECAPs, adaptation policies should be deployed. Moreover, it is interesting to note that writing and adopting a SECAP could take around one year and a half and should be adapted and revised every three years. During the three years, mayors must consult local citizens at least twice since the SECAPs definition is a participatory process.

Finally, SECAPs should be “neutral”, “objective”, and agreed upon by a large majority, meaning that if, after the election, a different party wins, they should not be deleted or reversed. Given these requirements, **a local tool showing citizens the SECAP plan, its possible effects, and why specific actions were included in the plan might be helpful**. Moreover, **features for tracking the evolution of the participatory process and involving the citizens in public discussions on the web and in real life might also be helpful**.

#### 4.3.2.5 CS5 - Tulcea

As for the other Case Studies representatives, **customising the tool to the local specificities is paramount**. While discussing En-ROADS with the Tulcea representative, she stated, "If we want a tool like this to be used at the local level, it should contain specific parameters **such as local utilities, infrastructures, population (increasing vs decreasing), simulation in local agriculture and animals**”.

Considering the system's users (local public administrations, local organisations, etc.), the local tool must be more straightforward and intuitive than the global one. It must be easy to navigate, with fewer parameters, understandable and editable by the user.

Another interesting suggestion, related to the EU and the local-scale tools, is to make them accessible to communication specialists to raise public awareness about climate change and effectively communicate scientific knowledge by exploiting available data.

## 4.4 Gamification and serious games for climate change: best practices and recommendations

One of the goals of NEVERMORE is to increase interest in the decision-making tools and forums through gamification, providing adequate information accessible to stakeholders, notably citizens, including the gamification tool for educational purposes (see Task 7.3).

Starting from the existing 'Crossroads II Game', the NEVERMORE gamification solution will continue to facilitate communication with civil society about the outcomes of the IAM. This task aims at applying advanced gamification principles and methodologies to develop Serious Games to allow users to explore different environmental, social and economic scenarios according to the input-output available variables in a playful manner. In this way, the in-game interaction will be complemented by existing out-of-game interactions via widespread communication channels (face-to-face, email, chat) to deliver pertinent information to design climate change mitigation strategies under modern social and cultural forms of interaction and in total alignment with the training activities taking place in T8.5.

### 4.4.1 Literature and web review

Serious games are games used for purposes different from entertainment that "provide communities with the opportunity to interactively explore different climate futures, build capability and capacity for dealing with complex challenges, and socialise adaptation priorities with diverse publics" (Flood et al., 2018). Typically, serious games tackling climate change issues have three main objectives (Flood et al., 2018):

- Teach knowledge and provide familiarity with the issues of climate change
- Make players aware of the challenges associated with global warming
- Encourage players to develop solutions

Gamification consists of applying game design principles to a non-gaming context; these principles can be progression paths with achievable goals, levels and rewards, giving players agency over their actions, making use of strategy and novelty to engage players, providing feedback, making use of social comparison or competition, encouraging cooperation between players, or various combinations of these principles (Douglas and Brauer, 2021). Through gamification, individuals are intrinsically motivated to engage with content and challenges related to the area where behaviour change is desirable. Douglas and Brauer (2021) reviewed the games and apps evaluated in empirical research in the last five years and provided insights on how gamification can be exploited to prevent climate change. Results suggest that apps that use elements of gamification, such as providing feedback or earning points for behaviour, are generally rated more positively by users than apps that attempt to change behaviour by providing information alone. Besides, gamification can lead to longer-term psychological engagement than other behaviour change methods, such as nudging.

Flood et al. (2018) reviewed 43 research outputs related to serious games and provided several recommendations for future research. To enhance the effectiveness of future games, maximise impact, and create new opportunities for learning and innovation, researchers need to clearly define the target and purpose of the game and identify a balance between different trade-offs:

- Between **gameplay length and complexity**: quick and simple games and games are very different from games that capture complexities of the science in more detail: "Quick and simple games can be useful conversation starters and establish a basis for further engagement with players" while "Longer games are more likely to create deeper player engagement that challenges existing mental models, changes player behaviour, and catalyses action by enabling players to make climate change adaptation decisions in the face of uncertainty".
- Between **scientifically optimal outcomes and those that decision makers find reasonable**: even if games are ways to explore possible futures, "the game must be able to represent real and reasonable options reflecting the motivations, values, aspirations and considerations of decision makers on the ground".

The work of van et al. (2022) suggests that gamification should consider a diversity of audiences for gamification to address climate change: most climate games are designed for students rather than policymakers. As a result, there is limited research on the impact of climate games on policy audiences, precisely their effectiveness in engaging science-policy processes. The authors find that role-playing simulation (RPS) games can enhance science-policy engagement regarding climate change. These games involve participants assuming specific roles and following predetermined rules that mimic the

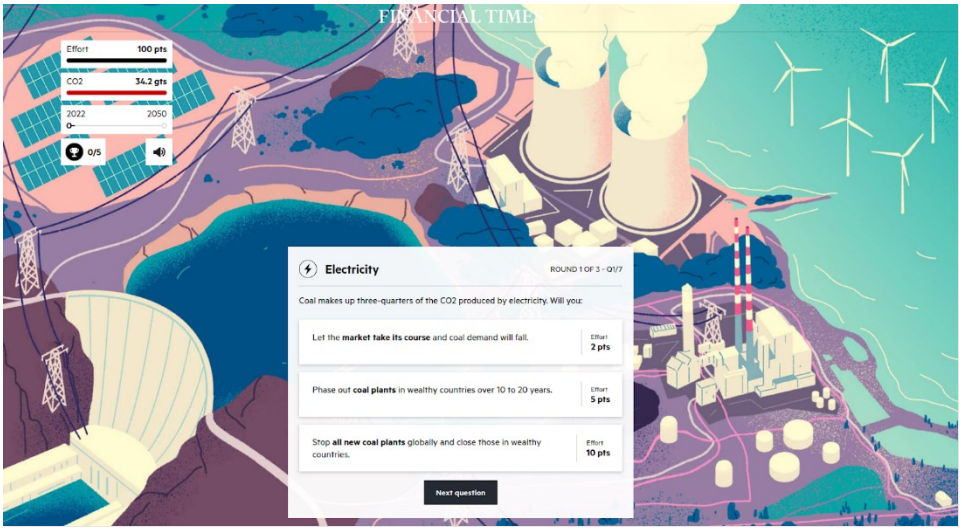
results of their actions. This approach enables participants to explore policy responses to intricate problems, gain knowledge of complex system dynamics, and simulate the future consequences of present policies and decisions. By doing so, they can experience and understand multiple perspectives of stakeholders.

Fernandez Galeote et al. (2021) performed a systematic literature review of 64 research outputs comprising 56 different gamified approaches in the field of climate change. They provided guidelines and an agenda for future research in gamification. We provide some of them:

- **Audience variety**: Various social, political and economic actors can benefit from game-based experiences. The authors suggest that the audience of game-based intervention in climate change can be enlarged through a user-centred design approach.
- **More information on the participants' backgrounds** is needed. Climate change is both a political and an environmental issue, and information about people's backgrounds, perceptions of climate change, and so on should be considered.
- **Focus also on emerging and developing economies**: climate impacts are expected to impact growing regions strongly, and more research on game-based interventions should be situated in emerging economies and linked to locally relevant adaptation measures.
- **Integrate game-based intervention with other interventions**: serious games are more effective in driving cognitive learning results when they span multiple sessions and/or are combined with additional instructional methods.

Many gamification apps and platforms for behaviour change around sustainability and environmental issues have been developed. We report the most interesting for the NEVERMORE project.

### The Climate Game

| | |
|---|---|
| FINANCIAL TIMES | The Climate Game has been developed by the newspaper Financial Times.<br>It is a web-based game in which the player could try to reach net zero by 2050 by choosing among different policies. The tagline is "See if you can save the planet from the worst effects of climate change". |
| **Website** | https://ig.ft.com/climate-game/ |
| **Screenshots** |  |

### Change Game

| | |
|---|---|
| | The Change Game has been developed by CMCC, a partner in NEVERMORE. It is a video game that can be played on a tablet and resembles famous games such as 'The Sims' or 'Civilization'. "Players will find out how their choices affect their environment and other people. By creating a city from scratch, they will discover how the decisions they make have an impact on climate change. By collaborating with other players, making the right investments, and pursuing sustainable development goals, they will help create communities resilient to natural disasters. Learning to recognise the importance of science is essential to understanding the world in which we live and the possible trajectories of future developments."<br>It is interesting because it can be played with other people and has both collaborative and competitive features. |
| **Website** | https://www.cmcc.it/article/change-game-your-chance-to-simulate-climate-change |
| **Screenshots** |  |

## 4.4.2 The expert perspective

The topic of gamification was addressed during the interview with CARTIF, who were interviewed based on their expertise on the subject and the fact they contributed to the EU project Locomotion, in which the game 'Crossroads II' was developed.

### Crossroads II Game

| | |
|---|---|
| | The tool has been created by the University of Valladolid and other partners of NEVERMORE in the context of the LOCOMOTION project. The tool is a participatory simulation game that allows users to test global greenhouse gas emission reduction policies and see their economic and environmental effects. The current version of the game is based on an interface enabling simulations with the MEDEAS-World energy-economy-environment simulation model developed by GEEDS-University of Valladolid (UVa). The new release will be based in the results of WILIAM model. Based on current trends in greenhouse emissions, players face the task of collaboratively designing goals and strategies to mitigate climate change in the coming decades. In teams defined by role, players make basic global and long-term decisions about economic and energy policies, technological evolution, etc., which are subsequently introduced into a mathematical dynamic simulation model, i.e., an IAM. The model indicates whether the agreed strategy allows (or not) reaching the desired levels of well-being by 2050-80, avoiding dangerous levels of climate change. |

| | |
|---|---|
| **Website** | https://www.locomotion-h2020.eu/locomotion-models/global-sustainability-crossroads-ii/ https://geeds.es/en/global-sustainability-crossroads/ |
| **Screenshots** |  |

There are 3 options on the main page: (1) participate in an already created game, (2) create a new game, and (3) register as a moderator. The moderator runs the game and can distribute participants into different groups. Each participant can choose among 4 roles and then be assigned to a group. Then, the game starts and consists of 10 consecutive questions. One question is posed to the group, and the group participants must discuss the question in the chat and agree on an answer chosen among three options. The group's response will influence the model's output (note that results are precomputed so that the interface can react in real time to group choices).

For each of the 10 questions, the group faces 3 choices, i.e., 3 possible routes they can choose. After the group chooses one of the options, they see the results, but interestingly they cannot see the results of the other 2 routes you did not select. At the end of the 10 questions, the group can change answers, but only if they use the chat to keep discussing the different choices and their effects.

Results of the effects of group choices (i.e., adopted policies) are shown in terms of mean global temperature and CO2 emissions and possibly other variables as GDP. At the end of the game, the group gets a mark based on how the simulation of the world has gone depending on group choices, and this mark can be compared with what other groups got. The analysis horizon is set in the mid-century (2050–80). The game can be used in presence but also remotely since there is a chat in the system. The presence of the moderator can help the group because its potential role is to explain the questions and facilitate the discussion.

The game has been tested by ~420 players in total, during 13 workshops in 2 countries (Spain and Italy), with sessions spanning a wide range of players (from 10 to 100 people) with a heterogeneous level of expertise, education, and age. The evaluation shows that Crossroads II Game has significant pedagogical potential: the game can generate discussions on crucial topics outside the public realm, such as the relationship between economic growth and sustainability, the role of technology, how biophysical constraints and the possibility of climate tipping points limit human desires. Some possible improvements are described in (Capellán-Pérez et al., 2019):

- Introduce flexibility in the game to allow players to check/modify decisions during each simulation.
- Downscaling environmental impacts, socio-economic implications, and potential solutions at the country level would help bring the issues closer to the players by developing localised game versions based on local (regional) models.
- Improve the socio-affective dimension of the game dynamics. Often, the simulations show results that challenge the participants' earlier notions of how the future may evolve. Hence, the game can generate conflicts (about cognitive, values, etc.) both at personal and interpersonal levels. Strategies for the proper management of these differences by the moderators should be refined to channel them towards new cognitive syntheses, leading to change and transformation processes.
- Important dimensions, such as the social ones (e.g., well-being and inequality), are not included yet in the game.

Interestingly, the CARTIF expert reported how a version for mobile phones is under development by the University of Valladolid (UVa).

### 4.4.3 The case studies perspective

#### 4.4.3.1 CS1 - Sitia

The gamification app could raise awareness among the general population, while the other tools could be meant for policymakers and professionals for their job duties. However, the interviewee states that there will always be a part of the population that will not be convinced, even by data.

Gamification could be used with children to familiarise them with climate change in a fun way. However, thinking of schools, the stakeholder suggests addressing first teachers and educators and convincing them; then, young people from 12 up to 18 years old who will soon be the future decision-makers and citizens, and finally, children under 12 years old with a more playful approach, for example changing graphics and simplifying concepts. The local stakeholder considered using games for the first local event to engage children in schools. However, they state that it is much better if there is a local dimension in it, i.e., policies and indicators related to Sitia.

#### 4.4.3.2 CS2 - Trentino

Reflecting on the role of ICT to sensitise about climate change and on playful education, several scenarios in which ICT can support behaviour change towards sustainability were envisaged by Trentino Case study representatives:

- An app that incentivises tourists to make sustainable choices while on vacation in Trentino through game mechanisms: tourists may receive incentives that support their behaviour. Relying on data on water consumption, both by the tourist and the accommodation facilities, mobility data, and information on other behaviours (such as separate waste collection and local product consumption), incentives can be distributed (e.g., free hotel accommodation).
- To engage a younger audience, such as a child on vacation in Trentino with their family, ICT could be incorporated into their daily experience (e.g., ICT could be present in the hotel room and used in the evening to reflect on the day's experiences and then provide feedback on

climate change issues related to those experiences. This approach allows for the tourist's experience to be monitored and sensitised to sustainability by connecting it to their experience on the territory.

- Communicate in a playful way the data related to water and energy consumption in the mountain areas to increase awareness of the limited availability of water resources in the mountains (e.g., for tourists in mountain huts). Information on consumption and how much water is left would justify certain decisions, such as limiting shower times. Experiencing this would be extremely useful and bring visitors closer to the theme of limits and mountain-related experiences.

#### 4.4.3.3 CS3 - Norrbotten

The Norrbotten case study leader thinks that some large municipalities with more resources could use playful apps to reach the population.

A few game and gamification examples from Sweden are

- A game for children in school and preschool age about resource management, where players can make choices and see the outcome. This game teaches players that having a green city has a cost. It is from the SMHI and there is also the English version: https://www.smhi.se/en/climate/education/climate-adaptation-game?l=null&l=null.
- An app encouraging change in consumption behaviour. This app shows a polar bear standing on an ice layer. The user would make purchases through the app, e.g., I would buy this for dinner, take the car or the bus, and see the ice sheet shrink if they made the wrong choice. It was popular, but it was hard to maintain because having all the shops connected to the app was impossible. In the end, the case study leader reflected on these kinds of behaviour change apps' limitations: "I think most people know [what is right to do], but there is something that prevents us from making the right choices.

#### 4.4.3.4 CS4 - Murcia

Games and playful websites are considered interesting for younger shares of the population. All the suggestions provided for the catalogue of policies, the EU scale tool, and the case study tool remain valid for the playful tools: they should be in Spanish, very easy to use, and, in this case, fun.

If young people and, consequently, their parents become aware of climate change in the world and in the region using a game, this is seen as positive so that they can apply pressure on mayors and elected representatives to work on climate change adaptation and mitigation policies actively.

#### 4.4.3.5 CS5 - Tulcea

ICT tools to raise awareness among the public should target an audience under 30, i.e., young generations and schools.

The main challenge that gamification or playful education should address is making the complexity of climate change understandable. A gamification app could be a good tool to simplify all the variables and dependencies involved in climate change and, thus, enable learning by doing or, better, learning by gaming. A significant barrier to using ICT for civil society in the Danube Delta region is that the Internet connection does not cover several areas.

## 4.5 Climate change portals and visualisation tools: best practices and recommendations

We conclude this Section on socio-technical requirements by analysing literature on climate change portals and visualisation tools in general, focusing in particular on recommendations which might be relevant for the ICT tools NEVERMORE will develop.

### 4.5.1 Climate Visualization Tools

Web-based climate change visualisation tools (CVT) are online platforms that use visual representations, such as interactive maps, graphs, charts, and animations, to communicate climate change data and information. These tools allow users to explore and analyse data related to climate change impacts, such as temperature trends, sea level rise, and extreme weather events, at various scales, from global to regional or local. Users can interact with the data by adjusting parameters or variables, selecting different periods or scenarios, and viewing different types of information. These tools can be used for educational purposes, policy-making, and public engagement, as they can help users better understand the complex nature of climate change and its impacts on society and the environment.

A recent comparative analysis of web-based climate change visualisation tools (CVT) performed by Lumley et al. (2022) considers forty-one public-facing CVTs. It compares them to capture the diversity of existing design practices in CVTs and identify key design issues needing more attention. The sample includes climate data portals, data journalism articles, decision support tools, and science outreach platforms.

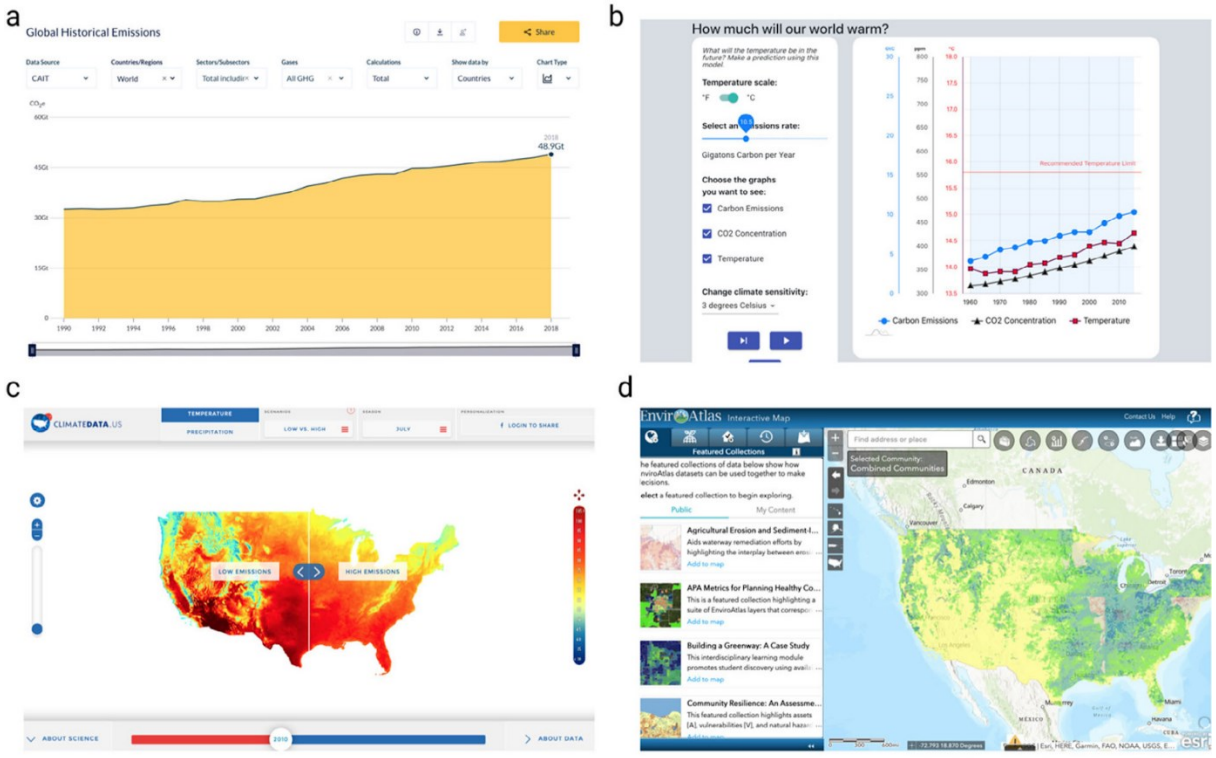



**Figure 9. Examples of four CVTs: (a) Climate watch; (b) The very, very simple climate model; (c) ClimateData.us; (d) EnviroAtlas. From (Lumley et al., 2022)**

CVTs can be classified as either ‘‘exploratory’’ or ‘‘explanatory’’, which is useful to characterise their visual and interactive complexity. These can be considered as opposite ends of a spectrum between ‘‘data explorers’’ (often specialists working with highly interactive tools to reveal previously unknown insights) and ‘‘data viewers’’ (often from the public working with more constrained tools to consume established insights).

The 41 CVTs have been classified and evaluated according to 5 dimensions: purpose, data content, visual representation, interactivity, and web technology:

First, the **purpose** of a CVT can be characterised by its provider, target users, and communication goals. The main providers of CVTs were universities (14; 34%), non-profits (11; 27%), and government agencies (10; 24%). Only six CVTs (15%) were commercial, and three were from news organisations and visualisation companies. It is interesting to note about target users: specialists were the most stated target user in the sample (44%), despite the focus on public-facing online CVTs and included application-oriented users with a professional or community need for climate data, such as journalists, planners, community organisations, policymakers, or researchers. This suggests a space and needs for tools considering the generic public as their main target. Also, tools addressed to education professionals, i.e., teachers, were very few, which is also an opportunity. Regarding the goal, just over two-thirds of CVTs supported exploration (28).

Second, the **data content** describes the quantitative and qualitative data manipulated and rendered by the CVT. Environmental changes were the most common data type (78%) in the form of air temperature, precipitation, and extreme weather events data. Eight CVTs (20%) contained social or economic impact data, and eight (20%) had data on climate change causes. Geographic scale is similarly distributed among global/continental, country/state, county/city, and neighbourhood/individual.

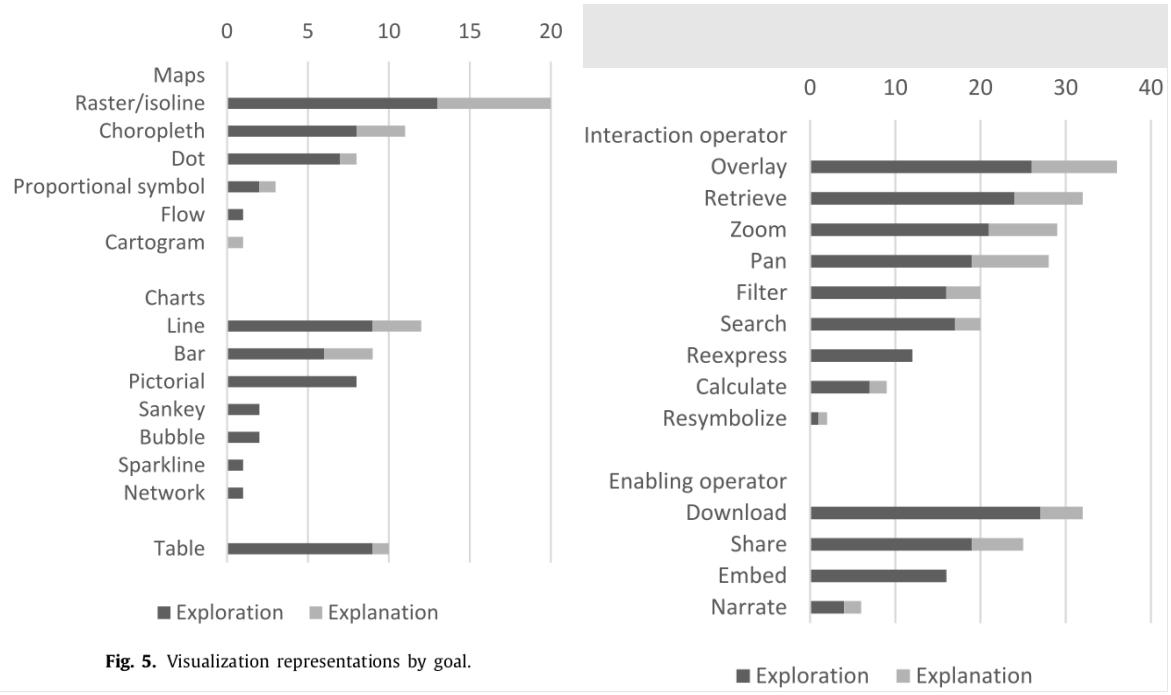



**Fig. 5.** Visualization representations by goal.

**Figure 10. a) Distribution of visual representations; b) distribution of digital functionalities**

Third, **visual representation** describes techniques used to encode climate datasets in the CVT graphically. Figure 4a shows the distribution of visual representations. Maps were the most common visualisation technique, included in 88% of the analysed CVTs, emphasising the centrality of cartography for climate visualisation, which also distinguishes climate from other domains using information visualisation.

Fourth, **interactivity** describes CVTs' digital functionality, enabling users to manipulate visual representations. Figure 4b shows the distribution of digital functionalities.

'Overlay' was the most common operator across the sampled CVTs (88%). It was used for displaying specific information on top of a map. 'Retrieve' (78%), 'zoom' (71%) and 'pan' (68%) were implemented in more than two-thirds of the sampled CVTs. This is not surprising since these 4 visualisation techniques constitute the common ‘‘slippy’’ web map experience. As for enabling operators, many CVTs support features for downloading data and sharing or embedding the created visualisation.

Fifth, **web technology** describes the software architecture used to implement the CVT. Most CVTs used JavaScript-based open web mapping or charting libraries (80%), thus reflecting the shift in visualisation over the past decade away from proprietary rich internet applications to development with open web standards.

The comparative analysis performed by Lumley et al. (2022) relies on findings on CVT developed by several authors. We provide the complete list of recommendations and results that may also be relevant for the development of CVT:

- Most tools have specialists as their target, so there is a space and need for tools that consider the general public as their main target. Also, tools addressed to education professionals, i.e., teachers, are very few, which is also an opportunity for exploitation and research (Lumley et al., 2022).
- Deciding if the primary goal of the tool is ‘‘exploratory’’ or ‘‘explanatory’’ can be a crucial design decision, as different users are explicitly considered and might be better supported by various features and visual metaphors (Lumley et al., 2022).
- Pan, zoom, overlay, retrieve, and filter interaction operators are widely used. There is also a shift towards modern web standards. (Roth et al., 2015).
- There is a lack of models' uncertainty communication (Roth et al., 2015), so it is advisable to investigate whether and how to represent models' uncertainty visually.
- Most tools are informational rather than advisory. The challenge of balancing representing climate change complexity with broad target user groups should be addressed (Neset et al., 2016).
- Commonly, most tools support sharing results with others (e.g., by printing or on social media) (Stephens et al., 2017).
- Producers of climate change maps are often not the publishers. Maps primarily focus on impacts, causes, and mitigation strategies. Map symbolisation includes choropleth, isoline, proportional symbol, and multivariate (Fish, 2020).
- The primary audience was the general public. There is an even divide of macro and micro geographic scope in the analysed tools. Most did not show solutions/actionable steps the user could take (Ferreira et al., 2021).

- Only one visualisation directly encouraged users to action. Designers of CVTs should not expect casual users to be motivated to navigate complex user interfaces. Narrative patterns can help to guide user navigation (Windhager et al., 2019).

Based on their analysis of 41 climate change visualisation tools (CVT), Lumley et al. (2022) compiled a list of design opportunities. We report below those that are more relevant for NEVERMORE.

- A first observation is that most explanatory CVTs focus on meteorological impacts and rarely report on other impact-related datasets like drought, flooding, severe storm events, or wildfire risk. Hence, for NEVERMORE, there is the opportunity to relate meteorological changes to other impacts and causes.
- Another opportunity is that it might be beneficial, from a visual perspective, to explore additional ways to compare two or more scenarios, such as including ways to juxtapose or superimpose related charts and maps for exploratory/decision-making purposes.
- About the interface, to enable collaboration and personalisation, it is suggested constantly to provide the functionality for sharing the current configuration so that it can be shared or embedded and work as a starting point for a discussion, possibly somewhere else, such as on social media. Moreover, capturing static views from the CVT for exporting can help secondary presentation, i.e., if the tool is intended for press or to be printed physically, there should be functionalities to capture snapshot images.

### 4.5.2 Climate change portals

Several climate portals have been developed in recent years, and the amount of available information and data about climate change continues to increase rapidly (Swart et al., 2017).

Despite the growing number of climate portals, models and services, users often evaluate these as scarcely relevant or inefficient (Swart et al., 2017). Several interconnected factors hinder their effectiveness in driving the decision-making process on climate change, including:

- Challenges in engaging stakeholders effectively: even if the interdisciplinary dialogue is considered a key factor for the design of climate services, it is still hard to meet it. Key barriers range from the lack of institutionalised and early engagement to power dynamics among actors.
- Lack of a deep understanding of users, user and system requirements, and the context of the use of models, tools, services
- Scarce recognition of the diversity of users (e.g., policymakers, experts, non-specialists, niche user communities), each having different objectives and skills (Swart et al., 2017);
- Missing or limited process of localisation and customisation of climate information that can lead to lack of relevance for users (Sultan et al., 2020).

Other interesting contributions to improve the effectiveness and relevance of climate portal have been developed by Harold et al. (2017). They provide useful guidelines to increase the accessibility of graphics to non-experts and have also presented ten evidence-informed guidelines to help climate scientists share their knowledge. These ten guidelines can be summarised in

- Present only the visual information that is required for the communication goal at hand;

- Make critical visual features perceptually salient so that they 'capture' the attention of the viewer;
- Choose and design graphics informed by viewers' level of familiarity with graphs and domain knowledge;
- Include only information needed for the graphic and breakdown the graphic into visual 'chunks';
- Remove or reduce the need for spatial reasoning skills by showing inferences directly in the graphic;
- Identify the critical relationships in the data to communicate;
- Cognitive principles should inform decisions to create animated graphics;
- Match the visual representation of data to metaphors that aid conceptual thinking;
- Keep the graphic and accompanying text close together;
- Use text to help direct viewers' comprehension of the graphic.

## 4.6 Transversal user requirements

Transversal user requirements refer to the characteristics a digital solution should satisfy: to be useful and acceptable to users, considering different types of users, such as PAs, private companies, and citizens with different skills and ICT expertise.

The adoption of new technology is affected by many factors: usability is an essential factor, but other factors play a crucial role as well: accuracy, price, physical appearance, security, function, interoperability, and robustness are all independent factors affecting user acceptance (Kim, 2015). Users' adoption of new technology is particularly challenging in the case of innovative technologies, which typically exhibit some technical shortcomings. Moreover, different users will weigh criteria differently and might have different needs related to a digital solution's final acceptability and hence adoption.

For the design and development of the NEVERMORE Toolkit, different criteria should be considered (usability, usefulness and acceptability, trust and credibility, privacy) based on the diversity of users of the solutions: PAs, private entities, and citizens.

### 4.6.1 Usability

Usability is a key factor for users' engagement with technology that conveys complex concepts, such as the implications of climate change, or provides interactive visualisations of complex models and algorithms. It refers to the ease of access or use of a product or website. The official ISO 9241-11 definition of usability is: "the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use." A usable interface has three main outcomes:

- *Effectiveness*, i.e., the accuracy and completeness with which users achieve certain goals. Indicators of effectiveness include quality of solution and error rates.
- *Efficiency*, i.e., the relation between (1) the accuracy and completeness with which users achieve certain goals and (2) the resources expended in achieving them. Indicators of efficiency include task completion time and learning time.

- *Satisfaction*, i.e., the users' comfort with and positive attitudes towards the use of the system. Users' satisfaction can be measured by attitude rating scales.

Several principles for good usability have been proposed. We summarised usability principles developed by Nielsen and Molich (1990) in the following table:

**Table 5. Principles for good usability developed by Nielsen and Molich (1990)**

| USABILITY PRINCIPLES | DESCRIPTION |
|---|---|
| **Visibility of system status** | Users should always be informed of system operations with easy-to-understand and highly visible status displayed on the screen within a reasonable amount of time. |
| **Match between system and the real world** | Designers should endeavour to mirror the language and concepts users would find in the real world based on who their target users are. Presenting information in a logical order and piggybacking on users' expectations derived from their real-world experiences will reduce cognitive strain and make systems easier to use. |
| **User control and freedom** | Offer users a digital space where backward steps are possible, including undoing and redoing previous actions. |
| **Consistency and standards** | Interface designers should ensure that graphic elements and terminology are maintained across similar platforms. For example, an icon representing one category or concept should not represent a different concept when used on a different screen. |
| **Error prevention** | Whenever possible, design systems so that potential errors are minimised. Users do not like being called upon to detect and remedy problems, which may occasionally be beyond their level of expertise. Eliminating or flagging actions that may result in errors are two possible means of achieving error prevention. |
| **Recognition rather than recall** | Minimise cognitive load by maintaining task-relevant information within the display while users explore the interface. Human attention is limited, and we can only maintain around five items in our short-term memory at one time. Due to the limitations of short-term memory, designers should ensure users can simply employ recognition instead of recalling information across parts of the dialogue. Recognising something is always easier than recalling because recognition involves perceiving cues that help us reach into our vast memory and allow relevant information to surface. For example, we often find the format of multiple-choice questions easier than short answer questions on a test because it only requires us to recognise the answer rather than recall it from our memory. |
| **Flexibility and efficiency of use** | With increased use, the demand for fewer interactions that allow faster navigation comes. This can be achieved using abbreviations, function keys, hidden commands and macro facilities. Users should be able to customise or tailor the interface to suit their needs to perform frequent actions more conveniently. |

| | |
|---|---|
| **Aesthetic and minimalist design** | Help users recognise, diagnose and recover from errors. Designers should assume users are unable to understand technical terminology; therefore, error messages should almost always be expressed in plain language to ensure nothing gets lost in translation.<br>Keep clutter to a minimum. All unnecessary information competes for the user's limited attentional resources, which could inhibit the user's memory retrieval of relevant information. Therefore, the display must be reduced to only the necessary components for the current tasks whilst providing visible and unambiguous means of navigating to other content. |
| **Help and documentation** | Ideally, we want users to navigate the system without having to resort to documentation. However, depending on the type of solution, documentation may be necessary. When users require help, ensure it is easily located, specific to the task at hand and worded in a way that will guide them through the necessary steps towards a solution to the issue they are facing. |

### 4.6.2 Acceptability and usefulness

Acceptability is a broader concept than usability; it is a high-level concept involving complex social, organisational, and financial aspects (Kim, 2015). According to Shackel and Richardson (1991), users balance the following four factors when deciding to use a novel technology:

- *utility*: which is the match between user needs and functionality
- *usability*, which is the ability to utilise functionality in practice
- *likeability*: affective evaluation
- *costs*: both the financial costs and the social and organisational consequences of buying a product).

According to Hassenzahl (2005), both pragmatic and hedonic qualities should be considered in the design of new technology. Their combination leads to positive or negative emotions and consequently guides the acceptance of the new technology. Hedonic qualities consider the "pleasure of use" and emphasise stimulation, identification and evocation generated by using a system or a product. Other product features also play an important factor in the formation of user experience, such as users' characteristics, the context of use and use over time, and the interrelationship between user experience dimensions (Merčun and Žumer, 2017). Another important factor to consider is that the user's experience with a product develops and changes over time: learnability, novelty, and pleasure may be crucial initially, but they do not necessarily motivate prolonged use. In the long term, usability is valued more than hedonic features (Hassenzahl, 2005). Besides, these characteristics, and hence perceived usefulness and acceptability, strongly depend on the type of technology and its context of use: aesthetics and identification with a product may be the key components forming positive or negative user experience in some cases, while more utilitarian products might be more dependent on the quality of interaction, perceived usefulness, and engagement.

The acceptance Model - developed by Davis (1989) - is one of the most popular research models to predict information systems and technology use and acceptance. The model suggests that when users are presented with new technology, two factors influence their decision about how and when they will use it: i) perceived usefulness and ii) perceived ease of use.

- *Perceived usefulness* (PU) is the user's subjective probability that using a specific application system will enhance his or her job or live performance.
- *Perceived ease of use* (EOU) can be defined as the degree to which the prospective user expects the system to be free of effort.

Moreover, according to extensions of the TAM model (Venkatesh & Davis, 2000), attitude and intention to use are jointly influenced by perceived ease of use and usefulness. In this perspective, attitudes, as conceptualised by social psychology theory (Ajzen, 1991), have a mediating role not only in behavioural intentions but also in the acceptance and continued use of technology.

### 4.6.3 Trust and privacy

The NEVERMORE ICT Toolkit will store and manage different types of data, which may raise issues of online privacy and security (see Deliverable D6.1). Trust and privacy are key aspects that strongly impact user acceptance of a system. Information privacy addresses the legitimate collection, use and disclosure of personal information, as well as "the interest an individual has in controlling or at least significantly influencing the handling of data about themselves" (Lichtenstein et al., 2002). Hence, the NEVERMORE ICT Toolkit should guarantee that data provided by users for the legitimate functioning of the platform will be managed in a trusted way. Key aspects that should be considered concerning privacy and security are taken from previous studies in the field (Cavoukian, 2012; Lichtenstein et al., 2002) and summarised in the following table.

**Table 6. Key aspects to consider in relation to privacy and security (Cavoukian, 2012; Lichtenstein et al., 2002)**

| Online Privacy Policy Guideline Category | Description |
|---|---|
| **Awareness** | The site/portal should facilitate user awareness of its online privacy policy (e.g., appropriate language, notification, collection, the purpose of use, disclosure, and third-party involvement). Users should be aware of the type of private pieces of information required and the motivation behind collecting specific data. |
| **Data quality** | Personal information should be maintained as complete, timely and accurate by the company. |
| **Security** | Personal information should be secured wherever possible (data transmission, cookies). |
| **Information movement** | Details of personal privacy provided in various states of information movement should be provided to the user (e.g., aggregation, transfer, personalisation). |
| **User identification** | Use and disclosure of a user's site identifier as Personally Identifiable Information (PII), anonymous, or pseudonymous, should be stated |
| **Accountability** | Company and the user should be held accountable for actions |
| **User access** | Users should be able to access essential information related to their data and eventually modify their privacy setting. Users should have the opportunity to participate in their personal information protection if necessary |

| | |
|---|---|
| **Choice** | The user should be given choices about collecting and using their personal information. |
| **Children's Privacy** | The policy should provide information regarding access by, and involvement of, children. |
| **Sensitive information** | How sensitive information (e.g., religion) is treated differently from other information should be explained. |

# 5 Results of task 2.5 activities: socio-technical requirements

This section of the deliverable digests the knowledge described in the previous sections into a list of selected requirements directly relevant to the NEVERMORE project. It is conceived as a technical inventory to be used as a reference guide by project partners to inform development decisions.

In this section, we provide recommendations considering each tool developed in NEVERMORE, merging data collected through the top-down approach (literature analysis, web search, experts' recommendations), bottom-up approach (the Consultations and through the semi-structured interviews) and transversal user requirements.

We report in the following tables the list of socio-technical requirements and recommendations clustered around each tool that will be developed:

- *ID*: a unique identifier that can be used to refer to the recommendation quickly;
- *Name*: a title that concisely describes what the recommendation is about;
- *Description*: a precise explanation of what is required + *Motivation/rationale*: a justification for the requirement. It is essential to trace where the requirement comes from and why it is important for the NEVERMORE project.
- *Source*: where the information emerges from
    - Stakeholders:
        - CS1: Sitia
        - CS2: Trentino
        - CS3: Norrbotten
        - CS4: Murcia
        - CS5: Tulcea
    - Expert perspective
        - CMCC
        - CARTIF
        - RINA-C
    - Literature review: references
    - Best practices/examples: name of the tool (e.g., En-ROADS), website

## 5.1 Catalogue of policies

The requirements for this tool have been identified by the acronym "C", which stands for "Catalogue", and a number (01, 02, 03…).

| ID. C01 | Integrate cross-sectoral challenges and measures and synergies and trade-offs between measures into the catalogue |
|---|---|
| Description | The catalogue should go beyond a list of policies and include cross-sectorial measures, synergies, and trade-offs between different and potentially conflicting measures.<br>These choices impact how the catalogue will be designed and the policies visualised.<br>The integration of trade-offs could lead to a less linear catalogue representation. |
| Source | CMCC, CS5 |

| ID. C02 | Include the "scale" dimension in the catalogue: both the local and the global scales should be included |
|---|---|
| Description | Both experts and stakeholders expressed interest in having a catalogue that includes local and global policies. The catalogue may indicate the possible measures that can be implemented in a territory and advise on how to adapt a policy to the local specificities. Having both global and local scales represent a challenge for the design of the NEVERMORE catalogue, which should include interaction mechanisms to filter and browse policies and measures at different scales. |
| Source | CMCC, CS2, CS5 |

| ID. C03 | Include the quantification of the impact of measures |
|---|---|
| Description | Stakeholders have expressed interest in measuring the effectiveness of policies, which requires policies to be linked with relevant efficacy measures and supported by both qualitative and quantitative data. Additionally, there should be clear information on which indicators were used to evaluate the policy. |
| Source | CMCC, CS2, CS3 |

| ID. C04 | Support the catalogue navigation through challenges |
|---|---|
| Description | Connect the general challenges experienced by the 5 territories to policies and measures.<br>The catalogue navigation may start with the challenges - issues experienced by stakeholders - and support the user in finding related policies and solutions (like the navigation offered by Nature4Cities). |
| Source | CMCC |

| ID. C05 | Support a simple and smooth navigation through a large corpus (set) of policies |
|---|---|
| Description | Many policies will be included in the NEVERMORE catalogue, policies and measures across sectors at the local and global levels. This represents a challenge for the interactive tool, which should be designed to support the users in navigating this large amount of information. Concerns about the navigation of policies were also expressed by stakeholders when evaluating the EEA environment and climate policy evaluation database. Lack of time is a general issue for stakeholders when dealing with ICT tools. |
| Source | CMCC, CS2, CS4 |

| ID. C06 | Make information actionable, give advice on how policies can be practically implemented |
|---|---|
| Description | Make information directly actionable so that it is possible to act soon rather than reading many documents and data. Include information and recommendation about how policies can be implemented, incentivised, and adapted to a specific territorial area in the catalogue (e.g., how can a particular policy be applied? Which incentives may be used to make the policy effective? How can a policy be applied to a specific geographical area?). |
| Source | CS2, CS4 |

| ID. C07 | Support progressive refinement and deepening of information and data |
|---|---|
| Description | The catalogue should allow users to go through the information with different granularities according to their needs: from initial high-level information to fine-grained data. |
| Source | CS2 |

| ID. C08 | Use a simple and immediate language |
|---|---|
| Description | The catalogue should provide usable, synthetic, and immediate information using simple and direct language. |
| Source | CS2, CS4 |
| ID. C09 | Policies and interfaces should be in the local language |
| Description | To be usable and relevant all the information should be available in local languages. |
| Source | CS1, CS4 |

| ID. C10 | Allow decision-makers to add content (policies, best practices) |
|---|---|
| Description | Stakeholders can play an active role as creators of content. Allow stakeholders to add policies and best practices to the catalogue. |
| Source | CS1 |

| ID. C11 | Connect the policy catalogue and the global tool and local tool |
|---|---|
| Description | From the user perspective, it would be helpful to connect the catalogue with the global tool: when the user selects a policy from the catalogue, there is the possibility to read all the specifications and see the policy impacts on the interactive tool. |
| Source | CS2 |

| ID. C12 | Provide filters about the geographical and climatic areas of application of the policies |
|---|---|
| Description | Enrich searchability by adding a filter about the geographical and climatic areas of application of the policies. (e.g., in Trentino, they might be more interested in policies about mountain tourism or applied to mountain areas rather than generic ones). |
| Source | CS2 |

| ID. C13 | Consider the effects and impacts of combining multiple policies |
|---|---|
| Description | Allow visualising the effect of combining multiple policies. By selecting multiple filters simultaneously, it would be useful to see the effects of combinations of policies and thus evaluate potential synergies or trade-offs. |
| Source | CS3 |

| ID. C14 | To be comparable and adoptable by other PAs, policies must be classified meaningfully |
|---|---|
| Description | Many factors may affect the applicability of a policy. The comparability of policies and measures depends on municipality size and geographical similarity. Understanding what elements define the comparability of actions will also determine the columns of our catalogue of policies. |
| Source | CS3, CS4 |

| ID. C15 | Include information on how policies can be financed |
|---|---|
| Description | PAs may benefit from information about the funding opportunities for implementing A&M policies, such as European funding. |

| Source | CS5 |
|---|---|

## 5.2 EU scale tool

The requirements for the EU scale tool are very consistent: literature review and web search, and the interview with experts (CARTIF) clearly indicate that there is a well-established research field about interfaces for climate change models and integrated assessment models based on system dynamics. In general, the tools we introduced to the case study leaders during the interview were unfamiliar to them. As a result, the case study leaders found them promising but needed some time to explore and understand their functionalities. It is also worth mentioning that the distinction between the EU scale tool and the local case study tool is often hard to draw, and it is mainly about the intended geographic scope and broadness but, at least in theory, the same EU Scale tool can show policies and simulation of indicators at the local level.

The requirements for this tool have been identified by the acronym "EST", which stands for "EU-Scale Tool", and a number (01, 02, 03…).

| ID. EST01 | Show effects of policies in real time |
|---|---|
| Description | The interface should be responsive and provide feedback in real-time. As soon as the user chooses a policy or changes a parameter, the effects of these changes should appear in the web tool. Technically, if model simulations take more than a few milliseconds, their results should be precomputed, and all possible combinations should be kept cached. |
| Source | En-ROADS, C-Roads, Ecoesione. |

| ID. EST02 | Support users with different level of expertise and purposes |
|---|---|
| Description | All case study leaders suggested that the interface should be easy to understand and use. For example, the first time the system is used, there could be an onboarding experience conducting the user through the interface, explaining the details step by step following a simple example. All terms and portions of the interface should have a button (such as a question mark) which, if clicked or hovered, could explain what that specific section is about and how to interact with it.<br>It is important to accommodate different levels of familiarity and technical expertise for this particular topic, i.e., the tool should be helpful for experts and specialists but also for ordinary citizens. The onboarding and help texts might benefit average users, but experts should be able to reach the more powerful instruments hidden from the main interface in a few clicks.<br>This attention to experts and non-experts is also to be considered for the specificity of simulation models and modelling approaches, which are the key elements of the EU scale tool. When thinking about requirements, it might be helpful to keep in mind the users' purpose in consulting a model, i.e., differentiating between an exploratory purpose (associated with specialists with precise and advanced information and simulation needs) and an explanatory purpose (for curious citizens which might start wondering about climate change). |

| | |
|---|---|
| **Source** | All case study leaders, Harold et al. (2017), Lumley et al. (2022), Windhager et al. (2019), Swart et al. (2017). |

| **ID. EST03** | **Reduce technical language** |
|---|---|
| **Description** | It is important to accommodate citizens who are not experts in climate change (see previous requirement). From this perspective, the use of technical language should be reduced as much as possible. Technical explanations of complex scientific concepts should be included for users willing to deepen their understanding, for example, by clicking the "help"/"information" buttons. |
| **Source** | All case study leaders |

| **ID. EST04** | **Provide an easy way to specify policies and change simulation parameters** |
|---|---|
| **Description** | It is important to investigate the most effective and simple way to specify policies and/or change simulation parameters. The way in which this is done in En-ROADS and other tools was appreciated because it allows to see by default the status quo (Business as usual) and then change parameters by deviating from it, and seeing for each graph the line which corresponds to the status quo and the line corresponding to the changed scenario. Also interestingly, Ecoesione allows to create a scenario simply by switching on or off some already introduced policies. |
| **Source** | Ecoesione, En-ROADS, C-Roads, Locomotion model explorer, CS3. |

| **ID. EST05** | **Consider adding cost of policies** |
|---|---|
| **Description** | If there are no theoretical limits to the policies a user can activate through the interface, they could start playing and try to activate all the policies positively impacting climate change indicators, such as the mean global temperature increase. In this case, the use of the tool might become detached from reality: in the real world, many policies have economic or social costs; otherwise, policymakers would have adopted them without excitation. Adding the cost of policies and, for example, setting a finite amount of credits the user can “spend” on policies might be useful to make the user experience more realistic. |
| **Source** | CS2, CARTIF |

| **ID. EST06** | **Model also behaviour change along policies** |
|---|---|
| **Description** | Policies might be perceived as top-down, i.e., imposed by policymakers on citizens. On the other hand, changes in behaviour at the individual level could be perceived more as bottom-up, spinning from the choices of single citizens (even if they can be facilitated by implemented policies). In this regard, it is important to consider which behaviour changes |

| | |
|---|---|
| | will be modelled and how to present them to the users through the interface. This element of novelty is not present in most tools, with the notable exception of EUCalc. However, the EU-scale tool should present the effects of both policies and changes in behaviour so that stakeholders can find a correct balance between the two. |
| **Source** | EUCalc, Lumley et al. (2022) |

| **ID. EST07** | **Decide what is the most appropriate geographic level for the interface** |
|---|---|
| **Description** | Both policies and indicators can be specified at different geographical levels. It is possible to consider the entire world and policies applying to every nation and human being. For example, the iconic 1.5 degrees refers to an increase in the global average temperature with respect to pre-industrial levels, and it is a global indicator averaged over the entire world. However, case study leaders, and people in general, seem to relate more with local impacts and policies, such as their nation implementing a specific law whose goal is to reduce emissions. This is evident with En-ROADS, which is global, and C-Roads, which allows differentiating among 6 macro-regions of the world (it should be noted that creators of C-Roads, adding more complexity and customizability at the geographic level, decided to reduce the number of indicators that the user can change through the interface).<br>Adding more details at the geographic level will depend significantly on what the chosen integrated assessment model (WILIAM) will be able to compute soundly at the level of a single nation or more. If only information at the global level is computable, there will be no option to show information at a more detailed level. In fact, the smaller the scale is, the more difficult it is to compute simulations, and most tools stop at the level of the entire world or a few macro-regions. WILIAM can show the impacts of policies at the level of a single EU country. Still, it is to be pondered if this level of detail is compatible with a simple and usable interface. Moreover, we shall consider that the local case study tool might be able to explore specific aspects at the local level in detail. |
| **Source** | En-ROADS, C-Roads, Sultan et al. (2020). |

| **ID. EST08** | **Visualise the impact of policies** |
|---|---|
| **Description** | All tools devote a large part of the interface to show the effects of chosen policies on specific indicators such as “Greenhouse Gas Net Emissions”, “Global source of primary energy”, “GDP", or “temperature change”. These graphs have time on the x-axis (typically up to 2100) and an indicator on the y-axis. A careful choice needs to be made on the indicators to show by default because they convey the message about which indicators are more critical for reasoning about climate change and the impacts of policies. Also, a reflection on the number of graphs to show needs to be made. Ecoesione and EUCalc show only one chart at a time (which gives plenty of space to analyse it but does not allow easy comparison among indicators evolutions in time), while most tools show two graphs at a time. It is also possible to have default visualisations of many correlated indicators, e.g., Kaya graphs. If the indicators shown in the diagrams are many, grouping them into categories and subcategories is worth considering. As a side point, it should be noted that visualisation on maps is not proposed in similar tools and is considered inappropriate. |

| | |
|---|---|
| **Source** | Ecoesione, Locomotion model explorer, EUCalc, En-ROADS, C-roads, Lumley et al. (2022) |

| **ID. EST09** | **Support collaboration and discussion within the tool** |
|---|---|
| **Description** | To avoid enabling only single uses of the tool and considering that learning and behaviour change are more likely to happen when interacting with other people, it might be useful to provide some discussion mechanisms directly on the website, like a chat or means for rating and voting the scenarios created. |
| **Source** | Ecoesione |

| **ID. EST09** | **Enable exporting of what is created** |
|---|---|
| **Description** | Providing a feature to share/export/print/embed the created simulation in other web apps would be interesting. This feature would allow the primary users of the model to spread the effects of specific actions taken against climate change. It would work like conveying the following message: "If we do nothing, this will happen (status quo). Instead, if we implement XX policy, this will happen." This feature might be compelling if used on social media. In that case, EU-scale tool users could become agents of change with an impact on more people. According to case study leaders, these features would be helpful to policymakers too to show citizens the effects of planned or deployed policies. In this case, the aim is to gain public consent on policy implementation through the tool and the scientific evidence it can provide. |
| **Source** | Ecoesione, CS2, CS3, CS4, Lumley et al. (2022), Stephens et al. (2017) |

| **ID. EST10** | **Acknowledge uncertainty in simulations** |
|---|---|
| **Description** | Integrated assessment models, and predictions in general, carry much uncertainty. Informed guesses can be made, but it is not possible to ensure that a particular indicator will assume a specific value in 2100 if certain policies are implemented. It would be important to reflect this uncertainty in the transparency of the model. However, none of the tools analysed in this report explicitly show uncertainty in predicted values. They could do it, for example, by adding continuous error bands on top of visualisations. One reason could be that the usability and understandability of the model could decrease, so it is important to consider the trade-offs between acknowledging uncertainty and keeping the interface understandable. |
| **Source** | CS1, CS2, CARTIF, Roth et al. (2015). |

## 5.3 Case study tool

The requirements for the case study tool result from a synthesis between the experts' perspective on the tool, provided by RINA-C, and the needs and desiderata that emerged from the interviews with the

case study leaders. Since we had no individual tool to propose to the interviewees as a technological probe (Hutchinson et al., 2003), we based the interview discussions on stakeholders' experience working with data, information, scenarios, and visualisation tools at the local level.

At this stage of the NEVERMORE project, there is no agreement on the purpose and content of the Case Study Tool. Different opinions emerged through interviews with both the technical partner in charge of developing the tool (i.e., RINA-C) and the five case study leaders. Below the main functions envisioned for this tool are reported:

- Support policymakers making decisions through policy simulation visualisation to understand policies' impact in contrasting climate change effects in the local territory in the medium term (CS1, CS2, CS3, CS4);
- Customise the tool to the local specificities, such as local utilities, infrastructures, population (increasing vs decreasing), and simulation in sectors of interest (CS2, CS3, CS5);
- Show how individual choices impact the overall local population and how society impacts individuals (CS1);
- Foster citizens' behaviour and attitude change towards contrasting climate change effects (CS4);
- Support the participatory approach municipalities need to set up with citizens for the definition of SECAPs as well as the writing, updating, and evaluating process of such documents (CS4);
- Provide policymakers with an estimation of the economic loss potentially provoked by extreme events in each case study region based on the vulnerability of artificial assets (RINA-C).

This fragmented vision does not support a uniform and straightforward set of requirements. A compromise between the needs and the development capacity of the project needs to be reached before a more refined list of requirements can be elaborated. Here, we propose high level requirements which include different use cases for the Case Study Tool.

The requirements for this tool have been identified by the acronym "CST", which stands for "Case Study Tool", and a number (01, 02, 03…).

| **ID CST01** | **Allow communication between the WILIAM model for the EU level and the local model for the case study tool** |
|---|---|
| **Description** | One of the biggest challenges for the NEVERMORE project is understanding how to shift the impact calculations from the global model (developed by UVa and CARTIF) to the local one (developed by RINA-C). Even if impact analysis is calculated by two different models, users from the case studies should be able to switch between the EU and the local scales of climate change impacts within the same tool. |
| **Source** | RINA-C, CS2 |

| **ID CST02** | **Customise the tool to the local specificities of five case studies** |
|---|---|

| | |
|---|---|
| **Description** | Case studies participating in NEVERMORE differ from one another not only for climatic regions but also for size, population density, main productive sectors, sectors affected by climate change, etc. It will be essential for the Case Study tool to accommodate the various local specificities such as local utilities, infrastructures, population (increasing vs decreasing), and simulation in sectors of interest. |
| **Source** | NEVERMORE Grant Agreement, (CS2, CS3, CS5) |

| **ID CST03** | **Consider multiple and diverse users and customise content, language, and interface elements accordingly** |
|---|---|
| **Description** | The target users of the case study tool are not defined. Even within the same case study, users could be multiple and diverse. Currently, the tool has been conceived for policymakers (i.e., politicians), decisionmakers, citizens, researchers. For this reason, it is important to show different levels of information moving from simpler information to more complex and technical one.<br>For example, for policymakers, the tool should provide a policy simulation visualisation to understand policies' impact in contrasting climate change effects in the local territory in the medium term, and an estimation of the economic loss potentially provoked by extreme events in each case study region based on the vulnerability of artificial assets.<br>While for citizens, the tool could show how individual choices impact the overall local population and how society impacts individuals, and foster citizens' behaviour and attitude change towards contrasting climate change effects. |
| **Source** | RINA-C, all case studies leaders |

| **ID CST04** | **Represent data correlations visually, for example through graphs** |
|---|---|
| **Description** | An interface with visual representations allows an immediate understanding of the information. For an in-depth understanding multiple visualisations may be needed or the combination of visual and text should be considered. |
| **Source** | RINA-C, CS1 |

| **ID CST05** | **Visualise information based on the geographical area, e.g., using maps** |
|---|---|
| **Description** | Organising information on a geographical basis would be beneficial for the Case Study Tool for multiple reasons:<br>• Even at small scales territories are not homogeneous. Representing data clusters, intensities, frequencies, and other data relationships distributed on a map would enable a more detailed understanding of phenomena, enable further data correlations with local knowledge of the area, and make data more actionable.<br>• Maps can be navigated through coordinates which allow to be very precise in localising phenomena and events and are universally understood. |

| | |
|---|---|
| | • Case study leaders are interested in data at the city level. |
| **Source** | RINA-C, CS3 |

| **ID CST06** | **Optimise the integration between back-end (the local model) and front-end (interface) of the Case Study Tool** |
|---|---|
| **Description** | The back-end and front-end of the case study tool will be developed by two different partners. Before starting to work on any of the two parts, it is important that the two partners meet and discuss development languages used, work methodologies, expected challenges, and mutual support required. |
| **Source** | RINA-C |

| **ID CST07** | **Ensure tool sustainability in the long term through continuous data updates by certified users** |
|---|---|
| **Description** | Besides exploiting the tool to inform their decision-making processes, registered and certified users, such as PAs, could update data. Dataset enrichment by users could be achieved by providing different usage rights to the users, e.g., “visualise only” or “edit”. |
| **Source** | RINA-C |

| **ID CS08** | **Be transparent on the level of robustness and reliability of the simulations it provides** |
|---|---|
| **Description** | To be used as a basis to make informed decisions, models should be transparent about the level of reliability and robustness of their algorithms. |
| **Source** | CS2 |

## 5.4 Gamification tool

Several interesting application scenarios and ideas emerged from local stakeholders for the gamification tool. Such insights are reported in Section 4.5.3. Given the variety of inputs and suggestions gathered, it is not easy to generalise and identify precise requirements. For instance, some stakeholders suggested incorporating local policies and indicators specific to their geographical area in the games to make them more relevant. Conversely, other stakeholders considered it more important to familiarise students with global challenges. In the following tables, we report general requirements that emerged from analysing existing gamification tools (e.g., Crossroads) and literature analysis.

The requirements for the gamification tool have been identified by the acronym "G", which stands for "Gamification", and a number (01, 02, 03…).

| ID. G01 | Frame model simulations as games |
|---|---|
| Description | Crossroads 2 is a participatory simulation game that uses WILIAM model simulations to let players see the effects of choices the game asks participants to take. Similarly, En-ROADS and C-Roads have been used as interfaces to provide the science behind players' decisions. With this respect, gamification enables participants to benefit from solid and complex scientific models and knowledge while playing and having a fun experience. |
| Source | Crossroads2, En-ROADS, C-Roads |

| ID. G02 | Enable role playing, group playing and facilitation, also in presence |
|---|---|
| Description | It is important to provide a clear structure and narrative to the game, defining the simulated setting (i.e., the group is acting as the delegation of a country in a simulated emergency climate summit organised by the United Nations). It is also possible to think of assigning different roles to participants, for example, government, business, or civil society representatives, scientists, vulnerable groups, etc., so that each participant can bring a different perspective and generate a more diversified discussion.<br>It is advised to have a trained facilitator or moderator (which might have the role of the UN Secretary-General who has convened the summit) who leads participants throughout the experience.<br>The setting and the facilitator should also enable situations in which participants are physically present in the same venue (for example, pretending to be at the United Nations headquarters): in this case, only one interface is projected on a global, large screen, and the facilitator controls the interface, following decisions taken by the different groups. |
| Source | Crossroads2, En-ROADS, C-Roads |

| ID. G03 | Understand different audiences and participants background |
|---|---|
| Description | Various social, political and economic actors can benefit from game-based experiences. The authors suggest that the audience of game-based intervention in climate change can be enlarged through a user-centred design approach. Besides, more information on the participants' backgrounds is needed. Climate change is both a political and an environmental issue, and information about people's backgrounds, perceptions of climate change, and so on should be considered. |
| Source | Fernandez Galeote et al. (2021) |

| ID. G04 | Focus also on emerging and developing economies |
|---|---|
| Description | It is important to also consider emerging and developing economies when researching game-based interventions for climate change. As climate impacts are expected to significantly affect these regions, research efforts should be directed towards these areas and linked to locally relevant adaptation measures. |
| Source | Fernandez Galeote et al. (2021) |

| ID. G04 | Integrate game-based intervention with other interventions |
|---|---|
| Description | Serious games are more effective in driving cognitive learning results when they span multiple sessions and/or are combined with additional instructional methods. |
| Source | Fernandez Galeote et al. (2021) |

| ID. G04 | Consider gameplay length and complexity |
|---|---|

| | |
|---|---|
| **Description** | When developing game-based interventions for climate change, it is important to consider the gameplay length and complexity. Quick and simple games are useful for initiating conversations and establishing a basis for further engagement, while longer and more complex games can create deeper player engagement, challenge mental models, change behaviour, and catalyse action by enabling players to make climate change adaptation decisions despite uncertainty. |
| **Source** | Flood et al. (2018) |

| **ID. G04** | **Find a balance between scientifically optimal outcomes and those that decision makers find reasonable** |
|---|---|
| **Description** | "The game must be able to represent real and reasonable options reflecting the motivations, values, aspirations and considerations of decision makers on the ground". |
| **Source** | Flood et al. (2018) |

| **ID. G04** | **Focus on schools and students** |
|---|---|
| **Description** | The stakeholder suggests using gamification to target teachers and educators first, followed by young people between the ages of 12 and 18 and children under 18 years old with a more playful approach. |
| **Source** | CS1, CS5 |

## 5.5 Transversal requirements

In this section, we list requirements valid for all the tools considered. These requirements could be considered overarching principles that guide the development of the entire NEVERMORE ICT Toolkit.

These requirements have been identified by the acronym "TR", which stands for "Transversal Requirements", and a number (01, 02, 03…).

| **ID. TR01** | **Multiple languages** |
|---|---|
| **Description** | To increase accessibility and the inclusivity of the ICT toolkit, it is important that the tools are available in many different languages used by the users, i.e., consider that English is not a language every person is confident with. |
| **Source** | All Case Study Leaders |

| **ID. TR02** | **Make data and information actionable** |
|---|---|
| **Description** | Encouraged users to action. Often web tools are informative about what could happen to the world or local region in case some policies are deployed, or some condition develops but often they lack to inform the user about what they can do to affect the world and conditions, i.e., change behaviour in some specific ways. |
| **Source** | CS4, Ferreira et al. (2021), Windhager et al. (2019) |

# Conclusions and open Challenges for the design and development of the NEVERMORE ICT toolkit

NEVERMORE aims to foster usability, relevance, and acceptability of climate change decision-support models and tools by leveraging participatory approaches, co-design techniques and interdisciplinary

knowledge exchange. D2.7. is meant to provide a first high-level list of socio-technical requirements that will be further specified in other Project Tasks, particularly in Task T7.1., T7.3. and T7.4. This list of socio-technical requirements will be further refined and specified, including all actors involved in the process (public administrations, citizens, technologists, companies, and third-sector organisations), according to an inclusive design perspective.

Our research (which followed a bottom-up and top-down approach) shows areas where requirements are consistent and well-defined, such as the catalogue of policies and the EU Scale tool. For other devices, particularly for the local-scale and gamification tools, requirements and desiderata are sometimes contradictory and do not indicate the features that should be implemented. Despite this, several examples of local-scale tools already in use and application scenarios have emerged from the interviews and consultations that can be taken into consideration to reflect on the role and future features of these tools.

Several interesting opportunities and challenges emerged that pave the way for an internal discussion among NEVERMORE partners:

- Overall, NEVERMORE deals with much information, data, and sources. Attention should be paid to selecting the most relevant information to be integrated into the ICT tools. Salient data, carefully selected and presented in an understandable and accessible manner, are prerequisites to allow stakeholders to make informed decisions and take appropriate actions.
- A simple, user-friendly, easy-to-understand and at the same time attractive interface should be provided to convey complex knowledge and simulation results to users. Basic usability principles should be followed (see section 4.6.2) to guarantee the acceptability and adoption of ICT solutions.
- Users with different skills and needs have been envisaged for the various tools (e.g., policymakers, experts, non-specialists, and niche user communities). Attention should be paid at the Project level to deciding the target of the different tools and designing the interface according to their objectives and skills (e.g., Should the local tool be accessible by XXX? Should the EU-scale tool be used also by XXX?).
- Several challenges have been identified in developing the Catalogue of Policies that significantly influence design choices for its user interface. In particular, the catalogue will not focus on a specific sector but will contain a large amount of data and information at both local and global scales and all the existing policies and measures related to the problem of adaptation and mitigation policies of climate change. Since lack of time to search for resources has been reported as a primary barrier for PAs to navigate interfaces with poor usability, a challenge for the interactive catalogue will be to support users in navigating this large amount of information meaningfully while minimising cognitive load.
- The requirements collected for the EU-scale tool are characterised by a high level of consistency supported by the availability of a well-established research field focused on interfaces for climate change models and integrated assessment models based on system dynamics. Some contradictory findings related to the EU-scale tool revolved around who the primary users of the tool are. Different perspectives were collected: while for most stakeholders interviewed, the primary users of the EU-scale tool are policymakers, some considered the tool meant for other users, such as experts in communication (to convey to the

public high-quality information related to climate change) and civil society (to better understand the impact of choices, etc).

- Currently, there is no shared vision of the purpose and content of the Case Study Tool. Different opinions emerged through interviews with the technical partner in charge of developing the tool (i.e., RINA-C) and the five case study leaders. While for the former, the tool should focus on risk calculation and predictions of damages caused by extreme natural events, the latter aims to see the effects of policies, as in a local version of the EU-Scale tool. A compromise between the needs and the development capacity of the project needs to be reached at the Project level before implementation tasks begin.
- Some challenges about the design of the EU-Scale and Local-scale tools are related to models. The stakeholders interviewed reported different levels of familiarity with models and modelling techniques. Apparently, the higher the level of understanding, the more scepticism toward the reliability of complex models involving large numbers of variables. Stakeholders with familiarity with models asked for transparency and explainability of the models rather than a "black box" approach (e.g., which assumptions are behind the model?).
- Furthermore, it is important to note that distinguishing between the EU scale tool and the local case study tool can be challenging. The primary differentiation lies in their intended geographic scope and overall comprehensiveness. However, in theory, the same EU scale tool has the potential to display policies and the simulation of indicators at the local level as well.

In conclusion, the requirements and desiderata provided in this deliverable are preliminary. They should be discussed at the Consortium level to address challenges that emerged, take decisions on contradictory aspects (e.g., the target users of the modelling tools), understand the feasibility of specific implementation choices and provide relevant inputs for task 7.1 and 7.2 for the implementation of the ICT architecture and data storage.

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# Annexes

## Annex I - Agenda for the First Consultation with Case Studies Leaders

**Table 7. Agenda for the first consultation with case study leaders**

| | |
|---|---|
| 09:00 - 09:15 (15 min) | Introduction to the workshop: purpose, topics, activities, timing. |
| | SPLIT in the 4 rooms |
| 09:15 - 09:45 (30 min) | Overview of the case study challenges, sectors, and priorities:<br>With the technical partners, you will go through the challenges of your territory that have been listed in the Grant Agreement and presented during the KoM and validate them and the sectors they affect.<br>Then, you will be asked to identify the priorities of your territory. |
| 09:45 - 10:15 (30 min) | For each priority of your territory, you will reflect on whether there are already existing policies and measures or not |
| 10:15 - 10:30 (15 min) | BREAK |
| 10:30 - 11:00 (30 min) | For each priority, reflect whether there are already existing policies and measures or not. |
| 11:00 - 11:45 (45 min) | Technology related to environmental change: what is already used, what could be useful, desiderata about the NEVERMORE tools. |
| 11:45 - 12:00 (15 min) | Wrap up:<br>● What topics do you imagine could be addressed with your local council?<br>● How could we (FBK) improve the consultation methodology with the remaining 4 case studies?<br>● Case studies will share the results of their consultations with the others during the next Case Study Meeting<br>● Among all the things we discussed today, what has been most relevant for you? |

# Annex II - Protocol for the Semi-Structured Interviews with Local Case studies

**Table 8. Dimensions explored in semi-structured interviews to collect socio-technical requirements**

| DIMENSIONS | QUESTIONS |
|---|---|
| **The regional situation regarding climate change**<br>Skip if the person was already involved in CS consultations | What are the most critical challenges in [case study region] concerning climate change and the environment?<br>How do these challenges differ from those at the national or EU levels? |
| **About the interviewee's job** (their role in the organisation) | What is your role at work?<br>For how long have you worked in this role?<br>How does climate change affect/pertain to your work? |
| **Information, data and decision-making** | EXISTING TOOLS AND PRACTICES RELATE TO CLIMATE DATA<br>• What **information/data** about climate change do you rely on for your work?<br>• For which **purposes** do you use this information? / Why is this information relevant to you? (explore decision-making/actions based on data...)<br>• Which **sources** do you use? (Where do you get the information/data you need from?)<br>• Are there any websites, dashboards, or other technological **tools** you refer to for monitoring climate change and operating in your job?<br>  ○ If yes, which ones?<br>  ○ If not, why? What barriers prevent you from using technology to get informed about climate change phenomena?<br>• Do you rely on information provided by other **colleagues**? e.g., do you get this information through reports written by others?<br>• How well are this information and data **accessible/understandable** for you?<br>PERCEIVED GAPS IN AVAILABLE TOOLS AND INFORMATION + EXPLORATION OF DESIDERATA<br>• Is there some information or tool you need but do not know where to find? If yes,<br>  ○ What kind of information or tool?<br>  ○ Why is this information or tool important to you?<br>[To ask only if the interviewee affirms to use no information about climate change]: How could climate change data be helpful for you? |
| Introduction to questions about **models** | Now, we will ask you about 3 types of technological tools that NEVERMORE will develop. First, I will ask some general questions, and then I will show you some examples.<br>The first tool is a web app that allows you to see how adopting different policies may affect climate change data, such as Co2 concentration, mean temperatures, etc. |

| | |
|---|---|
| Familiarity with **climate change models** (at both the global and local levels).<br><br>Desiderata:<br>● Forecasts vs evaluation of the effects of different decisions | <u>EXISTING TOOLS AND PRACTICES RELATE TO CLIMATE MODELS</u><br><br>● Do you use forecasts/predictions/simulation models about climate change in your work?<br>○ If yes,<br>i. What for purpose? (To understand future climate change developments or how climate policies might turn out too)?<br>ii. How?<br>iii. How is your experience?<br>iv. What do these models look like? Do they have some sort of interface?<br>○ If not,<br>i. Would any forecasts/predictions/simulations about climate change be useful in your work? Please, elaborate.<br>ii. What challenges do you perceive regarding using such models? What would you need to be able to use the model?<br><u>EXERCISE</u><br>● Provide the speaker with the opportunity to click on the link (https://en-roads.climateinteractive.org/scenario.html?v=23.2.1) and navigate the **En-Roads** interface, which is a Global tool. (Interviewees need to share their screen).<br>● Let them navigate it freely for a few minutes<br>● Give them a task connected to their work (e.g., "Let's assume we want to increase afforestation and see how Co2 emissions by source are going to change up to 2100").<br>● Discuss the navigation experience from the CONTENT perspective:<br>○ Was the information provided helpful? If not, what would it be?<br>● Discuss the navigation experience from the INTERACTION/UX/visualisation perspective:<br>○ Was information easy to find?<br>○ What would you need to be able to use the model? |
| Introduction to the questions about the **catalogue of policies** | Thank you, now we proceed with the second technological tool, a catalogue of policies. What is a policy? <Make 2 examples> A catalogue of policies is a website showing policies already created and implemented worldwide… |
| How would you use a **Catalogue of policies?** | ● How do policies affect your work?<br>○ For instance, do you contribute to creating new ones?<br>○ Or do you implement/apply existing ones?<br><br><u>Scenario 1: The interviewee is a policymaker</u><br>● When you are involved in defining a new policy, do you refer to other regional/national/European policies?<br>○ If yes, where do you find them?<br>○ If there is a database of policies, how does it look and work? |

| | |
|---|---|
| | ○ Is there any missing information that you would like to see there?<br>● When you need to implement a new policy, what information about similar policies would you like to have?<br><u>Scenario 2: The interviewee needs to know what policies are in use because they affect their work</u><br>● When you need to relate to a policy, do you refer to regional, national, or European ones?<br>○ Where do you find them?<br>○ If you know a database of policies, how does it look and work?<br>○ Is there any missing information that you would like to see there?<br><u>EXERCISE:</u><br>● Provide the speaker with the opportunity to click on the link (https://bit.ly/3wLwALT) and navigate the interface of the **Policy Evaluation tool** (interviewees need to share their screen)<br>● Let them navigate it freely for a few minutes/secs<br>● Give them a task connected to their work (e.g., for Sitia, find policies about floods)<br>● How would such a tool be useful for you?<br>● Discuss the navigation experience from the CONTENT point of view:<br>○ Is the information shown helpful? If yes, why?<br>○ If not, what would it be?<br>● Discuss the INTERACTION with the portal<br>○ Is the information easy to find? How can these types of catalogues be improved? |
| Introduction to questions about **gamification.** | Ok. Thank you. Now we proceed with the third tool. It will be a digital tool to sensitise people to climate change through playfulness and games. |
| How could playful digital technology sensitise to climate change? | ● We would like to explore ICT's opportunities to sensitise civil society to climate change.<br>● Where do you see opportunities for playfulness to sensitise to climate change about the **challenges** addressed in your case study or actions implemented to address climate change?<br>● How might ICT support this? |
| Demographic information about the interviewee | ● Affiliation to NEVERMORE/NEVERMORE case study<br>● Gender:<br>● Age: |

**Table 9. List of participants in the semi-structured interviews to collect socio-technical requirements**

| CASE STUDY | INTERVIEWER | DATE |
|---|---|---|
| **CS1 - Sitia** | Paolo Massa (FBK) | 09/05/2023 |
| **CS2 - Trentino** | Chiara Leonardi (FBK) | 18/04/2023 |

| | | |
|---|---|---|
| | Eleonora Mencarini (FBK) | 06/04/2023 |
| | Chiara Leonardi (FBK) | 16/03/2023 |
| **CS3 - Norrbotten** | Eleonora Mencarini (FBK) | 13/04/2023 |
| **CS4 - Murcia** | Paolo Massa (FBK) | 21/04/2023 |
| **CS5 - Tulcea** | Chiara Leonardi (FBK) | 04/05/2023 |

**Table 10. List of participants in the semi-structured interviews to collect socio-technical requirements**

| TOOL | TECHNICAL PARTNERS INTERVIEWED | INTERVIEWER | DATE |
|---|---|---|---|
| **Catalogue of policies** | CMCC | Chiara Leonardi (FBK) | 18/04/2023 |
| **EU-scale tool and Gamification tool** | CARTIF | Paolo Massa (FBK) | 21/04/2023 |
| **Case study tool** | RINA-C | Eleonora Mencarini (FBK) | 17/04/2023 |


## Contacts

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