



INNOVATION MANAGEMENT PLAN V2

ClimEmpower Work Package 6, D6.7, v2.0



Project ClimEmpower: User Driven Climate Applications Empowering Regional Resilience

Work package 6, Deliverable D6.7

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15/08/2026	Initial draft	Molina, P. (AQUATEC), Villanueva, A. (AQUATEC)	Worked and updated the first draft of the deliverable, based on annotations and internal meetings.
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List of Acronyms

AI/ML	Artificial Intelligence/Machine Learning
AIT	Austrian Institute of Technology
ANDALUS	Consejería de Sostenibilidad, Medio ambiente y Economía Azul
ANET	Anaptixiaki eteria kinotiton periochis troodoys ltd
AQUA	AQUATEC, Proyectos para la gestión del agua
BINGO	Bringing INnovation to onGOing water management (H2020 program, Grant agreement ID: 641739, 2015-2019; https://cordis.europa.eu/project/id/641739)
C3S CDS	Copernicus C3S Climate Data Store
CC	Climate Change
CCI	Commision for Climatology
CDS	Climate Data Store
CERTH	Ethniko kentro erevnas kai technologikis anaptyxis
CET	CETAQUA
CIC	Climate interaction context
CLARITY	Integrated Climate Adaptation Service Tools for Improving Resilience Measure Efficiency (H2020 program, grant agreement ID: 730355, 2017-2020; https://cordis.europa.eu/project/id/730355)
CLIMAAX	CLIMAAX - CLIMAt risk and vulnerability Assessment framework and toolbox (HORIZON-MISS-2021-CLIMA-02-01, Grant agreement ID: 101093864, 2023-2026; https://cordis.europa.eu/project/id/101093864)
CLIVAR	Climate Variability and Predictability - Component of the World Climate Research Programme (WCRP)
CoP	Community of Practice
CSF	Case Study Facilitators
DoA	Description of Action
DOI	Digital Object Identifier
DRIVER+	DRIVER+ project - DRiving InnoVation in crisis management for European Resilience, 2014-2020 (FR7 programme, Grant agreement ID: 607798, 2014-2020; https://www.driver-project.eu/driver-project/)
ECMWF	European Center for Medium-Range Weather Forecast
EO	Expected Outcomes
ESPRESSO	ESPRESSO project - Enhancing Synergies for disaster PREvention in the EurOpean Union (H2020 program, Grant agreement ID: 700342, 2016-2018; https://cordis.europa.eu/project/id/700342)
EU	European Union
EU-CIRCLE	A panEuropean framework for strengthening Critical Infrastructure resilience to climate change (H2020 program, Grant agreement ID: 653824, 2015-2018; https://cordis.europa.eu/project/id/653824)

ET	Expert Team
FAIR	Findable, Accessible, Interoperable and Reusable
FER	Sveučilišta u Zagrebu Fakultet elektrotehnike i računarstva
FRC	Frederick Research Center
GA	Grant Agreement
GDP/capita	Gross Domestic Product per capita
ICARIA	ICARIA - Improving ClimAte Resilience of crltical Assets (HORIZON-MISS-2021 program, Grant agreement ID: 101093806, 2023-2025; https://cordis.europa.eu/project/id/101093806)
IP	Impact Pathways
IPCC	Intergovernmental Panel on Climate Change
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
KISS	Keep it Short and Simple
KNOWING	Framework for defining climate mitigation pathways based on understanding and integrated assessment of climate impacts. Adaptation strategies and societal transformation (HORIZON-CL5-2021 program, GA project: 1011056841, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999999999/project/101056841/program/43108390/details)
KPI	Key Performance Indicators
MAIA	Maximising impact and accessibility of European climate research (HE Coordination Action)
MUs	Mission Users
OBZ	Osijek-Baranja County (Osječko-baranjska županija)
OBZ-AZP	Public Institution Agency for the Management of Protected Natural Values in the Area of Osijek-Baranja County (Javna ustanova Agencija za upravljanje zaštićenim prirodnim vrijednostima na području Osječko-baranjske županije)
PLINIVS	P.LIN.I.V.S. - Centro Studi per l'Ingegneria Vulcanica Sismica e Idrogeologica
PSTE	Region of Central Greece
RAs	Regional Authorities
RESCCUE	Resilient Cities facing Climate Change (H2020 program, Grant Agreement 70017, 2016 – 2020)
RES-TEC	Technical Results
RES-SCI	Scientific Results
RES-SOC	Societal Results
SICILY	Sicily Region
SMART	Specific, Measurable, Achievable, Relevant and Time-Bound
SO	Strategic Objectives
SOTA	State Of The Art
SSO	Specific Subobjectives
SyGMA	Grant Management System
TROODOS	Troodos Mountain Range in Cyprus

TSCC	Technical, scientific and cross-cutting
URI	Uniform Resource Identifier
WCRP	World Climate Research Programme
WP	Work Package

Glossary

Climate impacts	The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure (based on IPCC, 2018).
Climate risk	Climate risk is the potential for climate change to create adverse consequences for human or physical and ecological systems.
Climate Service	A climate service is the provision of climate information and tools to help end-users make climate smart decisions.
Community of Practice	Group of people who share a common interest or concern for a specific activity, practice or topic who engage in a process of collective learning within a shared domain by supporting each other and exchanging information through collaborative activities.
Exposure	Exposure is the situation of people, infrastructure, housing, production capacities and other tangible and intangible assets located in hazard-prone areas.
Hazard	Hazards have the potential to cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation.
Stakeholder	A person with an interest or concern in something
Vulnerability	Vulnerability refers to the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards.

Executive summary

This deliverable captures the innovation potential of ClimEmpower's outcomes at the project end – their scientific, societal and technological maturity and innovation potential. Presented innovative results are grouped according to the six Specific Objectives of the project:

- SO1 Understand regional background, challenges and expectation (WP1, societal)
- SO2 Addressing the gaps in availability and usability of CC data and services (WP2 and WP4, scientific)
- SO3 Identification, definition, estimating, and communication of climate impact/resilience indicators suitable for local end-users (WP2 and WP4, scientific)
- SO4 Simplify access to CC data and development of end user applications (WP3, technological)
- SO5 Empower the regions to activate and enhance their potential for addressing the climate change challenge. (WP4, societal)
- SO6 Ensure the use and impact of the ClimEmpower outputs (WP4 and WP5, scientific and societal)

Key innovative results of the project are documented on <https://climempower.eu/> and include:

- **Establishing Communities of Practice (CoPs, RES-SOC1):** Fosters stakeholder collaboration as one of the core results of the project. CoPs provide a platform for activating regional know-how, making decision-making more transparent, and allowing R&D partners to gain deep insights into the regional context. CoP members participate in the co-design process and validate outputs through trials and mini-trials to co-create "societally just" regional recommendations (RES-SOC2) that prioritize vulnerable, less affluent populations.
- **Addressing data gaps and developing methodologies to bridge them** (RES-SCI1, RES-SCI2): Focuses not only on data collection in terms of services, datasets, and indicators, but also on fostering a better understanding of them and creating high-resolution hazard downscaling tools (such as Sentinel-2 downscaling and social sensing crawlers) tailored to regional needs.
- **Development of a hybrid, data-driven platform** (RES-TEC3, RES-TEC4): Provides a modular, non-programming Web-GUI "mashup platform" pre-configured for five regional decision-support environments, powered by a robust backend integrating ECMWF's feature extraction library (RES-TEC1), AIT's indicators database service, and reusable Jupyter notebooks and Python scripts (RES-TEC2).
- **Leveraging indicator fact sheets, policy recommendation letters, and educational materials** (D4.2, D4.4): Transfers knowledge, fosters stakeholder engagement, and supports informed, long-term policy decisions. This is exemplified by actionable policy briefs like PL_48 (strengthening agri-food supply chains) to translate scientific findings into direct guidance for public administrations.
- **Raising awareness** through communication and strategic licensing: Ensures innovations reach a wide audience. While results are openly published, they are strategically protected under a Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) license where appropriate. This prevents third-party commercial exploitation of public assets while safeguarding the partners' rights to use their respective tools in consulting and teaching.

The deliverable also incorporates a risk and barriers assessment to identify potential challenges affecting the uptake and replicability of key innovations.

1 ClimEmpower project summary

ClimEmpower is a Horizon Europe collaborative research project dedicated to addressing the ongoing Climate Crisis in Europe by empowering the regional stakeholders in some of the most vulnerable European regions (Figure 1).

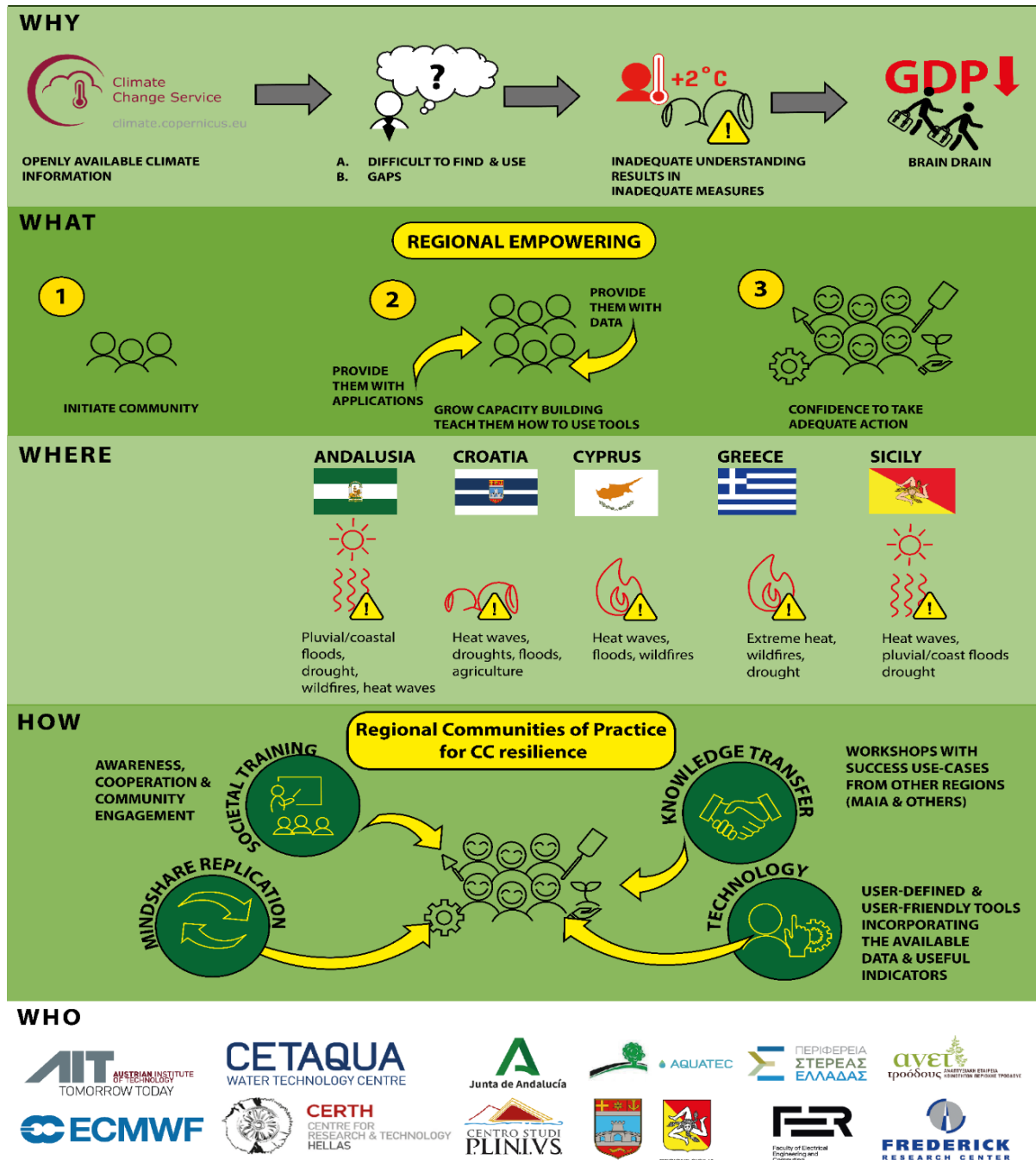


Figure 1: ClimEmpower at a glance: why, what, where, how and who.

1.1 Project Context

Climate risks results from a combination of a hazard, exposure, and vulnerability. Addressing all three aspects is crucial for effective increase of regional resilience. However, exposure, vulnerability, and related aspects, such as adaptive capacity, strongly depend on available knowledge and climate literacy. Consequently, global climate crisis frequently has a higher impact on socioeconomically vulnerable regions, thanks to a higher human and economic potential for addressing the issue in more affluent regions. To maximize its impact, ClimEmpower has therefore chosen to address the EU regions featuring a combination of high potential CC impacts and low and/or stagnant regional GDP/capita. This is mainly the case for regions in South and Southeast Europe (Figure 2).

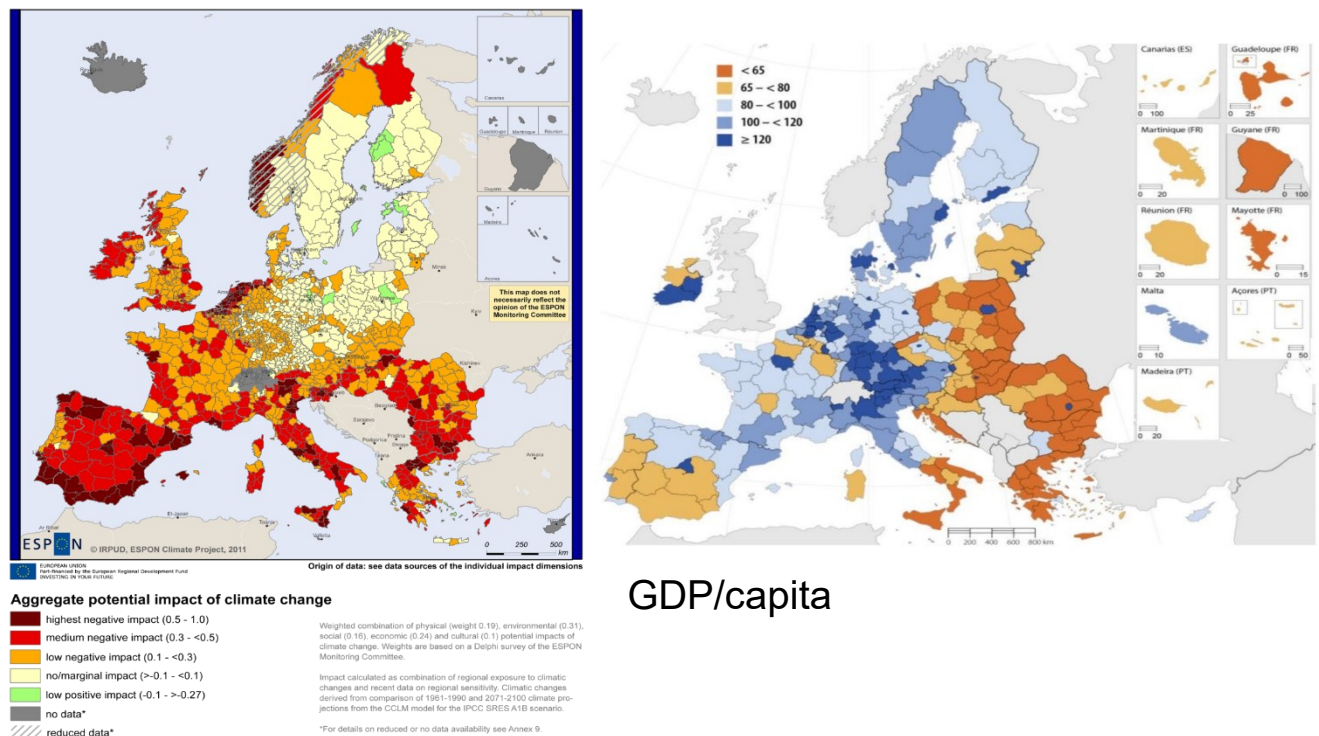


Figure 2 Aggregated potential impact of climate change (<https://www.espon.eu/climate-2012>); **GDP/capita** (from <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210303-1>).

The context the project addresses is thus one of an ongoing global warming, high regional vulnerability and low coping capacity of the participating regions, and the **overarching strategic objective of ClimEmpower** is to empower the Regional Authorities (RAs) and other Mission Users (MUs) in five EU-regions featuring a combination of exceptionally high climate hazards and exceptionally low coping capacity by improving their collective understanding of the Climate Change (CC) hazards, risks and resilient development pathways and supporting their knowledge-based regional planning and development through provision of relevant data, knowledge and user-defined and user-friendly decision support applications.

1.2 Project Objectives

To achieve this overarching goal, **ClimEmpower has identified six SMART¹ Strategic Objectives (SO)**, each one related to one or several work packages. The SOs have also been classified according to different categories: societal, contributing to improved dialogue, awareness, cooperation and community engagement as highlighted by the European Climate Pact (SO1, SO5); scientific, corresponding to research activities for advances beyond the state of the art (SO2, SO3); technological, suggesting and/or developing novel solutions, integrating state-of-the art and digital advances (SO4); and outreach, aimed at sharing ClimEmpower results to a broader scientific and non-scientific audience, including additional regions and communities, to maximize project impact (SO6).

- SO7 Understand regional background, challenges and expectation (WP1, societal)
- SO8 Addressing the gaps in availability and usability of CC data and services (WP2 and WP4, scientific)
- SO9 Identification, definition, estimating, and communication of climate impact/resilience indicators suitable for local end-users (WP2 and WP4, scientific)
- SO10 Simplify access to CC data and development of end user applications (WP3, technological)
- SO11 Empower the regions to activate and enhance their potential for addressing the climate change challenge. (WP4, societal)
- SO12 Ensure the use and impact of the ClimEmpower outputs (WP4 and WP5, scientific and societal)

ClimEmpower's key ambition is to **prove beyond doubt that CC-resilience should, and can, be an integral part of regional development everywhere in EU and beyond it**. That is, we anticipate that the regional stakeholders will recognise that CC-resilient development pathways offer multiple benefits to them, including but not limited to higher quality of life and reviving economy, and that these can be understood using available data, tools, and services. Second key ambition of the project is to **help the regions address the CC resilience in key community systems addressed in five ClimEmpower trials**.

Underlying philosophy of the project is to **"help the regions to help themselves"**. This will be achieved through various mechanisms, including co-creation and mediation of the regional **"Communities of Practice"**, provision of the **Climate Change -resilience training materials**, as well as in provision and training in use of the user-centric data and services – including those that have already been made available through previous research projects and EU initiatives.

¹ Specific (related to WPs), Measurable (by relevant KPIs), Achievable (the WPs in which they will be achieved are listed), Realistic (since they are referred and explained in the methodology section), and Timebound (each KPI is related to a deliverable and a month of achievement).

2 Introduction

2.1 Deliverable summary

This deliverable, part of WP6 - Project Coordination and Management, provides an overview of project results and their contribution to advancing project goals through innovation. It is a second and final version of the ClimEmpower's Innovation management plan and indicates the maturity and potential of the main project innovations at the project end.

2.2 Results and expected impacts

This deliverable presents a comprehensive overview of ClimEmpower's achievements, their innovation potential, and future pathways for outreach and sustainability beyond the project's end.

In this context, the Deliverables focuses on:

- **The Innovation Output Catalog:** Detailing and classifying the project's scientific, societal, and technological innovation outputs (Section 3 and Section 4).
- **Proof of Fulfillment of Strategic Objectives (SOs):** Providing a rigorous synthesis of the scientific, technical, and societal results achieved against each of the project's six specific objectives across all Work Packages (Section 5).
- **Retrospective Barriers, Lessons Learned, and Regional Impacts:** Evaluating real-world challenges encountered during co-creation and validation, alongside an analysis of regional socio-economic impacts and capacity-building outcomes (Section 6).
- **The Stakeholder Validation Framework:** Demonstrating how each technological, scientific, and societal result was tested, qualified, and validated through regional trials and Communities of Practice (Section 7.1).
- **Consolidated Exploitation and Licensing Strategy:** Establishing the final co-ownership pathways and strategic licensing configurations (including the CC BY-NC 4.0 framework) to ensure sustainable post-project replication (Section 7.2)

The main result of this work is a comprehensive, multi-dimensional assessment of ClimEmpower's social, scientific, and technological innovations. This deliverable systematically tracks their maturity and validation, identifying barriers and pathways to ensure their long-term sustainability, societal impact, and replication across European regions.

2.3 Relation to other work

This deliverable is an update of D6.6 Innovation management plan v1. It builds on the work carried out across the different Work Packages and deliverables, summarising the progress made and the innovation potential of the project's outputs. The main deliverables contributing to this update are the following:

- **D3.2 Reusable libraries and services for climate feature extraction, data processing and indicator building:** Outlining the underlying backend data services and feature extraction engines.
- **D4.2 Educational materials for increased regional CC resilience v2:** Providing the practical training portfolios, tutorials, and step-by-step exercises for replication.
- **D4.4 Regional CC-resilience recommendations v2:** Detailing the co-created, societally just recommendations and high-level policy recommendation letters.

- **D4.6 Community testing and validation report:** Synthesising the outcomes and stakeholder feedback from the five regional trials.
- **D4.8 Sustainability and exploitation plan v2:** Establishing the long-term regional sustainability plans, partner exploitation pathways, and IPR agreements.

2.4 Data, security, and ethics

2.4.1 Data interoperability

The tables of innovative outcomes produced in preparation of this deliverable are Excel files with “.xlsx” format that task and work package leaders collaboratively filled in. The required fields were designed in consultation with the project members. Accessing the tables requires Microsoft Excel or other software capable of displaying it.

2.4.2 Data accessibility and reuse:

In preparation of this document, previous project deliverables were extensively used, as they contain the primary outputs of ClimEmpower. The non-confidential deliverables are, or will be available on CORDIS after project review, and other outputs such as posters, presentations, and tables, are publicly available on Zenodo for broader accessibility.

Sensitive deliverables and outputs related to the Communities of Practice (CoPs) can contain confidential information about regional contexts or stakeholder data and are therefore restricted to the Consortium to ensure privacy and data protection.

All public deliverables of the project are either already available on CORDIS and on the project web site, or will be made available after the final review:

- CORDIS: <https://cordis.europa.eu/project/id/101112728/results>
- ClimEmpower site: <https://climempower.eu/results/>

Table 1: Data used in preparation of ClimEmpower deliverable D6.7

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
ClimEmpower Grant Agreement	PDF	5.2 MB	Sensitive	The Grant Agreement is a legally binding contract between the consortium and the European Commission. The document not public and available on SyGMA.	GA number 101112728
D1.2 scenarios	PDF	5 MB	Public	This document reports the ClimEmpower scenarios.	ClimEmpower D1.2
D2.2 Climate change resilience: indicators	PDF	4 MB	Public	This document analyses commonly applied climate, socio-economic and governance indicators	ClimEmpower D2.2
D2.3 Downscaling and data fusion for Climate Change resilience	PDF	5.2 MB	Public	This document defines a methodology for spatial data downscaling, social sensing and fusion of different data types	ClimEmpower D2.3

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
D2.4 Methodology of spatial data downscaling, social sensing and fusion of different data types	PDF	5.5 MB	Public	This document provides an overview of adaptation and mitigation measures and strategies, with anticipated impacts on indicators depicting CC-resilience, side effects and co-benefits	ClimEmpower D2.4
D3.2 Reusable libraries and services for climate feature extraction, data processing and indicator building	PDF	2.9 MB	Public	This document explains the different services, libraries and tools developed within ClimEmpower.	ClimEmpower D3.2.
D4.2 Educational materials for increased regional CC resilience v2	PDF	3.5 MB	Public	This document reports how and which were educational materials collected and produced by the project.	ClimEmpower D4.2
D4.4 Regional CC-resilience recommendations v2	PDF	5.9 MB	Public	This document presents the consensus reached through CoP activities in the form of generic and region-specific recommendations for decision makers in and beyond the five ClimEmpower regions.	ClimEmpower D4.4
D4.5 ClimEmpower application and trial specifications	PDF	2.5 MB	Public	This document contains ClimEmpower trial specifications, including the research questions, definitions of data gathering procedures and assessment criteria for technical and scientific tests to be conducted during the trial and for the community validation at the final trial workshop	ClimEmpower D4.5
D4.6 Community testing and validation report	PDF	1.8MB	Public	This document summarises the results of the regional trials and estimates the replication potential based on the exchanges and workshops with follower regions.	ClimEmpower D4.6
D4.8 ClimEmpower Sustainability and exploitation plan v2	PDF	4.8 MB	Sensitive	The document is not publicly available. It defines final regional sustainability strategies and exploitation plans for the outputs of the project.	ClimEmpower D4.8

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
D6.9 Data Management Plan v2	PDF	2 MB	Public	The document is available on project's website and CORDIS.	ClimEmpower D6.9
ICARIA D6.6 Innovation Management Plan	PDF	1.1 MB	Public	The document is available on project's website and CORDIS (link). It presents the methods to develop results beyond the state-of-art in the field of risk analysis and resilience assessment of critical assets.	ICARIA D6.6

Primary results of the work are tables of project outcomes, which are partially based on sensitive data. These tables will therefore not be made public. Instead, the summaries and insights derived from this data will be shared through this deliverable.

Table 2: Data produced in preparation of ClimEmpower deliverable D6.7

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
CE_Description and Exploitation Planning for Outputs	.xlsx		Sensitive (intended for project-internal use)	The document is available in the Project's document repository in the WP6 directory. Excel file containing the project outputs with its innovation potential.	N/A
ClimEmpower outputs summaries	PDF		Public	This PDF collects the most relevant outputs produced within the project and its potential utility and innovation. They summarize in one page each of the results in a visual way.	N/A

2.4.3 Security and Ethics

The work reported in this deliverable and the open data used or produced by the project are **not considered sensitive in terms of ethics or security**. All data collection involving human participants (e.g., surveys), in the whole project, was conducted in accordance with relevant EU and national legislation on data protection and research ethics. All project recommendations prioritise societal justice over protection of most valuable assets where appropriate.

Unlike D6.6 Innovation Management Plan v1, this document is designed to be public. Consequently, all potentially sensitive data relevant to this project have been removed from this document and included in D4.8 "Sustainability and exploitation plan v2"

3 Innovation Management Strategy

3.1 ClimEmpower specific subobjectives

ClimEmpower highly relies on innovation to address climate-related challenges by fostering new ideas and reaching new solutions. To guide this process, the project has identified six Strategic Objectives (SO) through the different work packages, classified according to four different categories:

- **Societal.** This include improving dialogue and engage citizens and local stakeholders in decision-making processes as highlighted by the European Climate Pact.
- **Scientific.** These objectives focus on advancing scientific knowledge and promote research activities that go beyond the state of the art.
- **Technological.** It focuses on providing technological advances and solutions by integrating the state of the art and innovative solutions.
- **Outreach.** Sharing the project's results with a broad audience to maximize project's impact, ensuring it reaches diverse audience and raises awareness.

The Table 3 summarises the six SOs of the project and indicates their classification.

Table 3: Strategic objectives

Number	Title	Category
SO1	Understand regional background, challenges, and expectations	Societal
SO2	Addressing the gaps in availability and usability of CC data and services	Scientific
SO3	Identification, definition, estimating, and communication of climate impact/resilience indicators suitable for local end-users	Scientific
SO4	Simplify access to CC data and development of end user applications	Technological
SO5	Empower the regions to activate and enhance their potential for addressing the climate change challenge	Societal
SO6	Ensure the use and impact of the ClimEmpower outputs	Outreach

3.2 Previous projects

Figure 3 provides an overview of former relevant EU projects and shows the tools, frameworks and methodologies developed that serve as background for ClimEmpower. Each of the projects include contributions from which ClimEmpower can innovate to address its specific challenges.

This way, ClimEmpower takes the “best practices” from former projects and fosters the re-use and improvement of the outcomes.



Figure 3: Previous EU-projects and outputs

3.3 ClimEmpower expected results

ClimEmpower anticipated to deliver relevant results through an integrated approach combining technical, scientific, and societal advancements. The expected results are categorized in three main areas: technical (RES-TEC, Table 4), scientific (RES-SCI, Table 5) and societal (RES-SOC, Table 6).

Table 4: Technical results

Technical Results (RES-TEC)	
RES-TEC1	Library and service implementing a feature extraction algorithm which allows extraction of CC data.
RES-TEC2	Climate data processing and indicator (micro)services required by ClimEmpower applications.
RES-TEC3	Web-GUI application components and GUI integration environment for user-centric applications.
RES-TEC4	DSS application prototypes to empower the regions.

Table 5: Scientific Results

Scientific Results (RES-SCI)	
RES-SCI1	Gap analysis of existing data and services, including availability and usability.
RES-SCI2	Methodology for overcoming the data gaps, including collection of local data and usage of ML/AI techniques.
RES-SCI3	Portfolio of training materials for enhanced CC-resilience, as well as training materials for the tools developed in the project.
RES-SCI4	CC risk and resilience indicators for local authorities to assess current and future risks as well as impact of measures.
RES-SCI5	Measures and strategies for increased Climate change resilience. Methodology for estimating the impacts of various measures and strategies on CC-resilience, including side-effects and co-benefits.

Table 6: Societal results

Societal Results (RES-SOC)	
RES-SOC1	Five regional CoPs to reach consensus on regional CC-resilient development.
RES-SOC2	Regional CC-resilience recommendations. Input for regional decision makers to be incorporated in regional development plans.
RES-SOC3	Community Validation. Results of trials in five ClimEmpower regions to ensure results meet the expectations of stakeholders.

3.3.1 Short-term outcomes

The short-term **expected outcomes (EO) of the project** focus on establishing a robust foundation for enhancing climate understanding, mobilizing stakeholders, and planning future pathways.

- **EO1.** Increased understanding of climate risks in case study regions. It will be achieved through the provision of training materials, available services and relevant datasets and indicators.
 - Related results: RES-SCI1, RES-SCI2, RES-SCI3, RES-SCI4, RES-SCI5

- Related objectives: SO1, SO2, SO3, SO4, SO5
- **EO2.** Mobilising support and engagement of local authorities, stakeholders, and citizens in case study regions. This will be achieved through CoPs to exchange CC knowledge from different sectors of society.
 - Related results: RES-SOC1
 - Related objectives: SO1, SO5
- **EO3.** Formulating a vision for climate resilient regional development in case study regions.
 - Related results: RES-SCI3, RES-SCI4, RES-SCI-5, RES-SOC2, RES-TEC4
 - Related objectives: SO1, SO5, SO6

3.3.2 Towards CC-resilient regions: the mid-term pathway

The mid-term pathway involves the transition from the initial groundwork to the continuation of the CoP activities beyond the project end and promoting the re-use of the results to enforce the project's impact.

- **EO4:** Continued operation of the CoPs after the project end.
 - Related results: RES-SCI3, RES-TEC4, RES-SOC1, RES-SOC2, RES-SOC3
 - Related objectives: SO5, SO6
- **EO5:** High Interest for replicating ClimEmpower results in follower regions and beyond. Follower regions will participate on regional COP workshops to learn about ClimEmpower and how to implement its results.
 - Related results: RES-SCI2, RES-SCI3, RES-SCI4, RES-SCI5, RES-TEC4, RES-SOC1, RES-SOC2
 - Related objectives: SO5, SO6
- **EO6.** ClimEmpower R&D results used and further developed by R&I community. Ensure that ClimEmpower results will be re-used and further developed in other R&I projects and eventually turn into commercial products.
 - Related results: RES-SCI2, RES-SCI3, RES-SCI4, RES-SCI5, RES-TEC4, RES-SOC1, RES-SOC2
 - Related objectives: SO2, SO3, SO4

3.3.3 Towards CC-resilient regions: the long-term pathway

ClimEmpower proposal aims to foster the resilience of EU regions and communities by providing practical knowledge about the potential impacts of climate related hazards, measures and strategies for improving the regional CC-resilience. This is achieved through development of training materials, models and services for mending the CC-resilience data and knowledge. The project has defined the following long-term objectives or **Impact Pathways (IP)**:

- **IP1.** Mobilise all actors, such as EU Member States, regional and local authorities, research institutes, investors and citizens to create real and lasting impact.
- **IP2.** Provide general support to European regions and communities (especially to less developed ones, with lower coping capacity) to better understand, prepare for and manage climate risks and opportunities. Accelerate transformations to climate resilience: cooperate with at least 150 regions and communities to accelerate their transformation to a climate resilient

future, supporting them in the co-creation of innovation pathways and testing of solutions.
Description of SSO and development beyond State of Art

- **IP3.** Demonstrate systemic transformations to climate resilience: deliver at least 75 large-scale demonstrations of systemic transformations to climate resilience across European regions and communities.
- **IP4.** Mission calls will foster the development of a balanced portfolio of solutions across the different climate risks and innovation areas, as identified in the Mission Implementation Plan and the different biogeographical regions, as defined by the EEA.

The following section provides a thorough description of each SSO together with the methods and tools that will contribute to their development and the tangible results expected in each case.

4 Summary of outputs and innovation potential

Error! Not a valid bookmark self-reference. presented a comprehensive overview of innovative project's outputs, along with their respective innovation potential. Each output has been assigned a numeric code (see first column) for easy reference throughout the document.

The table provides a summary of each output, highlighting its contribution to advancing the state of the art, format, and size, as well as the Work Package and task to which it belongs. This approach facilitates understanding of how the project's deliverables contribute to ClimEmpower objectives.

This table has been maintained throughout the project, used as input for ClimEmpower sustainability and exploitation planning in WP4, and used to tune the Dissemination, communication, and stakeholder's engagement activities in WP5.

Table 7 Innovation potential of ClimEmpower's outputs

CODE	Innovation type	Title	Summary	Justification of novelty	Prove nance	License /IPR	Unique ID
I01	Other (Scientific)	Knowledge hubs and educational materials	Knowledge hub integrating educational resources, AI-assisted knowledge access, and dissemination materials to facilitate the uptake and practical application of ClimEmpower results.	Innovative methodology for collecting, organising and disseminating educational resources through hazard–sector and user–dimension matrices. The Knowledge Hub has been expanded with educational materials describing the development and practical use of key ClimEmpower outputs. In addition, an AI-powered assistant trained on these resources facilitates interactive access to project knowledge. Public deliverables have also been transformed into accessible dissemination formats (e.g. presentations, videos, infographics, etc). Initial tests in cooperation with the MAIA CSA demonstrated the potential of Generative AI technologies to support and accelerate the organisation, analysis and dissemination of knowledge resources.	WP4, Task 4.1	Public	• ClimEmpower D4.1, • ClimEmpower D4.2 • 10.5281/zenodo.13944850 • https://climempower.eu/edu/

CODE	Innovation type	Title	Summary	Justification of novelty	Prove nance	License /IPR	Unique ID
I02	Presentation (Scientific)	ClimEmpower: Graphic summaries of CoP's key points	Graphic summaries with the main conclusions detected in the first CoP meetings in each region	Illustrations that were developed out of the first CoP meeting conclusions to be more understandable. It's a new format of presenting the inputs that will be used for the rest of WPs	WP1, Task 1.1	Public	10.5281/zenodo.13950188
I03	Other (Societal)	Community of Practice organisation and expectations	Deliverable with information from the regions	Stakeholders were reunited and the first CoP was held in the 5 regions to gather the information on the regions and their needs. Different innovative materials and methods such as questionnaires and interactive tools were used to engage stakeholders. All the information is collected in D1.1.	WP1, Task 1.1 and 1.2	Confidential	ClimEmpower D1.1 (not public)
I04	Other (Scientific)	Regional Climate Resilience Assessment of the ClimEmpower regions	Regional Climate Resilience Assessment (graphics and tables) according to 10 resilience components. It's part of D1.2.	A new methodology to evaluate climate resilience was applied in the 5 ClimEmpower regions, to provide an overview of the strengths and weaknesses regarding resilience in each region.	WP1, Task 1.3	Public	• ClimEmpower D1.2 • 10.5281/zenodo.1370245
I05	Other (Scientific)	Questions for regions	A template to assess the expectations of stakeholders regarding data services needs was provided to the regions. It is integrated in D1.2, and D2.1	It is a new way of categorizing service needs along two dimensions (customization and integration). It provides a structured yet flexible framework for evaluating and prioritizing project results. This method enables a comprehensive understanding of stakeholder expectations and allows the development of data services that align with their needs.	WP1, WP2, WP3, WP4	Public	ClimEmpower D1.2

CODE	Innovation type	Title	Summary	Justification of novelty	Prove nance	License /IPR	Unique ID
106	Other (Scientific)	Resilience Recommendation table	A table designed as a cross-referential matrix. It has columns that represent a taxonomy of possible interventions/action that could contribute to resilience. The rows are composed by different socio-economic, environmental and hazard components.	The matrix format allows for a comprehensive overview of the interplay between interventions and socio-economic, environmental, and hazard-related factors. The data at these intersections helps to inform and shape the broader resilience recommendations by illustrating how these efforts collectively contribute to overall resilience	WP4, Task 4.2	Public	Input for I17, published as part of the project's dissemination efforts.
107	Other (Scientific)	Combination of datasets for Regional Climate resilience	Integration of different datasets, indices, and methodological approach for susceptibility mapping in hazard identification	It is a more innovative approach in disaster management planning. The integration of data and methodological innovation indicates a tailored and adaptable approach applicable in any region according to their needs and their available data. The accuracy of susceptible mapping led to identification of vulnerable areas.	WP2, Task 2.2	Public	ClimEmpower D2.2
108	Other (Scientific)	S2 Data Downscaling	Downscaling S2 satellite images facilitating a multi layered analyses by combining optical data with other indices and historical data.	Downscaling data allows finer spatial resolution and localized hazard assessments by generated more detailed maps. Also improve data's utility and become an impressive tool for multi-scale analysis.	WP2, Task 2.2	Public	ClimEmpower D2.3
109	Other (Scientific & Technological)	Social Media Crawler	Collection of X's (former Tweets) provides crowdsourced insights in real time monitoring and offers an understanding of the impact for the community. Additionally social media posts are indicators for early hazard identification.	Social media is an important source information during natural hazards. Integration of Social media posts, Sentinel 2 images and susceptibility maps in hazard identification offers a comprehensive monitoring and real time validation for various hazards.	WP2, Task 2.2	Public	ClimEmpower D2.3

CODE	Innovation type	Title	Summary	Justification of novelty	Prove nance	License /IPR	Unique ID
I10	Software (Technological)	Polytope Data Access Software (RES-TEC1)	Software library and REST API for tailored access to Copernicus data for use in models	The library builds on the existing Copernicus data access APIs that only allow retrieval of global fields. This new library allows users to extract data specific to the region without the need for post-processing.	WP3 Task 3.1	Public	https://github.com/cmwf/polytope
I11	Other (Technological)	ClimEmpower application architecture	Modular implementation architecture for climate services and applications, designed with transparency, and reusability / transferability in mind.	ClimEmpower System architecture aims to facilitate rapid development of Climate Services and applications that are tailored to the needs of the regions / stakeholders. It provides a flexible and scalable framework that maximizes reuse of existing data, algorithms and software and facilitates transferability potential across ClimEmpower case study to other European regions.	WP3, Tasks 3.1, 3.2 and 3.3	Public	ClimEmpower D3.1
I12	Software (Technological)	Data processing and indicator services (RES-TEC2)	Set of reusable climate processing and indicator services.	This output combines provides an indicator database service with a highly practical framework of Python scripts and Jupyter notebooks (building on CLIMAAX) that automate regional risk mapping.	WP3, Task 3.2	Public	ClimEmpower D3.2
I13	Software (Technological)	Web-GUI components and integration environment (RES-TEC3)	Modular, reusable HTML5 frontend component library and backend integration environment	A versatile, modular mashup platform that can be pre-configured with region-specific datasets, allowing non-technical regional users to quickly set up customized decision-support interfaces without any programming knowledge	WP3, Task 3.3	Public	• ClimEmpower D3.2, • ClimEmpower D3.3
I14	Other (Societal)	Communities of Practice (RES-SOC1)	Five regional Communities of Practice (CoPs) bringing together diverse public, scientific, and civil stakeholders.	CoPs act as active, structured co-creation and feedback platforms. They bridge the gap between technical models and local planning needs, ensuring that stakeholder insights continuously inform the design of indicators, measures, and trial protocols	WP1, WP4	Public	• ClimEmpower D1.1 (confidential) • ClimEmpower D1.2, D4.2, D4.4, D4.6

CODE	Innovation type	Title	Summary	Justification of novelty	Prove nance	License /IPR	Unique ID
I15	Other (Societal)	Trials (RES-SOC3)	Methodological approach for testing and validating the innovative potential of sociotechnological solutions under real-world conditions	Adapts the "Trial Guidance Methodology" (originally from the DRIVER+ disaster management project) specifically to the climate change adaptation domain, establishing a systematic, repeatable framework for regional stakeholder validation.	WP4	Public	• ClimEmpower D4.5 • ClimEmpower D4.6
I16	Other (Scientific)	Measures and strategies for increased Climate change resilience (RES-SCI5)	An overview of scientific measures and strategies for increasing regional CC resilience	Integrates physical, socio-economic, and environmental risk dimensions to map out adaptation measures, which are qualitatively integrated into the DSS platform as step-by-step guidelines and translated into direct policy recommendations	Task 2.3	Public	• ClimEmpower D2.4 (pending review)
I17	Other (Societal)	Regional CC-resilience recommendations (RES-SOC2)	Consensus-driven strategic recommendations for climate-resilient and societally just regional development	Synthesizes CoP deliberations and regional trials into actionable planning guidance.	Task 4.2	Public	• ClimEmpower D4.3, • ClimEmpower D4.4
I18	Other (Technological)	Risk maps	Tailored multi-hazard risk maps developed using European and regional datasets, following the ClimEmpower and Andalusian methodologies.	The maps combine European datasets with stakeholder feedback and, in the Andalusian case, locally available data and regionally agreed weighting. The integrated assessment of pluvial and coastal flooding also provides an advance over existing regional risk mapping.	Task 3.2 Task 3.3 Task 3.4	Public	• ClimEmpower D3.2, • https://zenodo.org/records/21823904 • Maps available in project's platform
I19	Other (Technological)	Jupyter notebooks	Jupyter notebooks implementing the ClimEmpower risk mapping methodology, including data processing, combination of hazard, exposure and vulnerability datasets, and map generation.	The notebooks provide a reproducible implementation of the methodology that can be adapted to different regions and datasets, supporting the replication of the ClimEmpower approach.	Task 3.2 Task 3.3 Task 3.4	Public	ClimEmpower D3.2

CODE	Innovation type	Title	Summary	Justification of novelty	Prove nance	License /IPR	Unique ID
I20	Other (Societal)	Policy briefs (Policy recommendation letters)	Short, high-level policy recommendation briefs translating scientific project findings into direct guidance for policymakers	Bridges the gap between complex technical indicators and public administration, offering direct guidance on critical socio-economic vulnerabilities, such as strengthening local agri-food supply chains to mitigate food import dependency	WP4, Task 4.2	Public	ClimEmpower D4.4

4.1 Stakeholder validation mechanisms

Stakeholder engagement and validation are crucial not only for enhancing relevance and acceptance of innovation outputs, but also for ensuring long-term impact and usability. Mechanisms such as co-creation, user-feedback loops, and participatory design are repeatedly identified as enablers for bridging the gap between what is technically feasible and what end users actually need (Loureiro, Romero, & Bilro, 2020).

This is especially important in ClimEmpower project: innovations must be not only novel, but also acceptable and adaptable to the diverse contexts of case study regions. Therefore, each ClimEmpower innovative output undergoes a tailored validation process involving regional stakeholders from the five communities of practice.

The validation approach depends on the nature of each output:

- Knowledge-based and educational outputs (e.g. knowledge hubs, educational materials, recommendations) are reviewed through participatory feedback loops. Stakeholders in the CoPs assess their relevance, clarity, and usefulness, and refinements are incorporated in subsequent deliverables.
- Methodological outputs (e.g. resilience assessment frameworks, CoP structures, trials methodology) are validated first in expert consortium meetings and later through their practical application within the regions.
- Technological outputs (e.g. software tools, data services, APIs, GUIs) are validated through demonstrations, usability testing, and regional trials. Tutorials, prototype evaluations, and end-user feedback inform their continuous improvement.
- Cross-cutting outputs (e.g. integrated recommendations and composite tables) are validated through iterative discussions with stakeholders and experts, ensuring alignment between scientific, technical, and policy dimensions.

The Table 8 summarises the stakeholder validation mechanisms and current status for each innovative output.

Table 8. Stakeholder validation mechanism for each output

Output ID	Description of the output	Stakeholder validation mechanism	Validation status
I01	Knowledge hubs and educational materials	Presented and discussed during multiple Communities of Practice (CoPs), project trials and the mini-trial. Stakeholder feedback has been used to refine the organisation of the Knowledge Hubs and improve the educational materials. The mini-trial highlighted the need for more explanatory content on project results, leading to the development of dedicated reports describing the methodology, applications and practical use of the main ClimEmpower outputs.	Completed
I02	ClimEmpower: Graphic summaries of CoP's key points	Collected from stakeholders during CoP workshops using post-its, questionnaires, Mentimeter and open discussions. Validated by the Case Study Facilitators (CFS).	Completed

Output ID	Description of the output	Stakeholder validation mechanism	Validation status
I03	Community of Practice organisation and expectations	Functions as a validation mechanism itself through direct engagement of stakeholders. Expectations' information, in the first CoP, was collected through open discussion and workshops in the CoP.	Completed
I04	Regional Climate Resilience Assessment	Validated through extensive self-assessment processes completed by regional authorities across all five pilot regions, with results analyzed in D1.2 and published for open access on Zenodo.	Completed
I05	Questions for regions	Validated with regional representatives through a meeting and open discussion.	Completed
I06	Resilience Recommendation table	Validated through consortium meetings and the Communities of Practice (CoPs). The resilience recommendations were integrated into the final ClimEmpower platform and evaluated by regional stakeholders through dedicated surveys assessing their clarity, actionability and potential impact.	Completed
I07	Combination of datasets for Regional Climate resilience	The datasets and indicators were progressively validated and prioritised through the Communities of Practice (CoPs). Stakeholder feedback supported the selection of the most relevant datasets for integration into the ClimEmpower platform.	Completed
I08	S2 Data Downscaling	Validated externally by presenting the works in a conference and validated through CoPs during hands-on platform workshops.	Completed
I09	Social Media Crawler	Demonstrated and reviewed during regional CoP sessions and consortium meetings to gather feedback on event detection accuracy.	Completed
I10	Polytope Data Access Software (RES-TEC1)	Validated through extensive in-house laboratory testing (unit and integration tests) by ECMWF and AIT, and validated operationally through its successful integration as the core data-access and pre-processing backend within the ClimEmpower services.	Completed
I11	ClimEmpower application architecture	Integrated directly into the ClimEmpower platform, tested under laboratory conditions, and validated as a core structural component of the deployed end-to-end Decision Support System (DSS).	Completed
I12	Data processing and indicator services (RES-TEC2)	Validated through comprehensive backend integration testing and operational trial runs within the regional DSS configurations, where AIT's database-fetching services, Jupyter notebooks (AIT), and Python scripts (AQUATEC/CETAQUA) were successfully verified under trial conditions.	Completed (Partially Achieved)

Output ID	Description of the output	Stakeholder validation mechanism	Validation status
I13	Web-GUI components and integration environment (RES-TEC3)	Prototype demonstrated during the last two Communities of Practice (CoPs) to collect stakeholder feedback on the platform interface and functionality. This iterative co-design process guided the final platform's non-programming GUI-building features.	Completed
I14	Communities of Practice (RES-SOC1)	Continuous validation mechanism by nature; ensures co-creation and stakeholder ownership of outcomes. In some of the CoPs, questions about satisfaction with the event were answered by attendants.	Completed
I15	Trials (RES-SOC3)	Applied as the core methodological validation framework for testing and evaluating ClimEmpower's integrated technical and scientific solutions across the five regions.	Completed
I16	Measures and strategies for increased Climate change resilience (RES-SCI5)	Validated through qualitative integration into the DSS platform as interactive step-by-step guidelines and refined during regional consultation rounds with CoP members.	Completed
I17	Regional CC-resilience recommendations (RES-SOC2)	Validated through the CoP consensus process, incorporating feedback from all regional stakeholders. The final recommendations were integrated into the platform and evaluated by regional users via surveys assessing their actionability and policy relevance.	Completed
I18	Risk maps	Deployed under WP4 within the five regional DSS instances and validated during active trial runs by local civil protection and regional planning authorities.	Completed
I19	Jupyter notebooks	Validated through code testing, validation of risk map output algorithms, and hands-on developer workshops to ensure the replication workflows run successfully outside the core platform.	Completed
I20	Policy briefs (Policy recommendation letters)	Validated through direct review, presentation, and active deliberation within regional CoP workshops, ensuring that the actionable recommendations address local socio-economic vulnerabilities and meet regional policy requirements.	Completed

5 Description of SSOs and development beyond state of the art

Six strategic subobjectives have been established through the different work packages of the project. These SOs are designed to be SMART: Specific, Measurable, Achievable, Relevant and Time Bound, and they are categorized in societal, scientific, technological, and outreach.

The following points describe each SSO and how will they contribute to innovation within the project framework.

5.1 Innovation maturity and stakeholder validation framework

To ensure that ClimEmpower's innovations evolve consistently across scientific, societal and technological dimensions, a structured maturity tracking and stakeholder validation framework was established. The framework was designed to monitor the development, validation and exploitation potential of the project results throughout the project lifecycle.

Each exploitable result is assessed against five complementary evaluation dimensions, using a five-level scale from 1 to 5. The dimensions were defined through internal consensus among project partners and informed by recognised European assessment frameworks, including the Technology Readiness Levels (TRLs) and Societal Readiness Levels (SRLs). These frameworks were adapted and consolidated into a five-level scale to facilitate their application across the different types of results developed by ClimEmpower.

The five evaluation dimensions are:

- **Technical robustness:** assesses the technical maturity and reliability of results with a significant technical or digital component, from conceptual development to testing and operational deployment. This dimension is not applied to predominantly social results.
- **Scientific novelty and innovation:** assesses the degree of originality and innovation of the result in relation to the state of the art, from the adaptation of existing knowledge to methodological advances or demonstrated innovations.
- **Stakeholder validation:** assesses the level of stakeholder involvement, feedback and acceptance, ranging from initial interaction to testing, co-creation and potential integration into stakeholder practices.
- **Exploitation readiness and sustainability potential:** assesses the extent to which an exploitation pathway, responsible actors and continuation mechanisms have been identified, including both commercial and non-commercial exploitation.
- **Transferability and replicability:** assesses the potential for applying the result in other regions or contexts, considering its adaptability, dependence on local conditions and the effort required for replication.

The maturity of the results is considered across three complementary time horizons:

1. **Status at project start (before the project):** the initial maturity and readiness of the result, providing the baseline for assessing subsequent progress.

2. **Current status (at project completion):** the maturity, validation, exploitation readiness and transferability achieved by the end of the project.
3. **Expected post-project evolution (2–5 years after the project):** the anticipated development of the result beyond the project, considering further exploitation, uptake, replication and sustainability.

This approach allows the framework to capture not only the progress achieved during the project but also the expected pathway towards longer-term exploitation and impact.

In Figure 4, an example of the innovation maturity radar is presented, illustrating the evaluation of Risk maps.

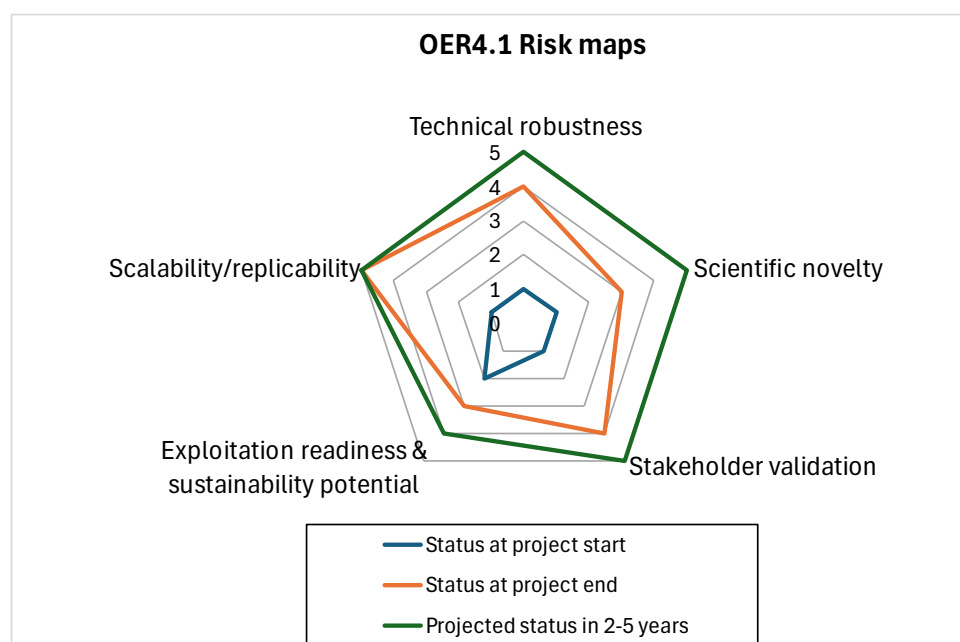


Figure 4 Example of maturity tracking system for OER4.1 – Risk maps

Stakeholder validation complements the maturity assessment. Feedback was collected through the Communities of Practice, regional trials, workshops, questionnaires and other participatory activities. This process provided evidence on the relevance, usability and applicability of the results from the perspective of regional and other end users.

The final maturity assessment and radar charts for the exploitable results are presented in the **Sustainability and Exploitation Plan**, where the scores and their evolution across the three assessment stages are analysed.

5.2 SO1.Understand regional background, challenges, and expectations

5.2.1 SO1 description

A Community of Practices (CoP) is a group of people who share a common interest or concern for a specific activity, practice or topic who engage in a process of collective learning within a shared domain by supporting each other and exchanging information through collaborative activities (Wenger-Trainer, 2022). Within ClimEmpower, five Regional Communities of Practice (CoPs) for climate-resilient development were established across the five project regions. The CoPs brought together regional stakeholders to develop a shared understanding of regional needs, capabilities, gaps and barriers

related to climate change resilience, and to identify priorities and opportunities for tailored, region-specific solutions. The knowledge and feedback gathered through this process were subsequently transferred to and integrated across the relevant Work Packages, supporting the co-creation, development and validation of ClimEmpower outputs.

5.2.2 Proof of fulfilment and integration of methodological knowledge

The fulfilment of SO1 is evidenced by the establishment and implementation of the Regional Communities of Practice and by the collection, structuring and transfer of the knowledge generated through these activities. The first CoP meetings were successfully organised and conducted in all five ClimEmpower regions, bringing together regional stakeholders to identify their needs, expectations, capabilities, gaps and barriers related to climate change resilience. This process is documented in Deliverable D1.1 and is coded in this deliverable as Innovation Output I03 Community of Practice organisation and expectations².

The knowledge gathered during the first CoP meetings was further structured and communicated through Innovation Output I02, *ClimEmpower: Graphic summaries of CoP key points*. These graphic summaries translated the main conclusions and regional inputs into an accessible format, facilitating their understanding and transfer to the subsequent project activities and Work Packages. The CoP process therefore provided not only a mechanism for stakeholder engagement, but also a structured approach for capturing and integrating regional knowledge into the development of ClimEmpower solutions.

The methodological knowledge generated through the CoP process was complemented by the regional resilience assessments (I04), which provided a structured analysis of the strengths, weaknesses, needs and opportunities identified in each region. These activities established the regional knowledge base that informed the subsequent development of ClimEmpower outputs to the contexts of the five regions.

1 ² Please refer to Summary of outputs and innovation potential

Error! Not a valid bookmark self-reference. presented a comprehensive overview of innovative project’s outputs, along with their respective innovation potential. Each output has been assigned a numeric code (see first column) for easy reference throughout the document.

The table provides a summary of each output, highlighting its contribution to advancing the state of the art, format, and size, as well as the Work Package and task to which it belongs. This approach facilitates understanding of how the project’s deliverables contribute to ClimEmpower objectives.

This table has been maintained throughout the project, used as input for ClimEmpower sustainability and exploitation planning in WP4, and used to tune the Dissemination, communication, and stakeholder’s engagement activities in WP5.

Table 7 and Table 8 for all Innovation Output definitions and Stakeholder validation mechanism.

5.2.3 Methods contributing to SO1

A key objective of the project has been the co-creation process with regional stakeholders. This involved significant efforts to understand the local context and expectations and to align project outcomes with regional needs.

The formation of a Community of Practice (CoP) to discuss CC-topics stands as an innovative element in ClimEmpower regions (I03). It was drawn on insights and successful practices from prior projects, such as BINGO (H2020 program, Grant ID: 641739, 2015-2019) and ESPREssO (H2020 program, Grant ID: 700342, 2016-2018).

Additionally, ClimEmpower reused the "Trial Guidance Methodology" (Fonio & Widera, 2020) from the DRIVER+ project (FR7 programme, Grant ID: 607798, 2014-2020), which has also been successfully applied by the same team in ICARIA (HORIZON-MISS-2021-CLIMA-02-03, Grant ID: 101093806), one of the sister projects of ClimEmpower. This methodology helps regions to understand new challenges, ways to tackle them and defines a validation pathway to ensure that the developed tools are relevant and applicable.

The CoP approach has been since the beginning planned and enhanced by the inclusion of the figure of the Case Study Facilitator (CSF), which plays a crucial role in maintaining oversight, informing WP leaders, and serving as a communication hub for CoP members. This system provided an innovative structure to support ongoing feedback and alignment with the project's evolving objectives.

The launch of the CoP was itself an innovative endeavour, with a detailed plan and a range of targeted materials created specifically to support effective initial engagement.

In addition, after gathering all the information from the CoPs, it was carried out a regional resilience assessment in each region (output I04), providing a comprehensive overview of the strengths and weaknesses of each region.

5.2.4 Specific results within SO1

In the following table, the status of this first objective, which has already been achieved in the first year of the project, is outlined. With a clear understanding of each region's background and expectations, the focus shifted to Work Package 4 to organize successive CoPs and develop a more detailed plan aimed at achieving CC-resilient solutions

Table 9: Status of expected specific results of SO1

Code	State	Objective	Description	Justification of novelty	Mechanisms of validation
RES-SOC1	 FINISHED	Communities of Practice for CC-resilient development.	The Communities of Practice (CoPs) were successfully launched across the five project regions, providing a collaborative space where stakeholders shared expertise, experiences, tools, and resources relevant to regional CC-resilience. A significant effort was also dedicated to ensuring that this information was effectively transferred to the rest of the project across work packages to allow cohesion and integration of local insights	This output represents the creation of structured CoPs that integrate diverse stakeholders. CoPs in ClimEmpower act as active co-creation and feedback platforms, ensuring that local knowledge continuously informs the design and testing of tools and indicators. These CoPs combine societal engagement with scientific input and technological support, advancing beyond the state of the art observed in other projects. The inclusion of graphic summaries, the delivery of CoP reports and the use of interactive engagement tools further enhances engagement.	Validation through iterative CoP workshops, questionnaires for participants and feedback loops integrated with WPs 2–4.

The established Key Performance Indicators (KPIs) have been addressed through an approach that involves stakeholder engagement and a comprehensive regional analysis. The key performance indicators for this subobjectives and the actions taken to fulfil them are the following:

- KPI1.1 [D1.1, section on CoP statutes, m6]: This indicator required the definition of CoP statutes and problem statements, outlining the goals of the CoPs, identifying participating stakeholders, and establishing FAIR data governance and management mechanisms. It also entailed a baseline understanding of regional climate change adaptation (CCA) preparedness, needs, gaps, and barriers. To fulfil this KPI, CoP meetings were organized to gather input from stakeholders, resulting in a compilation of their needs and insights within deliverable D1.1.
- KPI1.2 [D1.2, m9]: This KPI focused on developing case study scenarios that reflect the project's ambitions, encompassing data, knowledge, organizational structures, preparedness plans, and support tools for CCA and mitigation. Deliverable D1.2. was developed to address this, incorporating ClimEmpower scenarios. It includes a detailed analysis of regional challenges and opportunities, along with a resilience assessment to establish the initial strengths and weaknesses of each region.

5.3 SO2. Addressing the gaps in availability and usability of CC data and services

5.3.1 SO2 description

TSCC partners will perform a gap-analysis of existing European datasets (e.g. climate, land-use, socio-economic...), and services (e.g. Copernicus data store, Climate-ADAPT...) with respect to their completeness, spatial and temporal resolution, availability and usability for non-expert local users. In combination with the experiences from the participating regions, gaps are identified with respect to availability, retrieving and interpretation of local information.

The identified gaps were addressed through a combination of methodological developments and capacity-building activities. These included the selection and integration of relevant datasets for regional climate resilience, the development of methodologies for downscaling and enriching European-scale datasets, the use of crowdsourced information for hazard monitoring, and the development of accessible educational and explanatory materials. The resulting knowledge and resources were integrated into the ClimEmpower platform to facilitate their understanding and practical use by regional stakeholders.

5.3.2 Proof of fulfilment and integration of methodological knowledge

The fulfilment of SO2 is demonstrated by the completion of Deliverable D2.1 (analysis of data and service gaps) and by the development and integration of solutions addressing the main limitations identified. The work resulted in a set of outputs covering dataset selection and prioritisation, methodological approaches for overcoming spatial and data availability gaps, hazard monitoring and risk assessment, and capacity building.

The main evidence of fulfilment includes the combination of datasets for regional climate resilience (I07), and the methodologies collected in Deliverable D2.3 for developing S2 Data Downscaling methodology (I08), the Social Media Crawler (I09) and the methodology for climate risk mapping (I18). These outputs address different aspects of the gaps identified during the project and have been developed in WP3 and incorporated into the ClimEmpower platform and/or the project workflows.

The objective was also addressed from a usability perspective. Educational and explanatory materials were developed for the main ClimEmpower outputs, providing information on their development, application and practical use. Together with the explanatory content integrated into the ClimEmpower platform, these resources facilitate access to and understanding of climate-related information by non-expert users.

The combination of these outputs provides evidence that the gaps identified at the beginning of the project were translated into concrete methodological developments, data resources and capacity-building solutions.

5.3.3 Methods contributing to SO2

The first step taken toward addressing gaps involved compiling an inventory of regional datasets and services as part of deliverable D2.2 (see output I07 in the table). This inventory covers the three key components of climate risk: hazard, exposure, and vulnerability. It provides a comprehensive overview of existing datasets, climate services, and any gaps relevant to climate resilience assessments, that in many cases were unknown among regions. These mapped datasets were also validated in CoPs with stakeholders, creating an innovative and collaborative approach to identify data gaps.

Additionally, each region received a targeted sheet that was included in a presentation outlining specific data gaps to address, separated by type, such as crowdsourcing needs, downscaling needs or other data gaps, and specifying the objective of this data to shape and tailor solutions like models. This approach also allows to monitor data availability. In certain cases, these gaps can be filled directly through engagement with stakeholders, fostering a collaborative approach, which contributes to enhancing regional data resources for climate resilience planning.

In addition to this, ClimEmpower implemented a novel approach to enhance disaster management planning by integrating diverse data sources and methods for hazard identification, as part of deliverable 2.3 (output I07), including downscaling the spatial resolution of Sentinel-2 satellite imagery in the regions, offering high-detail visual data that can be used for precise hazard assessments.

Additionally, the project gathered crowdsourced data for monitoring, calibration, and the development of integrated indicators (in detail in outputs I08 and I09). By combining these crowdsourced insights with satellite imagery, ClimEmpower provides a more comprehensive understanding of identified hazards.

To train stakeholders in the use of tools and enhance their knowledge, educational materials were carefully compiled. Initially, these materials were collected from “knowledge hubs”—platforms and websites that gather accessible resources. Subsequently, the hubs were reviewed, and relevant materials were summarized and restructured to ensure easier access (output I01). This approach enables the re-utilization of resources from diverse sources and previous projects while presenting them in an innovative format tailored to ClimEmpower’s objectives.

For this subobjective, the following Key Performance Indicators have been defined:

- *KPI2.1 (D2.1, m9):* Data and service Gaps. Availability, usability, and gaps in data sets and services. To achieve this, it has been compiled an inventory of datasets and services covering hazard, exposure and vulnerability. Data gaps and limitations were identified and subsequently discussed, reviewed and prioritised with regional stakeholders through the CoPs.
- *KPI2.2 (D2.3, m15):* Methodology for overcoming the data gaps, by means of spatial data downscaling, social sensing and fusion of different data types. With the aim of monitoring and indicator development, it has been taken into account the downscaled sentinel-2 imagery for hazard assessment, and it has been incorporated crowdsourcing data.
- *KPI2.3 (D4.1, m12; D4.2, m30).* Educational materials for increased regional CC literacy and effective use of available data, applications and services successfully developed (50% for D4.1,

100% when D4.2 delivered). Educational resources were compiled and reorganised from existing “knowledge hubs” and other sources and were complemented with new materials explaining the development, application and practical use of the main ClimEmpower outputs. The materials were further refined throughout the project based on stakeholder feedback and integrated into the ClimEmpower knowledge resources and platform.

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5.3.4 Specific results achieved within SO2

The table outlines the status of the specific results included in this sub-objective. The gap service analysis, the methodology for addressing data gaps and a compilation of the training materials have already been achieved.

Table 10: Status of expected specific results of SO2

Code	State	Objective	Description	Justification of novelty	Mechanisms of validation
RES-SCI1	✓ FINISHED	Gap analysis of existing data and services	A comprehensive analysis was conducted across the regions, supported by CoP validation. One key conclusion from the gap analysis is the general scarcity of vulnerability data, highlighting a critical area for further development.	The novelty lies in integrating diverse data sources and stakeholder insights to systematically identify data and service gaps related to climate resilience. Unlike previous projects, this analysis does not only review available datasets but also connects the technical limitations with societal needs.	Validation through iterative consultations with regional representatives and CSF, ensuring that identified gaps reflect real user needs. Results were cross-checked through CoPs discussions and internal review among WP teams.
RES-SCI2	✓ FINISHED	Methodology for overcoming the data gaps	Achieved through release of D2.3; This document contains methodology to overcome data gaps, based on statistics, IA/ML methods, etc.	This methodology goes beyond traditional interpolation or empirical estimation techniques by introducing machine learning models that adapt to regional. It represents a methodological advancement over the state of the art in vulnerability and hazard mapping.	Feedback from regional experts and the CoPs used to refine performance and ensure practical usability. Final validation will be performed through trials.
RES-SCI3	✓ FINISHED	Portfolio of training materials for enhanced CC resilience	Related deliverables compile existing easy to use training and educational materials and aims to support the regional stakeholders in improving the knowledge on hazard, risk and potential adaptation and mitigation actions through self-study and group exercises.	The novelty stems from combining scientific outputs (data, models, indicators) with capacity-building tools tailored to local users. This portfolio is linked to project results (datasets, maps, CoPs outcomes), fostering science-to-practice transfer.	Feedback was collected from regional CoPs, regional partners and CSF. Improvements and additional materials were co-created during trials to ensure sustained applicability.

5.4 SO3.-Identification, definition, estimating, and communication of climate impact/resilience indicators suitable for local end-users

5.4.1 SO3 description

TSCC partners will analyse the available climate change and impact indicators, their suitability to describe CC related risks and their usability for local authorities and other end-users. A common set of indicators linking climate hazards with socio-economic impacts is set-up, tested and validated for the participating regions. In addition, indicators representing climate resilience were analysed by combining different datasets and dimensions of resilience, including physical, socio-economic and governance aspects. The relevance of adaptation and mitigation measures and their potential effects on regional resilience were also assessed, with the aim of supporting the identification and communication of suitable resilience actions for local end-users.

5.4.2 Proof of fulfilment and integration of methodological knowledge

The fulfilment of SO3 is demonstrated by the identification, assessment and regional validation of climate risk and resilience indicators, together with their integration into the ClimEmpower platform and their connection to resilience measures, recommendations and practical guidance for local end-users.

A comprehensive review of existing climate, impact, socio-economic and governance indicators was conducted to identify those most relevant to the needs and challenges of the five participating regions. Results and analysis are collected in deliverable D2.2.

The selected indicators are currently integrated into the ClimEmpower platform, where they are presented in connection with relevant resilience measures. A set of resilience recommendations (I06) and an overview of measures and strategies for increasing regional climate resilience (I07) were developed in this framework. The regional climate resilience recommendations (I17) further translated this knowledge into region-specific recommendations.

The platform also provides step-by-step information on the application of these measures, facilitating the interpretation of the indicators and their translation into practical resilience actions. The resilience measures and strategies are further documented in Deliverables D4.3 and D4.4.

In addition, policy briefs (described in D4.4) have been developed to further communicate the main findings and recommendations in an accessible format for decision-makers and other stakeholders. Together, these outputs demonstrate the integration of the methodological knowledge generated under SO3 into practical tools and communication resources supporting regional climate resilience.

5.4.3 Methods contributing to SO3

The same work as with climate datasets and services was performed to compile indicators from different sources (literature, regulations, previous European projects, among others) to create an ultimate “database” to facilitate tackle the regional challenges. This provides a comprehensive analysis of global wide and region-specific indicators.

The initial step involved conducting a literature review to evaluate the current state of indicators and determine the most effective design and application methods, tailored to each region’s unique context and challenges. Following this, relevant indicators were being carefully collected and selected to ensure alignment with regional needs. This task is part of output I07.

The selected indicators were subsequently presented and discussed during the Communities of Practice (CoPs) and through questionnaires addressed to regional representatives. Stakeholder

feedback was used to validate and prioritise the indicators and to assess their suitability and usability from the perspective of regional and local end-users.

The final indicators and related resilience measures were incorporated into the ClimEmpower platform. This provides a pathway from indicator-based assessment to the identification and implementation of potential resilience actions. Additional policy-oriented communication materials (policy briefs) were developed to facilitate the uptake of these results by decision-makers.

The Key Performance Indicators are outlined below:

- KPI3.1 (D2.2, m15): Summary of existing socio-economic, governance and climate (impact/risk/resilience) indicators covering the needs of all five regions (0-100%, max 20% per region if indicators fully cover the needs of D1.2 scenarios. A literature review was conducted to identify and assess existing indicators and to support their adaptation to the specific regional contexts. A comprehensive pool of indicators was compiled and subsequently reviewed, validated and prioritised with regional stakeholders through the CoPs. The selected indicators were incorporated into the ClimEmpower platform and linked to relevant resilience measures.

KPI3.2: (D2.4, m21): Methodology for estimating the impacts of various measures and strategies on CC-resilience, including side-effects and co-benefits. (0-100%, max 20% per region). The project developed and documented a set of regionally relevant resilience measures and strategies, including their expected effects, potential side-effects and co-benefits. These measures were linked to the selected resilience indicators and incorporated into the ClimEmpower platform, together with step-by-step guidance for their application. However, a methodology for **quantitatively** estimating the impacts of the different measures on climate resilience was not developed. Therefore, this KPI is considered partially achieved.

5.4.4 Specific results achieved within SO3

Table 11: Status of expected specific results of SO3

Code	State	Objective	Description	Justification of novelty	Mechanisms of validation
RES-SCI4	 FINISHED	CC risk/resilience indicators	Set of climate risk and climate resilience indicators suitable for local authorities to assess current and future risk as well as impact of measures, that has been validated through regional CoPs.	This output introduces a multi-dimensional indicator framework that integrates physical, socio-economic, and governance dimensions of resilience, going beyond conventional hazard- or exposure-based indices. Many resilience frameworks were researched and indicators were adapted to regional contexts to ensure local relevance.	Validation through feedback loops between regional CoPs and WP2, through workshops and questionnaires. Coordination with WP3 ensures that the indicators are technically feasible.
RES-SCI5	 PARTIALLY ACHIEVED	Measures and strategies for increased Climate Change resilience	Methodology for estimating the impacts of various measures and strategies on CC-resilience, including side-effects and co-benefits and concrete recommendation of solutions and strategies.	The novelty lies in developing an integrated assessment framework that quantifies not only the effectiveness of adaptation and mitigation measures but also their co-benefits and potential trade-offs. It considers resilience performance indicators and stakeholder preferences.	Validation through interactive use of the platform and open discussion in the regional trials

5.5 SO4.- Simplify access to CC data and development of end user applications

5.5.1 SO4 description

TSCC partners developed the “CC-resilience toolbox” - a set of data access, data transformation and visual analytics elements that will simplify the task of accessing the relevant openly available climate data and development of user driven applications and tools for regional and local authorities, and other end users, focusing on climate impacts, data and knowledge. The user-centric decision support applications built utilising the toolbox will help users to prioritize climate adaptation measures tailored to the local conditions that concurrently bring benefits in terms of greenhouse gas emissions, societal justice and sustainability.

5.5.2 Proof of fulfilment and integration of methodological knowledge

The fulfilment of SO4 is demonstrated by the development and integration of the main components of the ClimEmpower CC-resilience toolbox, covering climate data access, data processing and indicator generation, visualisation, and user-facing applications. Three deliverables collect the different steps and specifications of the platform: deliverable D3.1 (which serves as an introduction and reports the implementation architecture of ClimEmpower application); deliverable D3.2 (describes the libraries tools and algorithms developed) and D3.3 (reporting the application and services accompanied by a report describing the deployment).

The platform, available on <https://m4d-operational.iti.gr/clim-empower> integrates the datasets and indicators identified, selected and prioritised through the regional co-creation process (I07). It also incorporates complementary sources and functionalities developed within the project and from relevant external sources. These include crowdsourced information through the Social Media Crawler (I09), spatial downscaling approaches (I08), the HANZE flood database, the FIRMS fire information viewer, and risk maps developed using the WP2 risk mapping methodology (I18).

The technical basis of the toolbox is provided by the climate data feature extraction and processing services, together with the web-GUI components and integration environment (I13). The platform has been progressively demonstrated and reviewed through the Communities of Practice (I14), where stakeholders provided feedback on the relevance, usability and presentation of the information and functionalities.

Overall, SO4 has been fulfilled through the transition from individual datasets, algorithms and technical components to an integrated CC-resilience toolbox and platform. The resulting environment brings together information and functionalities developed across the project and provides regional stakeholders with a more accessible way of exploring climate data, indicators, risk information and resilience-related knowledge.

5.5.3 Methods contributing to SO4

To start creating the ClimEmpower platform and its architecture for regional stakeholders, a structured table was designed to serve as an input, allowing developers and technological partners to analyse requirements effectively (output I07). This document, grounded in prior research, categorizes potential applications along two key dimensions: customization and integration. This approach provides a basis for aligning stakeholder expectations with technical capabilities and defining the functionalities to be included in the platform.

In this context, an initial GUI prototype was created based on stakeholder expectations and presented during the CoP sessions for feedback (output I13). The platform was subsequently refined through iterative feedback loops with the regional stakeholders. In parallel, scientific and technological experts

from the consortium worked together to define the main structure and functionalities of the platform and support the development of the prototype.

The datasets and indicators to be included in the platform were selected, prioritised and validated through the CoPs (I07).

The Key Performance Indicators for the Strategic Objective 3 are listed below:

- KPI.4.1 (m12) (D3.1). Implementation architecture for rapid prototyping of climate adaptation planning applications. This deliverable was completed and describes the initial architecture of the platform.
- KPI.4.2 (m24) (D3.2). ClimEmpower services for climate feature extraction, data processing and indicator building on top of the C3S Climate Data Store and CopDS 2.0. This deliverable collects all the services developed within the platform.
- KPI.4.3 (m33) (D3.3). ClimEmpower HTML5 framework facilitating rapid development of climate risk assessment and adaptation planning applications, and applications based on this framework. This final deliverable was successfully delivered, describing the final version of architecture and services of the ClimEmpower platform.

5.5.4 Specific results achieved within SO4

Table 12: Status of expected specific results of SO4

Code	State	Objective	Description	Justification of novelty	Mechanisms of validation
RES-TEC1	 FINISHED	Climate data feature extraction library and service	This library has been made available both as a web service simplifying access to pan-European open data, and as a standalone library for use by the regions. It allows feature extraction on common datacube libraries such as xarray. This functionality will be future integrated with Copernicus Data Store.	The innovation lies in extending existing Copernicus Data Access APIs by introducing regionalized data retrieval and automated feature extraction capabilities. Unlike existing tools that only allow global queries, this system enables direct extraction of tailored regional datasets, reducing post-processing needs and supporting local-scale model applications.	Validation has occurred through integration testing in WP3 (Tasks 3.1–3.2), where the library has been used to feed ClimEmpower's microservices. Further validation includes user feedback from consortium partners using the service to assess ease of use and interoperability
RES-TEC2	 PARTIALLY ACHIEVED	Climate processing and indicator (micro) services	In a strategic pivot from the originally planned monolithic classical web service, this result was delivered as a highly practical, hybrid model combining a simplified indicator services with a suite of highly portable, reusable Jupyter notebooks and Python scripts that automate the climate risk mapping and indicator calculation workflows.	Shifting from a service-based to a lightweight, notebook-based architecture is a major innovation in post-project software survival. By packaging complex scientific algorithms into portable, modular Jupyter workflows, local technical staff are empowered to run and adapt the hazard models independently of external hosting or continuous consulting costs.	Validated through extensive in-house laboratory testing (unit and integration tests), successfully integrated as a core data-access and computational layer within the ClimEmpower platform backend, and operationally validated by regional end-users under trial conditions as part of the deployed Decision Support Systems (DSS).
RES-TEC3	 FINISHED	Web-GUI application components and GUI integration environment	The team has worked on an adaptable GUI component library and integration platform that uses a flexible and modular design.	The GUI integration environment introduces a modular and reusable set of interface components for rapid prototyping of regional climate adaptation applications. The novelty is in its interoperable design.	Validation has followed a participatory co-design process through Communities of Practice and regional trials. Technical partners reviewed early mock-ups and prototypes to ensure usability.
RES-TEC4	 FINISHED	Applications for enhanced CC-resilience	Applications were delivered and tested. These utilise the RES-TEC1, RES-TEC2 and RES-TEC3 and address the needs of the regional stakeholders.	Combines all previous technological outputs into complete, ready-to-use applications, offering an end-to-end solution: users can directly access climate data, process indicators, and visualize the results through interactive tools, all within a single environment. This simplifies the use of complex climate information and supports evidence-based decision-making.	Validation occurred through regional demonstration trials (WP4–WP5), where the applications were tested by end-users under real operational conditions.

5.6 SO5.- Empower the regions to activate and enhance their potential for addressing the climate change challenge.

5.6.1 SO5 description

Stakeholders from ClimEmpower trial regions have been empowered to address the CC challenges by improving their collective understanding of climate change risks and possibilities for increasing resilience at regional level through evidence-based and data-driven planning and governance.

5.6.2 Proof of fulfilment and integration of methodological knowledge

The fulfilment of SO5 is demonstrated through the implementation of the five regional Communities of Practice (CoPs) and the subsequent regional trials. The CoPs provided a continuous space for stakeholders to discuss regional climate risks, review project results and provide feedback on the tools, indicators and resilience measures developed throughout the project.

The information and feedback collected during the CoPs were documented in CoP reports and used to inform the development of project outputs. Stakeholders progressively reviewed and prioritised datasets and indicators, resilience measures, risk assessment methodologies, educational materials and platform functionalities. The final CoPs focused on the regional trials, where stakeholders interacted with an advanced version of the platform and provided feedback on the project results and their practical applicability.

The co-creation process also supported more informed discussions on regional resilience actions. Resilience recommendations were presented and discussed with stakeholders, and questionnaires were used to assess their actionability and potential impact. Educational and explanatory materials were also developed to facilitate the understanding and use of the project results.

Overall, the CoPs and regional trials provided a structured mechanism for stakeholder engagement, validation and knowledge exchange, supporting the transition from the identification of regional needs at the beginning of the project to the review and application of project results at its completion.

5.6.3 Methods contributing to SO5

The implementation of the CoPs followed a progressive approach throughout the project. The first CoP (I03) focused on understanding the regional context, including the main hazards, gaps, needs and expectations of stakeholders. Depending on the region, possible solutions and areas of interest were also discussed at this stage.

The subsequent CoPs focused on aligning the project developments with the identified regional needs. Stakeholders participated in the selection and prioritisation of climate indicators and resilience measures, discussed risk assessment methodologies and reviewed educational materials and early versions of the ClimEmpower platform.

The two final CoPs were dedicated to the regional trials, following the Trial Guidance Methodology. Stakeholders were able to interact with an advanced version of the platform through hands-on activities, while feedback was collected on the developed outputs and their applicability to regional needs.

Different participatory methods were used throughout the CoPs, including open discussions, Mentimeter, post-it activities, questionnaires and other interactive exercises. This combination of methods facilitated stakeholder participation and provided feedback for the progressive development and validation of the project outputs.

Key Performance Indicators:

- KPI5.1 (D4.2, m30). Consensus decision on regional recommendations for CC-resilient development reached in all five regional CoPs (20% per case study region where recommendations are available).
- KPI5.2 (D4.5, m24). Successful co-definition of trials achieved in all five regions
- KPI5.3 (D4.6, m36). Successful validation of the project results through regional trials.

5.6.4 Specific results achieved within SO5

Table 13: Status of expected specific results of SO5

Code	State	Objective	Description	Justification of novelty	Mechanisms of validation
RES-SOC2	 FINISHED	Regional CC-resilience recommendations	Recommendations for CC-resilient, sustainable, and societally just regional development, representing the societal consensus obtained through discussions in five regional CoPs. Input for regional decision makers to be incorporated in regional development plans. Presented as a combination of recommendations common to all regions and region-specific recommendations to ease re-use in other European regions and beyond Europe.	These recommendations have been co-created with regional stakeholders, combining scientific and societal inputs. The innovation lies in the structured integration of multi-regional consensus into recommendations, going beyond typical top-down policy guidance.	Validated through regional CoPs: workshops, questionnaires, and interactive discussions. Feedback loops with local stakeholders ensure that recommendations are relevant, actionable, and aligned with local priorities.
RES-SOC3	 FINISHED	Community validation	Results of trials in five ClimEmpower regions, indicating both technical/scientific soundness of the results and the level to which they meet expectations of the RAs and CoP members.	Introduces a structured validation framework combining scientific, technical, and societal evaluation.	Conducted through regional trials where stakeholders test tools, provide feedback, and assess applicability. Includes structured surveys, workshops, and feedback sessions to evaluate technical accuracy and societal relevance

5.7 SO6.-Ensure the use and impact of the ClimEmpower outputs

5.7.1 SO6 description

Ensure the implementation, replicability and exploitation of ClimEmpower methods and outputs through a participatory process involving and engaging local stakeholders within and beyond the project framework.

5.7.2 Proof of fulfilment and integration of methodological knowledge

The fulfilment of SO6 is supported by the dissemination, communication and exploitation activities carried out throughout the project. The ClimEmpower website provides access to the project results, including the final platform, educational materials, project outputs and other resources developed for regional stakeholders and wider audiences.

A range of communication and educational materials has been produced to facilitate the understanding and reuse of project results. In particular, explanatory materials have been developed for relevant project outputs, describing their development, practical application and potential uses. Public deliverables and project results have also been presented in different formats to facilitate their dissemination and accessibility.

The use and relevance of the project outputs have been further supported through the Communities of Practice, regional trials, workshops and other stakeholder engagement activities. Feedback from these activities has helped assess the applicability and potential reuse of the developed results.

Finally, the sustainability and exploitation strategies (collected in Deliverables D4.6 and D4.7) have identified potential pathways for maintaining, reusing and further developing the project results beyond the project lifetime. These include their use by regional stakeholders, integration into existing knowledge and information services, dissemination through scientific and public channels, and reuse in future projects and initiatives.

5.7.3 Methods contributing to SO6

Work Package 5 has supported the dissemination, communication and stakeholder engagement activities throughout the project. Information on project activities and results has been shared through the ClimEmpower website, social media, scientific publications, conferences and other dissemination channels.

The ClimEmpower website serves as the main access point for project information and results. It provides access to the project platform, educational materials, project deliverables and other resources developed during the project. Different formats have been used to communicate the results, including presentations, infographics, videos, podcasts and other visual materials.

Dissemination activities have also been supported through the Communities of Practice, regional trials, workshops, conferences and other events. These activities provided opportunities to present project results to stakeholders, collect feedback and promote their potential reuse.

The exploitation and sustainability of the results have been addressed through the Innovation Management Plan and the Sustainability and Exploitation Plan. These activities have identified potential users, exploitation pathways and actions for maintaining and further developing relevant project outputs beyond the project lifetime. The potential replication of relevant outputs in other regions and projects has also been considered through the exploitation and sustainability activities.

Key Performance Indicators:

- KPI6.1 [D4.6, m36]. Community Validation of ClimEmpower SCI and TEC results.
- KPI6.2 [D4.7, m27, D4.8, m36]. Sustainability and exploitation plan. [50% for D4.7, 100% for D5.6b].
- KPI6.3 [D5.1, m6]. Project web site.
- KPI6.4 [D5.2-D5.4, m6, m18, m36] Dissemination and communication plan [33% for each version].
- KPI6.5 [D5.5, m33] A set of dissemination materials that were developed by the project.
- KPI6.6 [D5.6-D5.8, m9, m21, m36] Stakeholders engagement plan and event reports.

6 Barriers, lessons learned and impacts

6.1 Barriers and lessons learned

A foundational operational challenge of the ClimEmpower project was underestimating the calendar time required to execute the planned, iterative co-creation cycles within pilot regions characterized by acute, pre-existing socio-economic, technical, and institutional capacity constraints. While targeting territories with severe baseline resource limitations was essential to fulfil the project's core mission of territorial equity and support “the regions that need it most”, it introduced significant systemic complexity. Because several of these regional administrations possessed limited technical staffing and lacked the established data-processing infrastructures required to readily digest complex climate services, each iteration loop demanded far more calendar time to execute, review, and refine than originally anticipated. **This challenge was fundamentally a constraint of calendar time rather than funding; the process of building local technical capacity, cultivating trust, and progressively co-designing tailored solutions with structurally constrained public administrations is intrinsically time-intensive and cannot be artificially accelerated through financial investment alone.** Consequently, genuine regional empowerment requires a highly flexible, patience-intensive, and generously time-buffered co-design framework.

Throughout the project, several challenges emerged during the development, validation, and exploitation of the project's outputs. Rather than being treated as project risks, these challenges are presented retrospectively as valuable socio-technical barriers and lessons learned. The analysis focuses on how these barriers were proactively addressed by the consortium, their implications for the final project results, and concrete recommendations that are highly relevant for future European climate resilience initiatives.

The main barriers identified are summarised in Table 14, together with the specific outputs affected, the corrective actions taken, and the strategic recommendations derived from the experience.

Table 14. List of identified challenges and lessons learned relevant to innovation

Barrier/challenge	Outputs affected	How it was addressed	Lesson learned	Recommendation / Future consideration
1. Availability and suitability of regional data required for hazard, exposure, and vulnerability mapping.	RES-SCI1, RES-SCI2, RES-SCI4, RES-TEC4	Technical partners supported the identification and collection of available datasets. Local gaps were bypassed by using downscaling techniques (RES-SCI2), open social sensing data, or purchasing specialized regional datasets where necessary.	The availability, resolution, and accessibility of local data vary considerably across European regions, with localized vulnerability and socio-economic datasets being particularly scarce.	Perform a structured regional data inventory and identify critical data gaps in close collaboration with local authorities before locking in the technical software requirements.

Barrier/challenge	Outputs affected	How it was addressed	Lesson learned	Recommendation / Future consideration
2. Aligning spatial/temporal resolution of open datasets with local stakeholder planning expectations.	RES-SCI1, RES-SCI4, RES-TEC4	Datasets and indicators were systematically reviewed and prioritized through the Communities of Practice (CoPs), consulting stakeholders directly on the level of detail required for operational decisions.	The mere availability of a dataset does not guarantee its usability for local planning. Spatial resolution and user-centric relevance must be evaluated together.	Define data requirements in relation to the final use case and involve end users when prioritising datasets and their required resolution.
3. Ensuring platform accessibility for users with highly diverse technical or non-programming backgrounds.	RES-TEC3, RES-TEC4	The platform interface was progressively demonstrated through CoPs and trials, allowing end-users to interact with early mock-ups and guide the interface design.	Technical prototypes must be exposed to non-technical end-users early in the development cycle. Hands-on testing yields far more actionable feedback than conceptual reviews.	Include end-user testing, interactive click-throughs, and hands-on trial demonstrations as early as possible in the software development lifecycle.
4. Limited timeframe for conducting technical validation and stakeholder-led regional trials.	RES-SOC3, RES-TEC4	The consortium organized a series of coordinated mini-trials, final validation trials, and a consolidated stakeholder workshop within the closing year of the project.	Scheduling critical final validation activities during the summer months (June–August) presents severe stakeholder engagement bottlenecks due to widespread seasonal shutdowns. While the consortium flagged this scheduling conflict to the funding authority from the project's outset, rigid administrative policies against project extensions prevented a timeline shift, demonstrating how inflexible structural constraints can actively impede operational validation.	Avoid scheduling project closure dates in August or December at all costs. Temporal feasibility and seasonal cycles must be aggressively addressed and locked in at the initial contract negotiation phase, as funding agencies' increasingly rigid policies make securing retroactive duration amendments highly difficult, regardless of proactive warnings.
5. Evolving stakeholder requirements as users become more familiar with the platform's technical possibilities.	RES-TEC3, RES-TEC4	Developers designed the Web-GUI (RES-TEC3) as a modular "mashup platform," allowing regional instances to be reconfigured on-the-fly by local facilitators without recoding the underlying service backend.	In a co-creation process, user requirements are dynamic; stakeholders only fully understand what they need once they start interacting with actual digital prototypes.	Build extreme modularity into the system architecture from day one , allowing the user interface to adapt to evolving expectations without triggering costly backend redesigns.

Barrier/challenge	Outputs affected	How it was addressed	Lesson learned	Recommendation / Future consideration
6. Technical constraints in deploying heavy, centralized automated web services for regional indicator generation.	RES-TEC2, RES-TEC4	The consortium pivoted from a centralized classical web service to a hybrid delivery model combining database-fetching services with a suite of highly portable, reusable Jupyter notebooks and Python scripts.	Lightweight, notebook-based architectures are often more resilient, easier to maintain, and far more useful for regional technical staff than complex, centralized web servers that depend on continuous external hosting.	Embrace hybrid, portable code architectures (like Jupyter workflows) for localized hazard models, supporting them with clear training tutorials to ensure post-project survival and replication.
7. Underestimating the calendar time required to execute planned iterative co-creation cycles with highly constrained pilot administrations.	RES-SOC1, RES-TEC3, RES-TEC4	The consortium dedicated significant additional calendar time and intensive direct mentoring through Case Study Facilitators (CSFs) to support the regions through each feedback loop, prioritizing thoroughness and capacity building over a rushed schedule.	True climate equity requires piloting tools in regions with the lowest adaptive capacities. While highly iterative co-creation cycles were planned from the outset, the raw calendar time required to execute each cycle was significantly underestimated. The barrier is not financial, but rather the time needed to iteratively co-design, simplify, and validate outputs when local capacity is low.	Do not underestimate the time cost of iterative co-creation in resource-constrained territories. Future funding frameworks and project designs targeting highly vulnerable public administrations must allocate significantly longer project durations and generous calendar time buffers specifically dedicated to repeating co-design loops, recognizing that capacity-building cannot be rushed by financial investments alone.

6.2 Perceived impacts in the study regions

he potential impacts of ClimEmpower were systematically explored through interactive co-design sessions within the Communities of Practice (CoPs, RES-SOC1), structured regional trial evaluations (RES-SOC3, D4.5), and targeted questionnaires distributed to regional stakeholders. Rather than focusing solely on technical performance, this assessment evaluated how the project's integrated outputs influence local decision-making, municipal planning, resource allocation, and the long-term adaptive capacity of public administrations.

Strengthening the Science-Policy Interface

Overall, stakeholders perceived the most immediate impact of ClimEmpower to be the strengthening of the connection between complex climate science and localized policymaking. This was made practically possible by the platform's modular Web-GUI components (RES-TEC3), which allowed non-technical regional officials to interact with advanced climate risk mapping tools without requiring programming expertise. In Central Greece and the Troodos Mountain Range (Cyprus), stakeholders emphasized that the platform enabled a more systematic, data-driven approach to planning. In Osijek-Baranja County (Croatia), participants associated the integrated indicators (RES-SCI4) with more transparent planning, better-informed decision-making, and a more efficient allocation of public resources. Similarly, in the Western Costa del Sol (Spain), the ability to easily overlay hazard, exposure, and vulnerability datasets was identified as a major advancement for daily regional risk management.

Ethical Decision-Making and Societally Just Adaptation

A key finding across the pilot regions is that climate resilience cannot be separated from territorial equity. In Sicily (Italy), stakeholders closely associated the scientific robustness of the ClimEmpower platform with ethical decision-making, as reliable, transparent models provide public administrations with the empirical justification needed to defend planning decisions. Crucially, the regional recommendations (RES-SOC2) are structured to be **"societally just"**, ensuring that adaptation planning actively prioritizes and directs resources toward vulnerable, less affluent populations with lower coping capacities. To bridge the gap between technical datasets and policy implementation, these recommendations have been translated into a series of actionable **"Policy recommendation letters" (compiled under deliverable D4.4)**, providing municipal authorities with realistic, phased roadmaps to protect local populations from systemic climate shocks.

From Reactive to Preventive Regional Planning

Across the board, stakeholders recognized a distinct **shift from reactive disaster response to proactive, preventive climate planning**. However, they consistently noted that long-term impact depends entirely on institutional uptake rather than the passive existence of a software platform. To prevent these digital tools from being abandoned post-project, ClimEmpower focused heavily on local capacity building. By packaging the platform's analytical core into reusable **Jupyter notebooks** and Python scripts (RES-TEC2) under a **CC BY-NC 4.0** license, regional technical staff are empowered with the training and source code necessary to run and update risk assessments independently, reducing long-term dependency on external consultants.

This **transition to long-term regional ownership** is driven by concrete post-project pathways tailored to each pilot region's institutional framework. These region-specific strategies—ranging from the formal integration of hazard maps into official environmental databases to the direct alignment of indicators with regional adaptation plans—are designed to embed ClimEmpower's assets directly into daily administrative workflows. To ensure maximum readability and avoid duplication within this deliverable, the detailed operational plans, regional priorities, and institutional hosting commitments for each of the five territories are presented in full under Section 7.2 (Specific sustainability plans per region).

7 Exploitation strategy to ensure maximum replicability of ClimEmpower results

7.1 Implementation and replicability strategy

In ClimEmpower, the replicability of results has been primarily assessed through the application of the Trial Guidance Methodology across five regional trial locations. This methodology provides a structured approach to test and refine the methods and tools developed during the project, ensuring their adaptability and scalability to other regions. By utilizing this framework, ClimEmpower aims to transfer innovative solutions and methodologies beyond the original trial areas, achieving a broader impact.

The first step in this process is to identify and define a specific challenge to address in each region. These regional objectives have been co-defined through deliberation in the Communities of Practice (CoPs) meetings, ensuring alignment with local priorities and hazards. Once the regional challenges are identified, the tools, materials, and methods developed within the project are tailored to address these specific needs.

Key results—including the service and indicator findings (RES-SCI4), training materials (RES-SCI3), actionable recommendations (RES-SOC2), adaptation strategies (RES-SCI5), tools (RES-TEC4), and the Graphical User Interface and integrated components of the ClimEmpower platform (RES-TEC3)—have been evaluated for feasibility and usefulness. Feedback loops involving local stakeholders have refined these functionalities, ensuring that the final solutions are highly effective and user-friendly.

This iterative process has enabled comprehensive testing and validation of the project's outcomes, ensuring their relevance and practical utility (Table 15).

Table 15. Results validation and related KPIs

Result Code	Validation	KPI related	KPI progress
RES-SOC1	Five regional Communities of Practice (CoPs) served as the structural foundation and essential pre-requisite for all trial activities. The CoPs were critical for defining regional baseline needs, prioritizing risk scenarios, and co-designing trial protocols. CoP members subsequently acted as the key evaluators who validated the final platform and trial outcomes.	KPI1.1 (CoP statutes and problem statements); KPI1.2 (Case Study)	Achieved. CoPs established in all five regions; baseline scenarios completed and validated (100%).

Result Code	Validation	KPI related	KPI progress
RES-SOC2	Regional CC-resilience recommendations were co-developed and validated through iterative feedback loops within the regional CoPs and co-design workshops. While serving as a strategic framework rather than a software tool, these recommendations integrated into the validation process by providing the policy and decision-making context that guided the selection of pilot scenarios and adaptation strategies.	KPI5.1 (Regional recommendations).	Achieved. Recommendations validated in all 5 regions. Deliverables D4.3 and D4.4 collect the first and second versions of the recommendations. D4.4 officially compiles these recommendations into a series of actionable "Policy recommendation letters" to provide direct, actionable policy guidance for public administrations.
RES-SOC3	Community Validation through Trials represents the core operational framework that structured the final validation phase of the project. It integrated all scientific (RES-SCI) and technological (RES-TEC) results by testing them under real-world conditions with local stakeholders during the five regional trials, verifying the platform's social and practical utility.	KPI5.2 (Co-definition of trials), KPI5.3 (Validation through regional trials) KPI6.1 (Community validation), KPI6.2 (Sustainability and exploitation plan); KPI6.6 (Stakeholders engagement plan & events report)	Achieved. Stakeholder engagement plan defined; Trials held in 5 regions to validate the outputs and discuss replication intentions and strategies. Sustainability and exploitation plans completed. Results are collected in D4.5, D4.6, D4.7, D4.8, D5.6, D5.7 and D5.8.
RES-SCI1	Gap analysis of existing data and services: Acted as an essential analytical pre-requisite for the validation process. By identifying regional data limitations (such as a lack of localized vulnerability and exposure data), it directly guided where spatial downscaling (RES-SCI2) and custom indicator building (RES-SCI4) were technically required to support the trials.	KPI2.1 (Data and service gaps)	Achieved Comprehensive gap analysis completed across all regions with CoP validation. Results are reported in D2.1.
RES-SCI2	Methodology for overcoming data gaps was validated by applying these technical methodologies (downscaling, social sensing, data fusion) to generate the high-resolution input datasets required for regional risk mapping. This integrated into the trials by ensuring the decision-support tools had robust, localized data to run trial-specific climate scenarios.	KPI2.1 (Data and service gaps); KPI2.2 (Methodology for overcoming data gaps)	Achieved. Methodology defined (D2.3) and used across Work Packages. Validation successfully completed through final trials (D4.6).

Result Code	Validation	KPI related	KPI progress
RES-SCI3	The repository of third-party educational materials was validated in mini-trials, and a tutorial for using the DSS tool was successfully tested during the main trials. To address feedback received from the trials, additional ClimEmpower educational materials were developed afterwards. These materials feature step-by-step instructions and exercises. They offer a highly practical and transferable pedagogical perspective on the knowledge generated by the project.	KPI2.3 (Educational CC materials)	Achieved. Compilation and implementation of educational materials completed and reported in D4.1, and D4.2.
RES-SCI4	Climate risk/resilience indicators were developed and integrated into the ClimEmpower Decision Support platform. The selection and weighting of indicators was validated by regional stakeholders in CoP sessions, and their real-world applicability was validated by using them to assess regional risks in trial runs.	KPI3.1 (Summary of indicators)	Achieved. Indicators defined and prioritized. Feedback collected from stakeholders. Implementation and final validation in trials.
RES-SCI5	Measures and strategies for increased CC-resilience were integrated as qualitative step-by-step guidelines built into the ClimEmpower DSS platform. They were validated by trial users who tested how the platform links specific adaptation options to regional risk profiles, ensuring the recommendations were practical for local planning	KPI3.2 (Methodology for impacts of measures on CC-resilience)	Partially Achieved. Step-by-step guidelines to implement measures and strategies have been defined, implemented in the platform and linked to indicators. Moreover, a set of "Policy recommendation letters", officially published as part of deliverable D4.4, provides high-level, practical guidance to help regional policymakers translate project findings into long-term strategic plans. However, the quantitative impact estimation was not developed, aligning with the qualitative focus in D2.4.
RES-TEC1	Climate data feature extraction library/service has been validated through extensive unit testing and backend integration testing. It integrated into the validation process by serving as the underlying data access and pre-processing engine that powered the on-demand climate processing microservices (RES-TEC2) utilized during the regional trials.	KPI4.2 (Services and climate feature extraction, data processing and indicator building)	Achieved. Library development completed. Technical description included in D3.2; codebase is public on GitHub. Related educational and training materials were also developed to explain its technical usage, and the library will eventually be integrated into the Copernicus Climate Change Service (C3S) climate data service.

Result Code	Validation	KPI related	KPI progress
RES-TEC2	Climate data processing & indicator microservices were partially validated through regional trials. While the classical automated web service originally planned by PLINIVS in D3.2 was not fully realized, the indicators were successfully made available in the platform by AIT via a simplified indicators service. The risk-map algorithms were implemented as a practical framework of Jupyter notebooks (building on CLIMAAX notebooks) and Python scripts, validated with local users, and supported by concrete training tutorials for replication.	KPI4.2 (Services and climate feature extraction, data processing and indicator building)	Partially achieved The indicator and risk mapping workflows are operational, integrated into RES-TEC4, and documented in D3.2 and D4.6. However, the technical implementation deviated from the initial classical service model to a highly practical framework of automated data-fetching services that provide RES-TEC3 with necessary indicators, and a set of algorithms that were initially drafted in D2.3 and D2.4 and subsequently implemented as a mix of Python scripts and reusable Jupyter notebooks. Educational materials were written to explain both the risk assessment principles and how to re-use the algorithms outside ClimEmpower
RES-TEC3	Web-GUI components & integration environment has been tested in laboratory and validated as RES-TEC4 through iterative user feedback sessions in regional CoPs.	KPI4.1 (Implementation architecture); KPI4.3 (ClimEmpower HTML5 framework)	Achieved. Platform interface and backend integration environment validated and successfully implemented. Results documented in D3.1 and D3.3. Final output is a versatile mashup platform that can be pre-configured with region-specific datasets, allowing local users to quickly set up customized decision-support interfaces without any programming knowledge. This front-end application is supported by an underlying backend engine that parses and provides all integrated spatial and climate data in a highly structured format that simplifies GUI rendering.
RES-TEC4	ClimEmpower applications/DSS tools were implemented as a pre-configured deployment of the mashup platform (RES-TEC3) customized for the five specific trial regions. Each region was provided with its own dedicated instance containing pre-loaded, region-specific environmental and social indicators, and local stakeholders were trained in workshops on how to manage, interpret, and operate these tools. Validated through full end-to-end regional trial runs.	KPI4.1 (Implementation architecture), KPI4.2 (Services and climate feature extraction), KPI4.3 (ClimEmpower HTML5 framework)	Achieved. End-to-end DSS tools successfully customized, deployed, and validated across all 5 pilot regions. Local stakeholders have been fully trained to run and update their regional applications. Results are documented in D3.3 and D4.6.

7.2 Exploitation strategy

The exploitation strategy of ClimEmpower follows two complementary pathways: commercial exploitation of selected technological results and open, non-commercial exploitation of scientific, technical and societal results. The table below provides an overview of the main project results, their ownership and their intended exploitation pathway.

Table 16 Overview of exploitable project results

CODE	Results	IPR Holder	Type of exploitation
ER1 (RES-TEC1)	Climate data feature extraction library and service. Enables server-side data reduction and integration with Copernicus Climate and Atmosphere Data Store.	ECMWF	Non-commercial - scientific
OER1.1 (I10)	Polytope Data Access Software – REST API for tailored Copernicus data access.	ECMWF	Non-commercial - scientific
KER2 (RES-TEC2)	Climate data processing and indicator microservices. Reusable services for CC resilience data and indicators.	AIT, CET, PLINIVS, ECMWF	Non-commercial - scientific (with potential commercial applications)
OER2.1 (I07)	Combination of datasets for regional climate resilience. Integration of datasets and susceptibility mapping.	AIT	Non-commercial - scientific
KER3 (RES-TEC3)	Web-GUI components and GUI integration environment. Enables rapid prototyping of user-centric climate apps.	CERTH, AIT	Commercial-Potentially commercial and Non-commercial - scientific
KER3.1	Web-GUI components. Includes the front-end components for building ClimEmpower applications.	CERTH	Commercial-Potentially commercial
KER3.2	GUI integration environment. Includes the backend components that are necessary for integrating e.g. indicators, recommendations, maps, user management as well as the API to easily interact with these elements.	AIT	Non-commercial - scientific
KER4 (RES-TEC4)	ClimEmpower applications for CC-resilience. DSS tools for hazard assessment, resilience planning, and measure comparison.	AIT, CET, CERTH	Non-commercial - scientific
OER4.1 (I18)	Risk maps - Interactive visualization of hazard and resilience indicators for regional planning.	AIT, AQUA, CET, PLINIVS	Non-commercial - scientific
KER5	S2 Data downscaling – higher-resolution hazard mapping for integration in microservices and visualization layers.	CERTH	Non-commercial - scientific
KER6	Social Media Crawler - real-time hazard detection and validation.	CERTH	Commercial – Potentially commercial
KER7 (RES-SCI4)	Climate risk / resilience indicators (for assessment of risks and impacts of measures).	AIT	Non-commercial - scientific
OER7.1 (I04)	Regional Climate Resilience Assessment (graphics/tables by resilience components).	CET	Non-commercial - scientific
KER8 (RES-SCI5)	Measures and strategies for increased Climate Change resilience – methodology and co-benefit analysis.	AIT, PLINIVS	Non-commercial - scientific
KER9 (RES-SOC2)	Regional CC-resilience recommendations – synthesis of regional CoP outputs into actionable plans.	PLINIVS, AIT	Non-commercial – scientific

CODE	Results	IPR Holder	Type of exploitation
KER10 (RES-SOC1)	Communities of Practice (CoPs) for CC-resilient development – stakeholder engagement and societal innovation framework.	AQUA, PLINIVS	Non-commercial – scientific
KER11 (RES-SOC3)	Community Validation through Trials – methodological validation of solutions and assessment of innovation potential.	PLINIVS, AIT	Non-commercial - scientific

Selected technological results, including the Web-GUI components (**KER3.1**) and the Social Media Crawler (**KER6**), hold direct potential for further commercial exploitation beyond the project's lifecycle, supporting advanced services in climate and disaster risk management. Other technical assets, such as the GUI integration environment (**KER3.2**), are primarily designated for research, consulting, and further non-commercial development.

In parallel, several core results are designed to support open uptake and replication by other regions. These include tools and methodologies for accessing climate data (**RES-TEC1**), processing indicators (**RES-TEC2**), and supporting stakeholder engagement (**RES-SOC1**). To support future research and innovation, these scientific and technical assets will be made available through open repositories (such as Zenodo and GitHub).

Although the majority of ClimEmpower's results are designated for non-commercial or scientific pathways, they possess significant exploitation potential through specialized training, academic teaching, and technical consulting. To safeguard this potential while promoting open dissemination, the consortium has applied the **Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0)** license to these assets where appropriate. This strategic choice prevents unauthorized third-party commercialization of the project's intellectual property, while preserving the partners' exclusive rights to leverage their respective outputs for commercial services and consulting, thereby securing the long-term sustainability of the innovations.

Sustainability actions are structured across distinct time horizons:

- **Short-term horizon:** Focuses on maintaining platform access, preserving project data in accordance with FAIR principles, and providing targeted educational materials (**RES-SCI3**) to facilitate continued use by regional stakeholders.
- **Medium to Long-term horizon:** Focuses on reusing the modular platform architecture in new research initiatives, integrating individual tools into regional climate services, and updating risk maps as new projections and datasets become available.

The long-term uptake of the results also depends on their integration into existing regional structures and planning processes. Each ClimEmpower region has identified potential pathways for continuing to use the project results according to its specific needs and institutional context. These include:

- **Western Costa del Sol, Spain:** integration of multi-hazard risk information into the Andalusian Environmental Information Network (REDIAM), supporting its use by municipalities and other public authorities in planning and risk management.
- **Central Greece:** use of ClimEmpower resilience indicators and recommendations in relation to the Regional Adaptation to Climate Change Plan, supporting the monitoring and assessment of adaptation actions.
- **Troodos, Cyprus:** use of the platform and educational materials to support more proactive preparedness for hazards such as wildfires and droughts, including activities targeting local communities and schools.

- **Osijek-Baranja County, Croatia:** application of spatial analysis and climate-risk information to support decisions related to water infrastructure, agriculture and wetland management, particularly in relation to flood risk.
- **Sicily, Italy:** potential use of the platform to support periodic climate assessments and facilitate technical dialogue between municipalities and regional authorities, with particular attention to heatwaves and flash floods.

Overall, the exploitation approach aims to ensure that ClimEmpower results remain accessible and useful beyond the project lifetime, while allowing individual outputs to follow different pathways depending on their ownership, maturity, intended users and potential for commercial or non-commercial uptake.

8 Conclusions

The final months of the ClimEmpower project (June-August 2026) mark the successful delivery and validation of an integrated, multidisciplinary framework spanning social (RES-SOC), scientific (RES-SCI), and technological (RES-TEC) innovations. By applying the Innovation Maturity and Stakeholder Validation Framework, the consortium has successfully transitioned these complex outputs into validated, highly reusable regional decision-support assets.

At the core of the project's societal impact are the regional Communities of Practice (CoPs, RES-SOC1), which co-designed and validated the platform through regional trials (RES-SOC3, D4.5). This collaborative effort produced "societally just" regional recommendations (RES-SOC2, D4.4) aimed at protecting not only the most valuable assets but primarily the vulnerable, less affluent populations.

To ensure practical utility, the technological platform was implemented as a robust hybrid architecture. Rather than a classical web service, the DSS integrates ECMWF's data extraction library (RES-TEC1), designed for future Copernicus Climate Data Store integration, with processing algorithms realised as reusable Jupyter notebooks and Python scripts. A service backend providing access to pre-processed maps, resilience indicators, recommendations and other data of interest to users and application developers powers a modular Web-GUI mashup platform (RES-TEC3) deployed across five pre-configured regional DSS environments (RES-TEC4).

To guarantee long-term replication, the consortium developed a highly practical portfolio of educational materials, step-by-step exercises (D4.2), public indicator fact sheets, and policy recommendation letters (D4.4). Furthermore, while most of the project's results are public, they are strategically protected under a Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) license. This prevents unauthorized third-party commercialization of the project's public assets, while preserving the partners' exclusive rights to exploit their respective tools and models through teaching and commercial consulting.

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