



REGIONAL CC-RESILIENCE RECOMMENDATIONS V2

ClimEmpower Work Package 4, D4.4, v2.1



Project ClimEmpower: User Driven Climate Applications Empowering Regional Resilience

Work package 4, Deliverable D4.4 v2.1

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List of Acronyms

Acronym	Definition
BGI	Blue and Green Infrastructure
CIC	Climate interaction context
CoP	Community of Practice
CSF	Case Study Facilitator / Case Study Facilitators
DRR	Disaster Risk Reduction
GDP	Gross Domestic Product
MU	Mission User / Mission Users
PPS	Purchasing Power Standard
RA	Regional Authority / Regional Authorities
SME	Small and Medium-sized Enterprise
SO	Strategic Objective
TGM	Trial Guidance Methodology
WP	Work Package

Glossary

Term	Definition
Adaptation	The process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities. In human systems, adaptation seeks to reduce vulnerability and strengthen resilience to climate-related risks.
BGI	Blue and green infrastructure refers to interconnected networks of natural and semi-natural systems that work together to enhance urban resilience and sustainability. While blue infrastructure focuses on water management through features like rivers, wetlands, and drainage systems, green infrastructure emphasizes the use of plants and green spaces, such as parks, green roofs, and forests, to provide ecosystem services. Together, they manage stormwater, reduce flooding, improve air and water quality, enhance biodiversity, and support climate adaptation in urban environments.
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 Resilience	The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.
Community of Practice	A group of stakeholders sharing a common concern, in this case the challenge of increasing climate resilience, who engage in collective learning by exchanging knowledge and supporting one another
Mitigation	Human interventions aimed at reducing greenhouse gas emissions or enhancing greenhouse gas sinks, thereby limiting the magnitude and rate of climate change.
Resilience	The capacity of social, economic, and environmental systems to cope with hazardous events or trends, responding or reorganising in ways that maintain their essential functions, identity, and structure while adapting and transforming when necessary.

Executive summary (publishable)

Deliverable D4.4 (Regional CC-Resilience Recommendations v2.1) presents the consolidated regional climate change adaptation and resilience recommendations co-designed with stakeholders across the five ClimEmpower pilot regions (Croatia, Cyprus, Greece, Italy, and Spain).

 **Core Focus of this Deliverable** Building on the intermediate recommendations of D4.3 and the quantitative indicators defined in WP2 (D2.2 and D2.4) and grounded in the participatory work of regional Communities of Practice (CoPs), this report provides both practical and strategic resources for policymakers and regional stakeholders seeking to strengthen climate resilience and support sustainable regional development. Compared to the first version, this deliverable places greater emphasis on implementation pathways, prioritised policy recommendations, and integration of these recommendations in ClimEmpower solutions. It also incorporates lessons learned from the Communities of Practice meetings conducted within WP4, highlighting barriers, enabling factors, and opportunities for improving climate adaptation planning and decision-making processes.

The report yields three primary outputs:

1. **The ClimEmpower Resilience Recommendations Matrix** (Section 4.2): 90 concrete recommendations mapped directly to 36 resilience indicators across seven fields of application and six dimensions.
2. **The Hazard–Sector Translation Framework (HSTF)** (Section 5): A spatial-planning methodology formalised within ClimEmpower that bridges scientific risk evidence with spatial planning by tracing hazard pathways through affected territorial systems, land-use domains, planning instruments, and intended resilience functions.
3. **The Policy Letters** (Section 6.1 and Annex A): A set of ten co-designed, four-page briefs translating high-interest regional recommendations into a direct, non-technical format for decision-makers.

To support the practical application of these three core outputs, Sections 6.2 and 6.3 reference ClimEmpower Decision Support platform, as well as related educational materials, step-by-step planning manuals, discovery matrices, and web tools from the broader ClimEmpower Educational Library (Deliverable D4.2).

All these outputs are published open-access on the ClimEmpower website (<https://climempower.eu/results/>) and/or on the ClimEmpower Zenodo community (<https://zenodo.org/communities/climempower>) to encourage translation and local public adaptation.

1 ClimEmpower summary

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

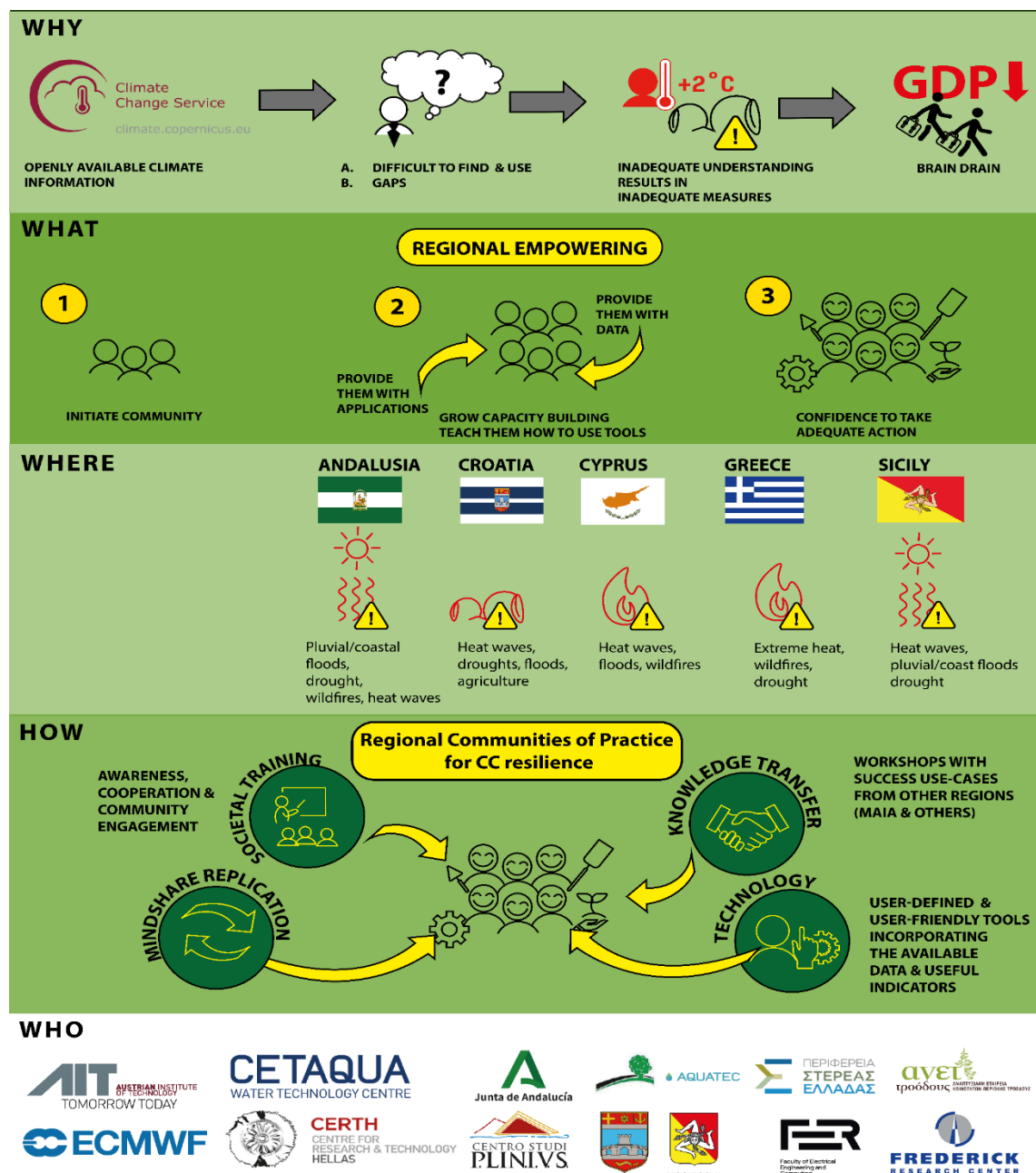


Figure 1: ClimEmpower at a glance: why, what, where, how and who.

1.1 Project Context

Climate risks result from a combination of hazard, exposure, and vulnerability (IPCC, 2022), and an effective increase in regional resilience depends on addressing all three. 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 ().

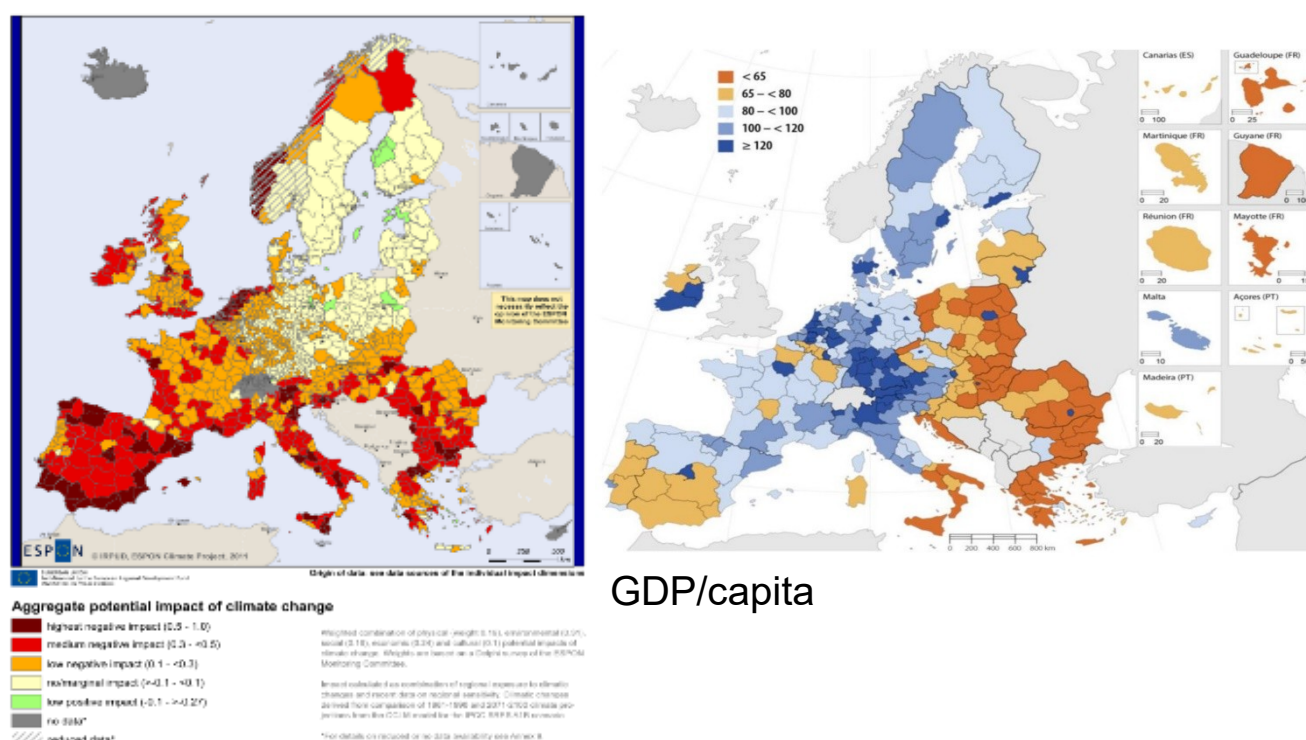


Figure 2: Aggregated potential impact of climate change (<https://www.espon.eu/climate-2012>); GDP/capita (based on <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210303-1>)

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).

- 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)

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 is a result of the T4.2 “Involve and empower regional actors” task within WP4 “Empowering the Regions” and complements the work performed in Tasks T4.1 “Provide educational materials”, and T4.3 “Co-design of tools, services and trials for increased regional resilience”.

While D4.3 focused on defining general and preliminary region-specific recommendations based on stakeholder engagement, D4.4 refines, validates and operationalises them through regional trials, testing activities and iterative feedback involving regional stakeholders and end-users. The deliverable also draws on the methodological foundations, participatory processes and technical developments established across several work packages, while contributing to the long-term uptake and replicability of ClimEmpower outputs.

The aim of this report is to provide regional authorities and local stakeholders with practical, evidence-based recommendations tailored to their context, in order to strengthen climate resilience, improve adaptive capacity and inform sustainable regional development. In doing so, the deliverable also helps identify transferable practices, governance approaches and implementation pathways relevant within and beyond the ClimEmpower regions.

Key results of this work consist of a second iteration of the **ClimEmpower resilience recommendation matrix** and **regional policy recommendation letters**.

ClimEmpower Resilience recommendation matrix is a structured tool designed to organise and operationalise resilience knowledge across the project. It brings together climate-resilience indicators, governance dimensions, sectoral priorities and adaptation actions emerging from the co-design work with regional stakeholders. Its architecture is interoperable with the WP3 platform and supports the implementation, testing and validation of recommendations during the regional trials, acting as a bridge between conceptual resilience frameworks and practical decision-support for regional adaptation planning.

ClimEmpower regional policy recommendation letters are an integral output of this deliverable. Ten letters, each developed around a single prioritised recommendation, are introduced in section 6 of this document and published both on the ClimEmpower web site, under the Results section, and on Zenodo. ClimEmpower web site, under the Results section, and on Zenodo. The full set is reproduced in Annex A of this deliverable.

Alongside these two results, section 5 introduces the **Hazard–Sector Translation Framework**, a complementary methodological layer developed within ClimEmpower and formalised in Xekalakis et al. (2026). It explains how the recommendations can be taken up in land-use and infrastructure planning, and provides the methodological link between the recommendations of section 4 and the policy-uptake instruments that follow.

2.2 Results and expected impacts

The deliverable presents the **consolidated and validated set of resilience recommendations** developed through the ClimEmpower project, operationalised through the indicator system developed in WP2.

In the first version of the recommendations (D4.3), the outputs were organised around five thematic sectors: new building construction and retrofitting, blue and green infrastructure, transportation, agriculture, and ecosystem conservation, which represented the initial sectoral priorities identified through the Communities of Practice. In D4.4, this grouping has been replaced by the six-dimension framework, which provides a more systematic and analytically grounded structure, better aligned with the indicator system and the regional validation activities carried out during the project:

- Health & Wellbeing
- Population & Education
- Economy & Labour Market
- Infrastructure
- Governance
- Environment, Nature & Settlement Areas

This structure reflects the analytical framework of the project and ensures coherence between the resilience assessment carried out in WP2, the decision-support tools developed in WP3, and the recommendations presented here. Where relevant, cross-sectoral connections between the recommendations are explicitly noted within each dimension.

in the first version of the recommendations (D4.3), the outputs were organised around five thematic sectors: new building construction and retrofitting, blue and green infrastructure, transportation, agriculture, and ecosystem conservation, which represented the initial sectoral priorities identified through the Communities of Practice. In D4.4, this grouping has been replaced by the six-dimension framework, which provides a more systematic and analytically grounded structure, better aligned with the indicator system and the regional validation activities carried out during the project. Where relevant, cross-sectoral connections between the recommendations are explicitly noted within each dimension. The recommendations take a **systemic approach to resilience**, integrating both mitigation and adaptation strategies and promoting solutions with multiple co-benefits, reinforcing environmental resilience and generating tangible socio-economic advantages. Rather than remaining just academic outputs, they were developed iteratively in close collaboration with the regions, tested under real conditions and refined based on practical feedback, which makes them both technically robust and territorially grounded. They draw on scientific evidence and technical expertise, on the participatory knowledge generated through the project's co-design and validation work, and on lessons learned from real territorial contexts.

A key focus of this version is the implementation process. Beyond identifying what needs to be done, the recommendations consider how resilience strategies can be put into practice, which governance level and implementation timeframe each measure requires, and how a solution developed in one region can be adapted and replicated elsewhere in Europe.

Particular attention is given to integrating ClimEmpower tools and services into existing regional planning and governance, and to the usability of climate data and decision-support resources for non-specialist users.

The **expected impacts** operate at two main levels.

- At regional level, the **recommendations are intended to strengthen the capacity of regional authorities to integrate climate resilience into planning instruments, investment strategies and governance frameworks**. By providing sector-specific guidance across the six resilience dimensions, they support a more coherent and coordinated approach to adaptation, moving beyond isolated interventions towards systemic, cross-sectoral responses. By addressing socio-economic co-benefits alongside environmental objectives, they also help make the case for climate investment to a wider range of actors, including those concerned primarily with economic development, social equity and territorial cohesion.
- At EU level, this **deliverable contributes to the European policy agenda on climate adaptation**, supporting the objectives of the EU Adaptation Strategy and the Mission on Adaptation to Climate Change by demonstrating how place-based, participatory approaches to resilience planning can produce results that are both locally relevant and scalable. The experience of the five ClimEmpower regions provides a model for other European territories facing similar climate challenges, and the recommendations are designed to remain flexible across the different institutional, environmental and socio-economic contexts.

Regarding the project's Specific Objectives, this deliverable contributes to:

- **SO5 Empower the regions to activate and enhance their potential for addressing the climate change challenge** (primary contribution), by strengthening stakeholder capacity in the ClimEmpower trial regions through validated resilience strategies. By incorporating the work of the regional CoPs work into a systematic resilience approach, it improves understanding of climate risks and supports better regional governance and planning, enabling regions to take informed, data-driven decisions.
- **SO4, Simplify access to CC data and development of end-user applications**, by complementing the ClimEmpower resilience toolbox with region-specific strategies that were tested in real operational contexts and by improving the usability of climate data, visualisation tools and knowledge resources.
- **SO6, Ensure the use and impact of ClimEmpower outputs**, by ensuring that project results are implemented, replicated and widely adopted, thus helping to scale resilience strategies beyond the initial trial regions through a participatory approach.

2.3 Relation to other work

Task 4.2 builds upon participatory and co-creation activities that were initiated in WP1, through maintenance of regional Communities of Practice (CoPs), organisation of regional workshops and other collaborative activities that were carried out over the course of the project.

Consequently, this **deliverable draws extensively from the work conducted in WP1**, where the Communities of Practice (CoPs) were established and regional vulnerabilities, priorities and stakeholder needs were identified through participatory engagement activities, initially

documented in **Deliverable D1.2** ClimEmpower Scenarios. This work provided the basis for defining the regional contexts, governance challenges and sectoral priorities that informed both the D4.3 “Regional CC-resilience recommendations v1” and their subsequent **refinement through continuous interaction with regional stakeholders** through CoP meetings, training sessions, collaborative exchanges and validation activities that were subsequently organised in WP4 context.

The deliverable is also closely connected to the work carried out in WP2, particularly the **resilience framework and the climate resilience indicators developed in Deliverables D2.2 Climate Change resilience indicators and D2.4 Measures and strategies for increased climate change resilience**. These reports provided the **analytical and methodological basis for understanding regional vulnerabilities, assessing adaptive capacity and supporting evidence-based planning**.

The indicators and resilience dimensions developed in WP2 played a central role in the regional validation and trial activities, enabling stakeholders to assess the relevance and usability of ClimEmpower tools and recommendations within different territorial and sectoral contexts. In particular, a **structured prioritisation exercise** was carried out with CoP members and regional authorities, who were asked to select a maximum of **ten most relevant measures for each region** from the full set of resilience recommendations that were previously defined in Deliverable D2.4.

In parallel, this report is also linked to WP3. The recommendations presented here contribute to improving the usability and operational relevance of WP3 solutions, including resilience indicators, hazard and risk maps, dashboard customization, and real-case scenario simulations.

Furthermore, the deliverable is connected to Deliverable D4.5 “ClimEmpower application and trial specifications”, which defined the trial methodology, regional scenarios, validation framework and data collection procedures that will be used during the community testing and evaluation activities, and thus also to WP3, which focuses on the development of the ClimEmpower platform, decision-support services and visualization tools.

The findings presented in D4.4 already integrate key lessons learned from technical assessments, stakeholder feedback, participatory observations, surveys and collaborative evaluation exercises that were executed in the context of T4.4 “Regional trials and community validation” task, in anticipation of the fully fledged D4.6 “Community testing and validation report”.

Finally, the outputs of this deliverable support the activities planned within WP5, particularly dissemination, exploitation, stakeholder engagement, and replication actions. The validated resilience recommendations, lessons learned, and good practices contribute to policy-oriented communication materials, policy letters and stakeholder engagement activities targeting follower regions and external communities; and will help embed climate resilience considerations into regional governance, planning processes and decision-making frameworks, reinforcing the long-term impact and transferability of ClimEmpower's results.

2.4 Data, security, and ethics

2.4.1 Data interoperability

Deliverable 4.4 integrates the consolidated outcomes of climate resilience assessments, socio-economic impact analyses and region-specific adaptation strategies across the five ClimEmpower case studies. Building on the framework established in D4.3, this deliverable incorporates the results of the iterative co-design phases carried out through the Communities of Practice, regional workshops and stakeholder feedback processes.

Some of the data used to write section 4 builds upon previous and ongoing EU-funded projects, such as DRIVER+ (DRiving InnoVation in Crisis Management for European Resilience), BINGO (Bringing INnovation to onGOing water management), ESPRESSO (Enhancing Synergies for Disaster Prevention in the European Union), ICARIA (Improving Climate Resilience of Critical Assets), KNOWING (Framework for defining climate mitigation pathways based on understanding and integrated assessment of climate impacts, adaptation strategies and societal transformation), and UP2030 (Urban Planning and design ready for 2030). These projects provided insights, methodologies and datasets relevant to climate adaptation, resilience planning and stakeholder engagement.

The resilience recommendations developed are structured across six dimensions (Health & Wellbeing, Population & Education, Economy & Labour Market, Infrastructure, Governance, and Environment, Nature & Settlement Areas), building on the resilience dimensions, indicators and methodological framework described in Deliverable D2.4. They are compiled in an Excel file (.xlsx) developed jointly by task and work package leaders based on input from ClimEmpower partners, CoP participants and external experts. This dataset has been published as an open-access resource on Zenodo (DOI: 10.5281/zenodo.14945632). Opening the file requires Microsoft Excel or other software capable of displaying .xlsx files, such as Apache OpenOffice or Google Sheets.

2.4.2 Data accessibility and reuse:

Primary data sources used to prepare D4.4 consist of the ClimEmpower deliverables listed in the Table 1. All ClimEmpower public deliverables are available for download from the ClimEmpower web site (<https://climempower.eu/results/>), as well as from CORDIS (<https://cordis.europa.eu/project/id/101112728/results>)

Table 1: Data used in preparation of ClimEmpower deliverable D4.4

Data set name		Format	Size	Owner & re-use conditions	Potential Utility within and	Unique ID
Deliverable Community Practice organisation expectations	D1.1 of and	PDF	10,19 MB	Sensitive	Documents the organisation of CoPs	ClimEmpower D1.1
Deliverable ClimEmpower Scenarios	D1.2	PDF	5 MB	Public	Documents the regional needs and expectations at the project start.	ClimEmpower D1.2

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Deliverable D2.1 Climate Change resilience identified data, services, and gaps	PDF	6,02 MB	Public	Documents available data and services, as well as the perceived data gaps.	ClimEmpower D2.1
Deliverable D2.2 Climate Change resilience indicators	PDF	3,73 MB	Public	Documents resilience indicators methodology and proposes concrete indicators.	ClimEmpower D2.2
Deliverable D3.1 ClimEmpower application architecture	PDF	9,65 MB	Public	Documents ClimEmpower application architecture	ClimEmpower D3.1
Deliverable D4.2 Educational materials for increased regional CC resilience v2	PDF	2,6 MB	Public	Documents a rich set of educational materials that were developed and curated by the project.	ClimEmpower 2D4.1
Deliverable D4.3 Regional Resilience Recommendations v1	PDF	2,33 MB	Public	Initial version of this deliverable	On Teams (Project Outputs)

The main data outcome of D4.4 is the set of resilience recommendation letters, published on ClimEmpower web site <https://climempower.eu/> and in the ClimEmpower Zenodo channel <https://zenodo.org/communities/climempower> (Table 2).

Table 2. Data produced in preparation of ClimEmpower deliverable D4.4

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Policy Letters	PDF	1.9 MB	ClimEmpower, CC-BY-NC 4.0 international	Available on ClimEmpower web site and Zenodo. Can be reused and adapted by regional authorities and other stakeholders for climate adaptation planning and governance processes.	10.5281/zenodo.22211630
ClimEmpower Resilience recommendations V1	.xlsx	25.9 KB	ClimEmpower, CC-BY 4.0 international	Resilience recommendations suitable for decision makers	10.5281/zenodo.14945632

2.4.3 Security and Ethics

Resilience recommendations carry significant policy implications: they are linked to decisions on resource allocation and to long-term adaptation strategies that can affect communities and institutions in lasting ways. Addressing this responsibly calls for careful attention to equity, particularly where climate vulnerabilities are unevenly distributed across social groups and territories.

In line with the ClimEmpower project's objectives, all recommendations in this deliverable have been assessed against a Just Transition framework to ensure they are consistent with the principles of fairness, inclusivity and social equity. In D4.4 this assessment was reinforced by the participatory work of the Communities of Practice and the regional validation activities, in which stakeholders directly contributed to refining and prioritising the proposed measures. The region-specific character of the recommendations further supports this aim, since each set of measures has been adapted to the social, economic and territorial conditions of the respective region.

This process reflects the project's commitment to climate adaptation measures that strengthen resilience while also promoting a fair distribution of the burdens and benefits associated with the transition to a climate-resilient society.

Generative AI Assistance: The editing and linguistic polishing of this deliverable, as well as the generation of alternative presentation formats in D4.2, were supported using Generative AI tools. Human expert review was maintained throughout to verify scientific accuracy and alignment with project results

3 ClimEmpower Conceptual and Analytical Framework

This chapter outlines the conceptual and analytical foundations of the Resilience Recommendations developed in ClimEmpower. It provides the theoretical and methodological context for how climate resilience has been conceptualised, operationalised and applied across the project's regions, and serves as a reference for the recommendations presented in the subsequent sections of this deliverable.

Building on the work developed in Deliverable D2.4, the chapter explains how climate resilience is understood within ClimEmpower and how this concept has been translated into an operational framework able to support evidence-based territorial decision-making. This translation required bridging the gap between the broad and often abstract debate on resilience in academic and policy literature and the concrete analytical tools needed to assess vulnerability, identify priorities and formulate actionable recommendations at the local and regional scale, one of the central methodological contributions of the project.

The chapter is structured around three connected themes that constitute the analytical backbone of the ClimEmpower resilience assessment. The first is the definition of resilience adopted by the project, situated within current resilience thinking and clarifying the dimensions and properties the project set out to capture. The second is the process followed to identify, select and structure the resilience indicators used to operationalise these dimensions, including the criteria that guided their development and the procedures adopted to ensure scientific robustness and policy relevance, as well as the data-related limitations encountered, particularly regarding the uneven availability, comparability and resolution of datasets across regions. The third is the participatory mechanisms built into the framework to ensure that the analytical tools and resulting recommendations are grounded in the needs and priorities of the territories involved.

3.1 Definition of Resilience in ClimEmpower (based on D2.4)

The concept of resilience has been debated and refined across a wide range of academic disciplines over the recent decades. Its meaning has shifted from the original ecological interpretation, where it described the ability of ecosystems to return to equilibrium after a disturbance, toward wider applications in urban planning, climate adaptation, disaster risk reduction and territorial governance. This shift reflects a growing recognition that resilience, when applied to complex socio-technical and socio-ecological systems, cannot be reduced to a simple notion of resistance or recovery. In climate research and policy, resilience is no longer understood only as the capacity to withstand a shocks and return to a previous state, but as a dynamic, multidimensional and context-dependent property that allows systems, and the communities to anticipate, prepare for, respond to and progressively adapt to changing environmental conditions and emerging climate risks.

Building on the review of resilience frameworks conducted in Deliverable D2.2, ClimEmpower adopted the IPCC (2022) definition of resilience as the shared reference point for the project:

"The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions."

This definition was chosen because it is independent of any specific hazard type, while still requiring sound knowledge of relevant hazards and their potential impacts and risks to support territorial transformation. It also goes beyond a purely reactive understanding: as the IPCC notes, resilience covers not only the ability to maintain essential function, identity and structure, but also the capacity for transformation. This transformative dimension is relevant to ClimEmpower's aim of producing recommendations that contribute to lasting territorial change rather than short-term solutions.

A distinctive feature of the ClimEmpower approach, developed in D2.4, is its reliance on a quantitative, data-driven assessment of resilience indicators rather than the more common qualitative approach based on expert questionnaires. While qualitative methods capture local knowledge and contextual, they are inherently subjective and dependent on the individuals involved. ClimEmpower draws instead on standardised, openly available datasets to ensure objectivity and comparability across regions, while the qualitative dimension is retained through the Communities of Practice in WP4.

The project also recognises that climate risks rarely occur in isolation; they tend to generate cascading impacts that simultaneously affect multiple dimensions of territorial systems. A severe heatwave, for example, does not only pose direct risks to human health, but also strain energy infrastructure, reduce labour productivity, exacerbate existing social inequalities and expose weaknesses in emergency management systems. Resilience in ClimEmpower is therefore assessed through a multidimensional framework of six dimensions, developed through an extensive literature review, scientific expert input and iterative feedback from the regional Communities of Practice. These were originally defined in D2.4 as: Health & Wellbeing, Population Society & Education, Economy & Labour Market, Infrastructure, Governance Strategy & Planning and Environment Nature & Settlement Areas. In the operationalisation of the resilience recommendations in WP4, and as reflected in the dataset published on Zenodo (DOI: 10.5281/zenodo.14945632), two of these labels have been simplified ("Population, Society & Education" to "Population & Education", and "Governance, Strategy & Planning" to "Governance") to improve usability and accessibility for regional stakeholders and decision-makers. The six dimensions as used throughout this deliverable are:

- **Health & Wellbeing**, focusing on the ability of individuals, communities and healthcare systems to adapt to and recover from the health impacts of climate change, including heat stress, emerging diseases and extreme weather events, with particular attention to vulnerable populations.
- **Population & Education**, addressing the social structure, demographic characteristics and educational preparedness that determine how effectively a community can respond to and recover from climate-related events, including the proportion of the population trained in emergency preparedness and disaster risk reduction.

- **Economy & Labour Market**, examining the capacity of economic systems to remain stable, adapt to disruptions and recover, including the strength and flexibility of economic sectors, financial systems and labour markets, and the ability to support sustainable and future-oriented employment.
- **Infrastructure**, covering critical sectors, transportation, telecommunications, energy, water supply and safety systems, and their capacity to maintain essential services during climate-related events.
- **Governance**, addressing the policies, planning processes and institutional frameworks that shape a region's resilience, including the effectiveness of governance structures and the availability of resources to support adaptation and response.
- **Environment, Nature & Settlement Areas**, focusing on the spatial and land-use conditions that shape exposure and adaptive capacity, including the interaction between natural ecosystems and human settlements, the extent of natural areas, soil impermeability, water stress and the proportion of residential buildings in hazard zones.

Each indicator within these dimensions is also characterised according to five resilience properties defined in D2.4, Reflectiveness, Resourcefulness, Robustness, Flexibility, and Inclusivity, which clarify what aspect of a system's resilience the indicator captures and guide its interpretation in territorial decision-making.

The project also recognises that resilience measures can generate significant co-benefits beyond climate adaptation. Investments in green infrastructure, for example, may improve air quality, enhance biodiversity, reduce urban heat and benefit physical and mental wellbeing. Accounting for these co-benefits allows ClimEmpower to assess resilience actions, aligned with integrated territorial development and in support of for cross-sectoral investment in adaptation.

3.2 Resilience Dimensions, Indicators and Data Gaps

This section presents the resilience dimensions and the associated indicator set developed in ClimEmpower and discusses the main challenges encountered in relation to data availability, comparability, and calculation. By addressing both the analytical outputs and their limitations within the same section, the aim is to ensure methodological transparency and provide an honest account of the robustness of the assessment. This is particularly important in a multi-regional project such as ClimEmpower, where the diversity of territorial contexts, institutional arrangement and data ecosystems, inevitably introduces variability that must be managed and documented.

Following the conceptual definition established in Deliverable D2.4, the multidimensional concept of resilience was translated into an operational framework built on a structured set of measurable indicators. This was necessary to move from theoretical definitions to a spatially explicit, evidence-based assessment capable of supporting territorial decision and targeted recommendations. Designing such a framework for contexts as diverse as the ClimEmpower regions required careful methodological choices, particularly regarding which dimensions to prioritise, which indicators were feasible to compute given available data, and how to maintain cross-regional comparability without losing local relevance. The framework was therefore

conceived not as a rigid standardised tool, but as a flexible structure that could be applied while accommodating the particularities of each territorial context.

Resilience was assessed across the six dimensions introduced in Section 3.1: Health & Wellbeing, Population & Education, Economy & Labour Market, Infrastructure, Governance, and Environment, Nature & Settlement Areas, each reflecting a distinct but interdependent component of territorial systems. These dimensions were structured to capture both the degree of exposure to climate hazards and the underlying capacity of territories to respond, adapt, and restructure over time. Their interdependence is a fundamental aspect of the approach: weaknesses in one dimension can amplify vulnerabilities in others and investments that strengthen resilience in one area often produce positive effects across several at once.

To operationalise these dimensions, each was linked to a set of indicators connected to the main climate hazards analysed in the project; primarily heatwaves, pluvial flooding, environmental vulnerability and socio-economic exposure. In total the framework includes 36 indicators, selected to identify areas of heightened vulnerability, detected critical weaknesses in territorial systems and prioritise intervention areas in a way that could be communicated clearly to local authorities and technical practitioners. Indicators include, among others:

- percentage of impermeable surfaces;
- access to green spaces;
- share of population exposed to heat stress;
- extent of flood-prone areas;
- elderly population distribution;
- availability and redundancy of critical infrastructure;
- socio-economic deprivation indices;
- presence of institutional preparedness measures;
- adaptation planning instruments.

These indicators were not applied uniformly but were weighted and contextualised according to the hazard profiles and territorial characteristics of each region.

The selection process was guided by a combination of criteria:

- scientific relevance and alignment with established resilience assessment methodologies;
- policy applicability and consistency with existing adaptation frameworks at national and European level;
- data availability within the project's timeframe and resources;
- comparability across regions operating under different data ecosystems;
- feasibility of translating results into recommendations that local authorities could realistically act on.

Where possible, preference was given to indicators computable from open or publicly accessible datasets, to support reproducibility, long-term monitoring and replication beyond the project.

The indicator framework so built helps to identify territorial resilience priorities and to support the participatory prioritisation process carried out with local stakeholders and Communities of Practice.

3.3 Role of Communities of Practice in Prioritising Indicators

The quantitative, data-driven approach described in Section 3.2 provides the analytical backbone of the ClimEmpower resilience assessment, but a central methodological choice was to complement this objective layer with a structured participatory process, so that the indicator framework and the recommendations reflect not only what the data shows but also what regional stakeholders consider relevant, feasible and meaningful within their contexts. This role was carried out by the Communities of Practice (CoPs), which acted as the main interface between the analytical work of WP2 and the practical knowledge of local and regional actors.

In ClimEmpower, a Community of Practice is a group of stakeholders sharing a common concern, in this case the challenge of increasing climate resilience, who engage in collective learning by exchanging knowledge and supporting one another. Each CoP brings together a diverse mix of actors: technical experts from government and civil sectors, researchers, industry and private sector representatives, and members of civil society. This diversity was to ensure that project outcomes are scientifically sound, practically useful, and socially relevant at the same time. In each of the five regions, the CoP are coordinated by Case Study Facilitators (CSFs), project partners responsible for managing and supporting community engagement, who ensure active participation, maintain alignment with project objectives and connect the CoPs with other workstreams.

The CoPs contributed to the indicator framework through a dedicated prioritisation process, carried out across all five regions during the second half of the project in close coordination between WP2 and WP4. The methodology, stakeholder feedback and resulting resilience indicator framework are fully documented in Deliverable D2.4. Within the present deliverable, this work provides the basis for the development and contextualisation of the resilience recommendations. The methodological structure was consistent across regions, although each CSF could adapt the format to local conditions, including the choice between in-person and online sessions, the use of paper questionnaires or digital tools, and the organisation of plenary meetings or bilateral consultations.

In Croatia, the CoP meeting was held in person in Osijek, with fifteen participants who completed structured paper questionnaires following an introductory session. In Greece, the session was held online due to a heatwave, with six stakeholders using the Mural application to submit their indicator priorities. In Sicily, the process began with a bilateral meeting between the CSF and the Regional Authority to develop a shortlist of the most relevant indicators, which was then validated during a CoP meeting. In Andalucía, a structured survey was distributed to

local authorities, with each indicator accompanied by a brief explanatory note. In the Troodos Mountains, thirteen mayors representing communities within the Troodos Geopark were contacted and asked to rate indicator relevance on a three-point scale, with a short definition to support consistent interpretation.

The feedback collected served two interconnected purposes. First, it informed the final selection and weighting of indicators enabling the research team to contextualise the assessment according to each region's specific hazard profile, data ecosystem and governance priorities. Second, and more directly relevant to this deliverable, it provided the empirical basis for the region-specific prioritisation of resilience recommendations: CoP members and regional authorities were asked to identify, from the full set of recommendations developed across the six dimensions, up to ten measures most relevant and actionable within their territorial context.

The integration of CoP feedback into the indicator framework is a methodological contribution of ClimEmpower. It shows that data-driven assessments and participatory processes are not competing approaches but complementary layers of a more robust and legitimate knowledge production process. The CoPs did not just validate analytical choices but shaped the direction of the assessment, surfaced local constraints that would not have been visible through just quantitative data, and helped ensure that the final framework remains in the realities of the communities it is meant to serve.

4 From Measures to Resilience Recommendations

This chapter describes the methodological pathway through which the ClimEmpower resilience recommendations were developed, describing how the analytical and participatory work presented in Chapter 3 was translated into actionable outputs for regional decision-makers.

The starting point is Deliverable D2.4, which provided, for each of the 36 resilience indicators across the six dimensions, a set of direct and indirect measures aimed at improving indicator performance. Grounded in scientific literature, risk assessment methodologies and CoP feedback, these measures are the technical foundation on which the recommendations were built. Section 4.1 describes how this indicator-level set was structured and how it informed the first version of the recommendations in D4.3.

Section 4.2 then sets out the methodological approach of D4.4 to refine, validate and operationalise this initial set into the region-specific resilience recommendations. This integrates two levels of input: the quantitative resilience assessment from WP2 and the regional prioritisation carried out through the CoPs. The result is a structured set of recommendations organised by resilience dimension, each linked to the indicator it addresses, characterised by type of action, level of governance and implementation timeframe, and contextualised to the specific conditions of each region.

4.1 From Measures (D2.4) to Recommendations (D4.4)

The resilience recommendations presented in this deliverable are the outcome of a multi-stage process that spans the full arc of the project, from the analytical groundwork of WP2 to the participatory validation activities done in WP4. This section reconstructs that process, clarifying how each step shaped the final outputs of D4.4.

The starting point is Deliverable D2.4, which compiled for each of the 36 resilience indicators a structured fact sheet including a description, the corresponding resilience dimension and characteristics, the relevant datasets for computation and a set of direct and indirect measures for improving indicator performance. These measures were grounded in a systematic review of scientific literature, EU adaptation frameworks and the methodological contributions of previous projects such as BINGO, ESPREsSO and ICARIA. At this stage, the outputs were intentionally cross-regional and general, designed as a universally applicable reference framework rather than territory-specific guidance.

The transition from indicator-level measures to structured recommendations was operationalised in Task 4.3, with outputs documented in D4.3. This first step involved a thematic restructuring: drawing on the priorities identified through the Communities of Practice, D4.3 reorganised the outputs around five sectoral intervention areas: new building construction and retrofitting, blue and green infrastructure, transportation, agriculture and ecosystem conservation, presenting them as structured recommendation tables, one per sector. This made the content more directly usable by regional authorities accustomed to

sectoral planning. At that stage, however, the recommendations remained broadly applicable across all ClimEmpower regions and did not yet include co-benefits, implementation timeframes or categories of intervention. D4.3 therefore represented an intermediate output: a first participatory structuring of the D2.4 measures, designed as the reference point for the deeper elaboration carried out here.

In this deliverable the work advances on several dimensions, the most substantive is a content enrichment: each recommendation is structured to include the proposed action, its environmental, social and economic co-benefits, and a policy roadmap articulated across short, medium and long-term implementation horizons. Recommendations are further organised by category of intervention: Governance, Planning & Finance, Essential Services & Critical Infrastructure, Preparedness, Response & Community Capacity, Economy & Supply Chains, and Health & Social Care, giving decision-makers a layered picture of available actions, governance levels and timeframes. This structure is grounded in the IPCC (2022) framework for climate-resilient development and reflects the project's aim of producing recommendations that are both scientifically robust and practically implementable within existing institutional and policy frameworks. The full dataset is published as an open-access resource on Zenodo (DOI: 10.5281/zenodo.14945632).

4.2 The ClimEmpower Resilience Recommendations Matrix: Methodological Approach and Criteria

The recommendations in this section were developed following a structured methodological approach that integrates quantitative data, participatory inputs, contextual analysis and references to best practices. This section describes the logic behind their construction, the criteria guiding their selection and the framework used to organise and present them.

The core principle of D4.4 is the direct link between resilience indicators and recommendations. Each recommendation is not a generic good practice but a targeted response to a specific indicator value and therefore to a measurable territorial condition. The logic follows three levels of increasing complexity, as developed within Task 4.3. At the simplest level, a low indicator value triggers a set of recommendations aimed at improving that specific dimension of resilience. At the intermediate level, the indicator value is combined with climate hazard information linking, for example, low infrastructure resilience with high flood risk to generate recommendations that address both the structural weakness and the specific hazard context. At the most detailed level, the combination of low resilience, high risk and a specific action type allow targeted interventions filtered by field of application, governance level, and implementation timeframe. This tiered structure means the recommendations can be used at different levels of analytical depth, according to the capacity and needs of each regional authority or decision-maker.

Each recommendation is assigned to one of seven fields of application, which define the type of action required and the institutional actor primarily responsible for it:

- Governance: policy instruments, planning obligations, regulatory standards and institutional coordination mechanisms;
- Planning & Finance: spatial planning instruments, land-use strategies, urban design measures, investment programming and financial mechanisms;

- **Essential Services & Critical Infrastructure:** engineered systems, infrastructure upgrades, nature-based solutions and digital monitoring applied to the networks and facilities on which essential services depend, including health, water, energy, transport and digital infrastructure;
- **Preparedness:** monitoring, surveillance, early warning, contingency planning and strategic stocks that build anticipatory capacity;
- **Response & Community Capacity:** operational emergency response arrangements, together with the training, awareness and volunteer capacity of communities;
- **Economy & Supply Chains:** measures safeguarding economic activity, employment and the continuity of supply chains under climate stress;
- **Health & Social Care:** preventive and curative health measures and social care provisions addressing climate-sensitive health risks.

This classification allows decision-makers to identify not only what actions are recommended, but also through which governance and implementation channels they can be pursued and at what scale.

A distinctive feature of the D4.4 methodology is the systematic characterisation of each recommendation by its co-benefits and its implementation timeline. For each recommendation, three types of co-benefits are identified: environmental (biodiversity enhancement, heat reduction, improved water management), social (improved equity, reduced vulnerability of marginalised groups, community empowerment), and economic (reduced emergency costs, increased property value, labour market benefits). This co-benefit framing, grounded in the IPCC (2022) approach to climate-resilient development, allows ClimEmpower to make the case for cross-sectoral investment in resilience by demonstrating that individual measures generate returns across multiple policy domains at once.

Each recommendation is also associated with a policy roadmap that distinguishes between short-term actions (immediate regulatory or planning steps), medium-term interventions (programme and project implementation), and long-term transformative measures (structural change at the systemic level). This temporal dimension is particularly valuable for regional authorities operating within multi-year planning cycles, as it supports the sequencing and prioritisation of actions within existing strategic frameworks.

The recommendations were selected and structured according to five criteria:

- **Relevance:** alignment with the regional priorities expressed through the CoPs and with the resilience dimensions most critical for each pilot territory.
- **Feasibility:** technical and financial implementability within the governance and resource constraints of regional and local authorities.
- **Impact:** expected contribution to improving the performance of the linked resilience indicator, as supported by scientific literature and regional trial outcomes.
- **Replicability:** potential for the recommendation to be adapted and applied in other European regions.
- **Co-benefits:** capacity to generate positive effects across environmental, social, and economic dimensions, supporting integrated territorial development.

The construction of the recommendations drew on four complementary sources. The quantitative resilience assessment from D2.4 provided the analytical baseline, identifying the indicators and dimensions where each region is more vulnerable. The CoP prioritisation ensured that the selection of recommendations reflects the expressed needs and preferences of regional stakeholders. Finally, references to international best practices and EU-funded project experiences, including BINGO, ESPRESSO, ICARIA, KNOWING, and UP2030, provided a broader knowledge base of strong approaches to adapt to ClimEmpower regional contexts.

The full dataset of recommendations, including detailed descriptions, best practice references, and hazard relevance tags, is available as an open-access resource on ClimEmpower web site and on Zenodo (DOI: 10.5281/zenodo.14945632). The following subsections present, for each of the six resilience dimensions, a contextual introduction and a summary table of the recommendations, organised by indicator and field of application.

Sections 4.2.1 to 4.2.6 constitute the ClimEmpower Resilience Recommendations Matrix. The matrix comprises 90 recommendations, each linked to one of the 36 resilience indicators defined in D2.4 and assigned to one of the seven fields of application listed above. Table 3 gives an overview of its composition; the machine-readable version, including detailed descriptions, best-practice references and hazard relevance tags, is the dataset published on Zenodo.

Table 3: Composition of the ClimEmpower Resilience Recommendations Matrix

Resilience dimension	Indicators addressed	Recommendations
Health & Wellbeing	5	18
Population & Education	8	27
Economy & Labour Market	6	22
Infrastructure	5	11
Governance	5	5
Environment, Nature & Settlement Areas	7	7
Total	36	90

4.2.1 Health & Wellbeing

The Health & Wellbeing dimension addresses the capacity of individuals, communities and health systems to withstand and adapt to the health impacts of climate change. The recommendations target five indicators: hospital bed availability, unmet medical treatment needs, life expectancy, access to first aid and community water storage. They range from climate-proofing health infrastructure and expanding emergency response networks to the development of preventive care programmes and decentralised water supply systems.

The primary hazards addressed across this dimension are heatwaves, which amplify health system demand and mortality risk particularly among elderly and vulnerable populations, and drought, which threatens water supply security and increases the risk of water-borne diseases. Several recommendations also address the cascading health impacts of flood events, including the disruption of emergency services and supply chains for essential medicines.

The co-benefits associated with this dimension are significant. Investments in preventive care and decentralised water infrastructure generate direct social returns by reducing inequities in access to health services and improving quality of life for marginalised groups. Climate-resilient health facilities produce economic co-benefits by reducing emergency response costs and the long-term burden of climate sensitive chronic disease. Recommendations targeting water storage and nature-based solutions also contribute to environmental co-benefits, including improved water cycle regulation and reduced urban heat.

In terms of implementation, short-term actions focus on regulatory and governance steps (establishing minimum hospital bed standards and emergency stock protocols) while medium term interventions address infrastructure investment, telemedicine expansion and preventive care programme deployment. Long term measures target systemic change: the full integration of climate risk into public health planning and the structural redesign of health infrastructure to meet future climate scenarios.

Table 4: Resilience recommendations for the Health & Wellbeing dimension

Indicator	Field of Application	Recommendation
Number of hospital beds per 100,000 inhabitants	Governance	Strengthen climate-resilient hospital bed capacity and emergency preparedness at community level
	Preparedness	Expand capacity through temporary hospital units/ spaces that can be deployable during emergencies
	Planning & Finance	Promote equitable territorial distribution of hospital bed capacity between urban and rural areas
	Essential Services & Critical Infrastructure	Invest in climate-resilient health facilities that are energy efficient and disaster proof
Unmet needs for medical treatments	Economy & Supply Chains	Develop regional stocks of essential medicines to reduce climate-related supply chain disruptions
	Health & Social Care	Invest in preventive care programmes targeting climate-sensitive diseases to reduce future medical treatment needs
	Response & Community Capacity	Expand telemedicine and remote care infrastructure to ensure continuity of medical treatments during disruptions
Life expectancy	Health & Social Care	Promote public health campaigns (nutrition, active mobility, etc.) that reduce chronic disease risks
		Improve life expectancy by integrating climate adaptation into public health prevention
	Preparedness	Integrate surveillance systems to anticipate health risks (e.g. heat mortality, air pollution, disease outbreaks)
	Governance	Identify and address socio-economic inequities that magnify vulnerability

Indicator	Field of Application	Recommendation
Percentage of people with immediate access to first aid	Response & Community Capacity	Expand first aid responder networks, create/expand community-based first aid networks
		Promote public awareness and training
	Preparedness	Expand first-aid coverage and climate emergency response readiness
Community water storage volume (cubic metres)	Essential Services & Critical Infrastructure	Increase decentralised storage capacity (rainwater harvesting, cisterns, aquifer recharge)
		Improve efficiency of water use and reduce leakage in supply systems to improve storage capacity
	Planning & Finance	Integrate nature-based solutions to enhance natural storage and water quality
	Preparedness	Increase and diversify water storage for drought and service disruption resilience

4.2.2 Population & Education

The Population & Education dimension captures the social, demographic and educational conditions that shape a community's ability to anticipate and recover from climate-related events. The recommendations address eight indicators: age group vulnerability, employment rate, population exposure to natural hazards, large family resilience, early warning system coverage, education levels, disaster risk reduction in schools and proximity to essential food services.

The hazards most directly addressed in this dimension are those with the highest exposure impact on vulnerable populations: heatwaves, which disproportionately affect elderly residents and large households with limited resources; pluvial and coastal flooding, which threatens communities in high-risk settlement areas and compound events that simultaneously affect employment, food access and physical safety. The recommendations on early warning systems and disaster risk reduction in schools respond specifically to the need to reduce the human cost of extreme weather events through preparedness and timely information.

Co-benefits are strongest in the social domain: measures that expand early warning coverage, integrate disaster risk reduction into school curricula and support localised food systems contribute simultaneously to community cohesion, educational outcomes and social equity. Economic co-benefits include labour market stabilisation through reskilling programmes and post-disaster employment support. Environmental co-benefits, though less prominent in this dimension, emerge through recommendations that promote food localisation and the development of proximity services aligned with the 15-minute city model.

Short-term actions concentrate on regulatory frameworks (restricting development in hazard-prone areas, mandating disaster risk reduction) and awareness campaigns to promote early warning uptake. Medium term interventions include investment in multi-channel communication infrastructure and support for managed relocation pathways. Long term transformations address structural social vulnerabilities, including the redesign of employment and education systems to build community level resilience capacity.

Table 5: Resilience recommendations for the Population & Education dimension

Indicator	Field of Application	Recommendation
Age groups	Health & Social Care	Targeted climate adaptation for age-related vulnerability
Employment rate – % of active population	Planning & Finance	Establish post-disaster livelihood recovery funds and employment support mechanisms
	Economy & Supply Chains	Support reskilling and upskilling programmes for workers transitioning from vulnerable sectors Strengthen climate-resilient employment through green skills and economic diversification
	Response & Community Capacity	Encourage local job creation through community-based and resilience-focused projects
Percentage of population at high risk from natural hazards	Planning & Finance	Support managed relocation and climate adaptation pathways for high-risk settlements Restrict new housing and infrastructure development in hazard-prone areas
	Response & Community Capacity	Strengthen community-based disaster risk management programmes
	Preparedness	Improve multi-hazard early warning systems and risk communication
	Governance, Planning & Finance	Reduce population exposure through risk-informed land-use, protection, and managed adaptation
Percentage of large families (>= 4 people per family unit)	Response & Community Capacity	Provide integrated parenting support, childcare access, and financial resilience programmes for large families
		Ensure targeted disaster and emergency support for large families (child-friendly shelters, mental health support)
	Health & Social Care	Strengthen climate resilience for large households through housing, cooling support, and emergency preparedness
Percentage of city population covered by multi-hazard early warning	Preparedness	Enhance inclusive early warning system coverage and accessibility Implement public education programs for emergency protocols and warnings Invest in multi-channel emergency communication infrastructure Universal multi-channel early warning system (EWS) integration

Indicator	Field of Application	Recommendation
High education index	Preparedness	Integrate Disaster Risk Reduction (DRR) into all education and training levels
		Promote vocational training for green and resilient employment sectors
		Establish knowledge-sharing platforms for science, policy, and community
		Resilience literacy and knowledge-based risk management
Percentage of schools teaching DRR	Preparedness	Mandate Disaster Risk Reduction in school curricula
		Expand community-led DRR training
		Mainstream DRR in educational curricula
Percentage of population living within 1km of a grocery store	Essential Services & Critical Infrastructure	Incentivise grocery store development in underserved areas
	Economy & Supply Chains	Support localised food systems and community markets
		Secure local food access and “15-minute city” resilience

4.2.3 Economy & Labour Market

The Economy & Labour Market dimension examines the capacity of regional economies to absorb climate-induced disruptions, maintain productive activities and adapt over time. The recommendations address six indicators: food import dependency, sectoral economic diversification, agricultural yield performance, SME resilience, insurance coverage for high-risk hazards and regional GDP.

The hazards most directly addressed are drought and heatwaves, which threaten agricultural productivity and food supply chains, and flooding, which disrupts business continuity and exposes SMEs to uninsured asset losses. Compound events that affect multiple sectors simultaneously (for example, a prolonged drought that reduces both agricultural output and energy availability) are also a key reference for recommendations on economic diversification and strategic investment.

Co-benefits are particularly pronounced in this dimension. Measures supporting smart agriculture and seed diversity generate environmental co-benefits through improved soil health, reduced water consumption and enhanced agrobiodiversity, while also providing social returns in the form of protected rural livelihoods and food security. Recommendations targeting SME resilience and insurance penetration produce economic co-benefits by stabilising local employment and reducing post-disaster recovery costs for both businesses and public budgets. Regional GDP investment recommendations generate spillovers across infrastructure, innovation and institutional capacity.

Short-term actions focus on financial instruments (expanding access to insurance in high-risk zones, establishing emergency liquidity mechanisms for SMEs) and regulatory steps to align

agricultural policy with climate adaptation objectives. Medium-term interventions address supply chain diversification, the scaling of smart practices and investment in green and innovative growth sectors. Long term transformations target systemic economic restructuring: the full integration of climate risk into regional development strategies and investment frameworks.

Table 6: Resilience recommendations for the Economy & Labour Market dimension

Indicator	Field of Application	Recommendation
Food import dependency	Economy & Supply Chains	Strengthen local agri-food supply chains to reduce food dependence on food imports
		Promote agricultural diversification
	Planning & Finance	Enhance sustainable food systems
% of economic output attributed to different sector	Economy & Supply Chains	Diversify regional economy to reduce dependency on single sectors
		Strengthen intersectoral linkages and economic spillover effects
	Planning & Finance	Invest in sustainable and innovative growth industries
Crop production & yield (Total production, yield per hectare, seed variety performance)	Economy & Supply Chains	Climate-smart agriculture & seed diversity transition
	Planning & Finance	Facilitate access to finance for SMEs
Percentage of SME businesses relative to total number of businesses	Economy & Supply Chains	Provide infrastructure for SME growth and innovation
		Strengthen the broader SME support ecosystem
	Response & Community Capacity	SME business continuity and resilience support networks
Percentage of properties with insurance coverage for high-risk hazards	Planning & Finance	Expand access to affordable insurance in high-risk zones
		Integrated disaster risk financing and insurance penetration
	Governance	Implement mandatory insurance schemes for hazard-prone properties

Indicator	Field of Application	Recommendation
	Preparedness	Launch hazard awareness campaigns to promote insurance uptake Strengthen public insurance and financial literacy
Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values	Planning & Finance	Invest in productive sectors and resilient infrastructure for economic growth
	Economy & Supply Chains	Foster innovation and entrepreneurship to increase regional GDP
	Governance	Support comprehensive regional development and institutional capacity
	Essential Services & Critical Infrastructure	Strategic investment in regional resilience infrastructure Diversify community access and exit routes

4.2.4 Infrastructure

The Infrastructure dimension covers the robustness and adaptability of critical systems that must remain functional. The recommendations address five indicators: transport route availability, infrastructure age, emergency communication equipment, energy provision for critical facilities and public investment in maintenance.

The primary hazards addressed are flooding, which disrupts transport connectivity and threatens the operational continuity of critical facilities and compound climate events that overload energy and communication systems simultaneously. The age of infrastructure is treated as a cross-cutting vulnerability factor: ageing networks are more exposed to all hazard types and less capable of adaptive response.

Co-benefits in this dimension are concentrated in the economic and social domains. Modernisation of transport infrastructure and investment in off-grid energy systems reduce long term maintenance costs, improve service reliability and generate employment in construction and technical sectors. Environmental co-benefits emerge from the promotion of nature-based flood management measures alongside structural infrastructure upgrades.

Short term actions include regulatory requirements for infrastructure resilience standards and investment in emergency communication equipment. Medium term interventions address the systematic modernisation of ageing networks and the deployment of off-grid energy systems for critical facilities. Long term transformations target the full integration of climate risk into infrastructure planning cycles and public investment frameworks.

Table 7: Resilience recommendations for the Infrastructure dimension

Indicator	Field of Application	Recommendation
Number of land transport routes to enter/exit community	Essential Services & Critical Infrastructure	Reducing the mean age of infrastructure through modernisation programmes Risk-resilient transport infrastructure Promoting multimodal transport connectivity
Average age of infrastructure e.g the water supply network, road network, electrical grid	Response & Community Capacity	Strengthening communication systems for emergency
	Essential Services & Critical Infrastructure	Strengthening infrastructure maintenance and monitoring
Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event	Essential Services & Critical Infrastructure	Promote off-grid energy systems for critical infrastructure
	Response & Community Capacity	Strengthening emergency communication preparedness
Percentage of critical facilities served by off-grid energy	Planning & Finance	Increase investment in maintenance and upgrading of urban services
	Essential Services & Critical Infrastructure	Promote resilient decentralised energy systems Protect critical energy infrastructure
Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget	Planning & Finance	Promoting the adoption of local flood risk management plans

4.2.5 Governance

The Governance dimension reflects the institutional frameworks, planning instruments and coordination mechanisms through which climate adaptation is delivered. The five recommendations in this dimension, one per indicator, target flood risk management planning, hazard mapping, community participation in preparedness, emergency response governance and structural disaster risk protection.

Governance is treated in ClimEmpower as the enabling condition for all remaining dimensions: without effective governance structures, measures in health, economy, infrastructure and environment cannot be implemented at the pace and scale that climate change demands.

Co-benefits from governance measures are systemic. Strengthening emergency response coordination and community participation in preparedness generates social co-benefits through increased trust, civic engagement and community cohesion. Making hazard maps publicly available and up to date produces economic co-benefits by informing private investment decisions and reducing uninsured losses. Structural risk reduction measures protect property values and reduce the long-term fiscal burden on public budgets.

Short-term actions focus on regulatory requirements and on establishing community preparedness networks. Medium-term interventions strengthen inter-institutional coordination and invest in the governance infrastructure required for adaptive management. Long-term transformations address the full mainstreaming of climate risk into regional and national institutional frameworks.

Table 8: Resilience recommendations for the Governance dimension

Indicator	Field of Application	Recommendation
Percentage of municipalities with local flood risk management plans	Governance	Making hazard maps available and up to date
Availability of hazard maps	Preparedness	Encourage public participation in disaster preparedness initiatives
% of population who actively participate in a local organisation that aims to prepare for disasters	Preparedness	Enhancing community participation in disaster preparedness and local resilience networks
Existence of emergency response organisation	Governance	Strengthening emergency response governance and coordination
% of population protected by structural disaster risk measures for hazards	Essential Services & Critical Infrastructure	Enhancing population protection through structural risk reduction measures

4.2.6 Environment, Nature & Settlement Areas

The Environment, Nature & Settlement Areas dimension addresses the spatial and land use conditions that shape a region's exposure to climate hazards and its capacity for natural regulation. The seven recommendations in this dimension, one per indicator, target soil sealing, natural area coverage, groundwater overexploitation, water stress, preservation of undeveloped hazard areas and residential exposure in danger zones.

The hazards most directly addressed are pluvial and fluvial flooding, which are amplified by soil impermeability and encroachment on hazard-prone areas, drought and water stress, linked to groundwater overexploitation and land-use patterns that reduce natural water retention, and urban heat, exacerbated by the progressive reduction of natural and vegetated

surfaces. The recommendations in this dimension use planning and governance instruments as the primary lever for reducing territorial exposure before hazard events occur, rather than responding to them after the fact.

Environmental co-benefits are the most pronounced in this dimension: protecting natural areas, reducing soil sealing and managing groundwater sustainably all contribute simultaneously to biodiversity conservation, air and water quality, carbon sequestration and urban cooling. Social co-benefits include improved access to green spaces and the protection of communities from flood and landslide risk. Economic co-benefits emerge from the long-term reduction of disaster response costs and from the ecosystem services that well-managed natural areas provide to local economies.

Short-term actions include land-use regulatory measures and the establishment of groundwater monitoring systems. Medium-term interventions address the restoration of natural areas and the scaling of nature-based solutions for water retention and urban heat reduction. Long-term transformations target the structural realignment of spatial planning systems with climate adaptation objectives, ensuring that territorial development patterns remain within the bounds of ecological and hydrological resilience.

Table 9: Resilience recommendations for the Environment, Nature & Settlement Areas dimension

Indicator	Field of Application	Recommendation
Surface impermeability (and related indices) (Annual soil impermeability index)	Planning & Finance	Reducing soil sealing to enhance urban climate resilience
Percentage of natural areas	Planning & Finance	Enhancing climate resilience through the protection of natural areas
Percentage of groundwater bodies in poor condition due to overexploitation	Governance	Reducing groundwater overexploitation to strengthen water resilience
Water stress index	Governance	Reducing systemic water stress through adaptive water governance
Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	Planning & Finance	Limiting exposure by preserving undeveloped high-hazard areas
'Settlement areas in danger zones': Proportion of residential buildings in a hazard zone	Planning & Finance	Reducing residential exposure in hazard-prone areas
Change in the percentage of built and altered surfaces compared to 20 years ago	Planning & Finance	Managing long-term land take to reduce climate exposure

5 Translating Climate-Resilience Recommendations into Land-Use Planning Action

The resilience indicators, measures and recommendations developed within ClimEmpower provide a structured basis for identifying regional vulnerabilities and defining potential adaptation responses. However, an additional methodological step is required to connect this information to the territorial systems and planning instruments through which climate-resilience actions can be implemented. Climate risks do not affect territories in an abstract or uniform manner: the same hazard may generate substantially different consequences depending on the exposed system, the spatial context and the institutional mechanisms available for intervention.

To address this translation challenge, a complementary methodological framework was developed within ClimEmpower and subsequently formalised by Xekalakis et al. (2026) as the Hazard–Sector Translation Framework (HSTF). The framework provides a planning-oriented structure for linking regional climate-risk conditions with affected territorial systems, land-use domains, recommendation families, planning instruments and intended resilience functions.

The HSTF does not replace the resilience dimensions, indicators or recommendations presented in the preceding chapters. Rather, it provides an additional analytical layer through which these outputs can be interpreted from a spatial-planning perspective. In this sense, the six ClimEmpower resilience dimensions used in D4.4 remain the primary structure for organising the project recommendations, while the HSTF identifies the territorial interfaces through which selected recommendations may become relevant for land-use and infrastructure planning.

The methodology was developed through a qualitative cross-regional synthesis of the five ClimEmpower regions: Sicily, Costa del Sol, Osijek-Baranja County, Central Greece and the Troodos Mountain Range. These regions were treated as contrasting territorial archetypes rather than as directly comparable risk cases, allowing the methodology to examine whether heterogeneous climate-risk contexts could be interpreted through a common planning logic while preserving their regional specificity.

5.1 Methodological Positioning and Analytical Rationale

Climate-risk assessments commonly identify the hazards affecting a region, such as heatwaves, drought, flooding, wildfire, water scarcity or extreme weather. Although this information is essential for understanding regional exposure, a simple inventory of hazards does not in itself indicate how planning systems should respond. For land-use planning purposes, the relevant question is not only which hazard is present, but also through which territorial system the hazard produces consequences and where planning intervention is possible.

The HSTF therefore adopts the concept of a hazard pathway. A hazard pathway describes the dominant relationship through which a climate-related pressure interacts with an exposed

territorial system and creates a consequence relevant to planning. For example, extreme heat can affect dense urban areas through building performance, public-space conditions and energy demand, whereas the same climatic pressure can affect agricultural systems through soil-moisture depletion, crop stress and irrigation demand. Similarly, wildfire may become a planning issue through forest management, rural settlements, transport accessibility, evacuation capacity and tourism safety.

This pathway-based interpretation allows climate-risk information to be connected to the sectors and spatial systems through which practical intervention is possible. The methodology therefore moves from the identification of climate pressure toward the identification of the affected system, the relevant planning domain and, ultimately, an appropriate recommendation and implementation mechanism.

The approach is particularly relevant to ClimEmpower because the project combines climate information, resilience indicators, stakeholder-derived regional needs and practical recommendations. The HSTF provides a structured method for bringing these different evidence streams together without assuming that all ClimEmpower regions face the same risks or require identical adaptation measures.

5.2 Empirical Basis and Cross-Regional Analytical Design

The methodological development was based on ClimEmpower material generated through several complementary project activities. These sources were not treated as equivalent datasets; rather, each provided a different type of evidence required for the analytical process.

Community of Practice documentation and stakeholder-engagement material provided information on regional conditions, adaptation gaps, stakeholder priorities, perceived implementation barriers and locally relevant climate-resilience needs. Regional resilience recommendation material provided the main basis for identifying and grouping adaptation actions. The climate-resilience measures and indicators developed within WP2 supported the interpretation of hazards, exposed assets, indicator relevance and intended resilience functions. Technical material related to climate-data processing, indicator classification and recommendation-assignment logic supported the traceability of the framework, while trial and application material informed its positioning in relation to stakeholder validation and practical implementation.

The five ClimEmpower regions were selected as contrasting cases because they represent substantially different territorial configurations. Sicily is characterised primarily by an urban heat–pluvial flooding–water scarcity interaction; Costa del Sol combines coastal development and tourism with drought, water scarcity, flooding and wildfire pressure; Osijek-Baranja County represents an agro-ecological and wetland system affected by drought, heat, flooding and hail; Central Greece combines wildfire, flood, drought, heat and productive-sector pressures; and the Troodos Mountain Range represents a mountain socio-ecological system in which wildfire, water stress, agriculture, protected ecosystems, rural settlements, transport accessibility and tourism are closely interconnected.

The purpose of the cross-regional analysis was therefore not to rank the five regions according to hazard severity or vulnerability. Instead, the regions were used to examine how different

climate pressures become planning-relevant through different territorial systems and whether those relationships can be organised through a common analytical structure.

5.3 The Hazard–Sector Translation Sequence

The HSTF follows a sequential analytical process consisting of six interconnected elements:

1. Hazard pathway. The dominant relationship between climate pressure and territorial consequence is identified. This goes beyond listing individual hazards and focuses on the mechanism through which climate conditions become relevant for spatial planning. Where several hazards coexist, the pathway describes the principal planning relationship rather than attempting to reproduce the entire regional hazard inventory.

2. Affected territorial system. The analysis identifies the spatial, ecological, infrastructural or socio-economic systems through which the hazard pathway produces relevant consequences. Depending on the regional context, these systems may include buildings, drainage networks, agricultural land, wetlands, forests, protected areas, transport networks, rural settlements, tourism assets, water systems or public-safety infrastructure.

3. Land-use resilience domain. The affected system is connected to the planning interface through which intervention can be organised. Across the five regions, the analysis identified five recurring land-use resilience domains: buildings, agriculture, blue-green infrastructure, transportation and protected-area conservation.

These five domains should be understood as spatial-planning interfaces and not as replacements for the six ClimEmpower resilience dimensions used to organise the recommendations in D4.4. The two structures operate at different analytical levels: the resilience dimensions provide the broader project framework for characterising regional resilience, while the HSTF domains identify the territorial sectors through which selected climate-resilience recommendations can be translated into land-use action.

4. Recommendation family. Individual adaptation measures are grouped according to their common planning purpose. Building-related recommendations may, for example, address passive cooling, thermal performance, water efficiency or flood-sensitive design. Agricultural recommendations may include efficient irrigation, crop adaptation, soil-water conservation and climate-informed scheduling. Protected-area recommendations may include habitat restoration, ecological connectivity, wildfire prevention, ecosystem monitoring and adaptive management.

Grouping individual measures into recommendation families helps avoid treating adaptation as a disconnected catalogue of individual actions and instead identifies coherent intervention strategies linked to specific territorial problems.

5. Planning instrument. Each recommendation family is associated with the planning or governance mechanisms through which implementation could be pursued. Depending on the institutional context, these may include building standards, zoning provisions, urban-regeneration programmes, water-sensitive planning guidelines, agricultural advisory services, rural-development plans, protected-area management plans, transport-continuity plans, civil-protection plans or visitor-management strategies.

The framework identifies the type of planning instrument that may provide an implementation pathway; the detailed legal competence, institutional responsibility and feasibility of individual

instruments must subsequently be assessed within the relevant national and regional governance context.

6. Resilience function. Finally, the intended contribution of the intervention to resilience is explicitly stated. Resilience functions may include reducing exposure, lowering vulnerability, improving adaptive capacity, maintaining service continuity, supporting recovery or protecting ecosystem services.

The resulting sequence establishes a traceable relationship between the initial climate-risk condition and the intended planning outcome:

Hazard pathway → Affected territorial system → Land-use domain → Recommendation family → Planning instrument → Resilience function

This structure constitutes the core of the Hazard–Sector Translation Framework (Figure 3) and provides a common analytical language through which heterogeneous regional climate-risk information can be transformed into sector-specific and territorially relevant planning recommendations.

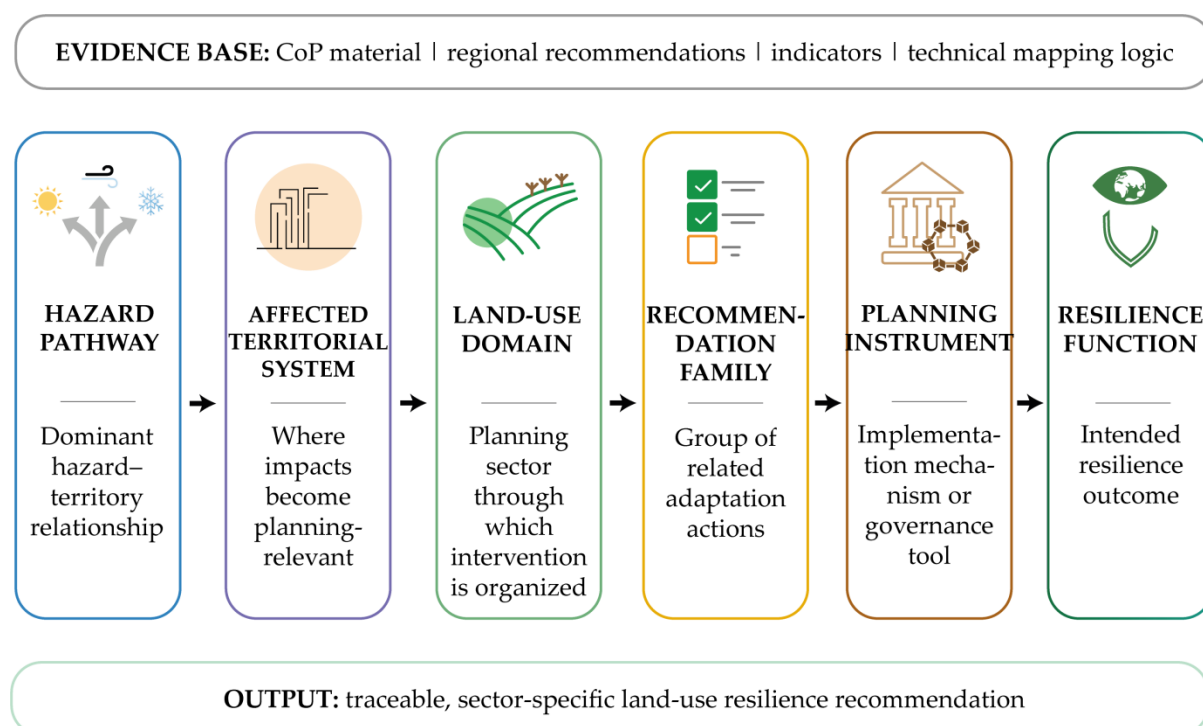


Figure 3: Aggregated Hazard–Sector Translation Framework (Xekalakis et al., 2026)

5.4 Shared Land-Use Domains and Regional Specificity

A central outcome of the cross-regional analysis was that highly heterogeneous climate-risk conditions can nevertheless converge around a relatively limited number of planning interfaces. Buildings, agriculture, blue-green infrastructure, transportation and protected-area conservation repeatedly emerged as the principal territorial domains through which climate pressures can be addressed.

This convergence does not imply that the same interventions should be implemented in every region. On the contrary, the methodology is designed to maintain regional specificity. The

same land-use domain may respond to substantially different hazard pathways and perform different resilience functions depending on the local context.

For example, blue-green infrastructure may be particularly relevant in an urban context for reducing pluvial runoff and urban heat, while in an agricultural or wetland landscape it may contribute to water retention, ecological connectivity and ecosystem conservation. Transportation may function primarily as a mobility system under normal conditions, but in wildfire- or flood-prone regions it also becomes a critical component of evacuation, emergency access and service continuity.

The five land-use domains therefore provide a common structure for comparison without imposing uniform adaptation strategies across the ClimEmpower regions. This distinction between a shared analytical structure and region-specific intervention pathways is fundamental to the transferability of the methodology.

The cross-regional synthesis also demonstrated that governance, institutional capacity, training, data availability and coordination should not be treated as an additional land-use domain. Instead, they operate as cross-cutting enabling conditions that influence whether technically appropriate recommendations can move from analysis to implementation.

5.5 Traceability, Quality Control and Implementation Conditions

A key methodological objective of the HSTF is to strengthen the traceability of climate-resilience recommendations. Each recommendation should be interpretable in relation to the regional climate-risk pathway that motivates it, the territorial system affected and the planning domain through which action is proposed. This reduces the risk of producing generic adaptation catalogues in which measures are presented without a clear explanation of why they are relevant to a particular territory.

Quality control in the methodological development was based on several complementary checks. First, internal consistency was assessed by ensuring that each identified hazard pathway was connected to a clearly defined affected territorial system before being associated with a recommendation. Second, the same analytical sequence was applied across all five ClimEmpower regions to support cross-regional consistency. Third, recommendation families and planning relationships were cross-checked against the underlying project recommendation and indicator material. Finally, the analytical categories were refined iteratively to maintain a common framework while preserving regional differences.

The methodology is qualitative and planning-oriented. It does not calculate hazard probability, exposure values, vulnerability indices, expected economic losses or cost-effectiveness. Nor does it determine automatically whether a proposed intervention is legally, financially or institutionally feasible. These aspects require complementary hazard assessment, spatial analysis, legal review, feasibility analysis and consultation with the competent regional and local authorities.

Governance therefore represents an important implementation condition throughout the translation process. Institutional mandates, legal competence, technical capacity, available funding, stakeholder acceptance and long-term monitoring can determine whether a recommendation that is technically appropriate can be transformed into an operational planning action.

For this reason, the HSTF should be interpreted as a methodological bridge between climate-risk knowledge and planning action rather than as a substitute for established risk-assessment or planning procedures.

5.6 Role of the Framework within the Climate-Risk-to-Planning-Action Chain

Within the wider ClimEmpower methodological architecture, the HSTF occupies an intermediate position between climate-risk and resilience assessment and the subsequent design and uptake of planning actions (Figure 4).

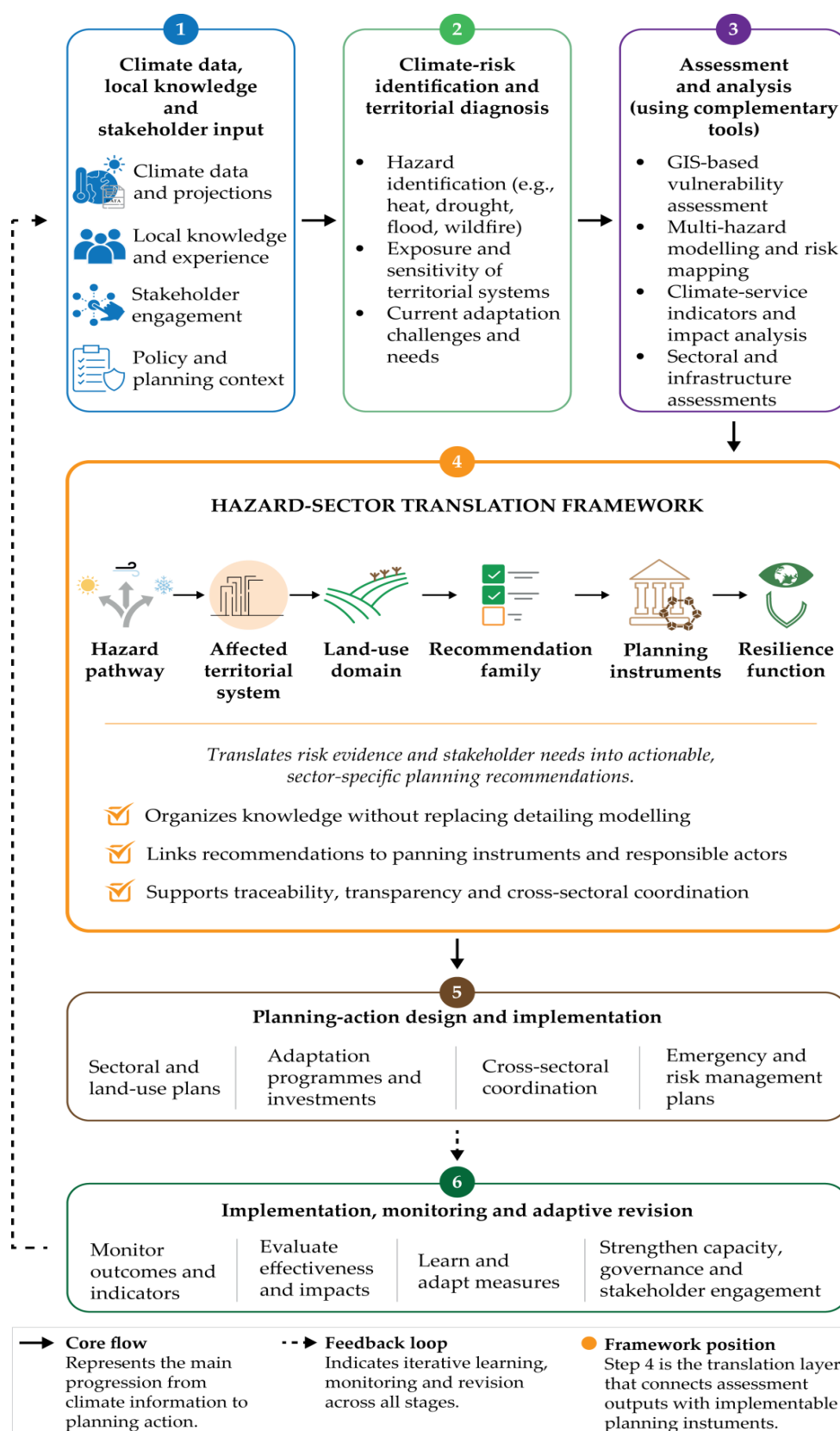
Climate data, resilience indicators, local knowledge and stakeholder input provide the evidence needed to identify climate pressures and regional vulnerabilities. GIS-based analysis, risk mapping, climate services and other assessment methods can further characterise exposure, vulnerability and hazard intensity. The HSTF then reorganises this evidence into hazard pathways, affected territorial systems, land-use domains, recommendation families, planning instruments and intended resilience functions.

The resulting structure can subsequently support the development of planning measures, implementation programmes and policy-oriented communication products. In the context of D4.4, this provides a methodological connection between the resilience recommendations described in Chapter 4 and the policy-uptake mechanisms presented in the following chapter.

The framework can be applied under different levels of data and institutional capacity. In data-rich regions, it can be used after detailed climate-risk or GIS-based assessments to translate analytical findings into planning-relevant intervention structures. In regions where quantitative information remains incomplete, it can support the preliminary organisation of stakeholder knowledge, available indicators and identified territorial problems. It may also be applied during participatory planning processes to maintain a transparent connection between stakeholder priorities, scientific evidence and proposed planning actions.

The methodology is therefore intended to be transferable without being prescriptive. Its analytical sequence can be applied consistently across different territorial contexts, while the specific hazard pathways, affected systems, recommendations and planning instruments remain defined by local environmental, socio-economic and governance conditions.

The HSTF thus complements the broader ClimEmpower resilience framework by providing an explicit territorial translation step. It supports the transition from understanding regional climate-resilience conditions to identifying where intervention is needed, which type of action is appropriate, through which planning mechanism it may be implemented and what resilience function it is expected to support. This methodological linkage provides the basis for the policy-uptake approaches discussed in the following chapter.



Note: The framework complements, rather than replaces, modelling, assessment and planning tools. It can be applied before detailed modelling, after analytical assessment, or in parallel with participatory planning.

Figure 4: Position of the Hazard–Sector Translation Framework within the climate-risk-to-planning-action chain (Xekalakis et al., 2026)

6 Policy Uptake

This chapter addresses the translation of the ClimEmpower resilience recommendations into policy-oriented outputs designed to support decision making at regional and local level. It describes how the recommendations, developed through the iterative co design and participatory validation work, have been operationalised into two complementary forms: **Policy Letters**, conceived as concise and actionable tools for decision-makers, and **climate services integrated into the ClimEmpower platform, which embed the recommendations in an operational digital environment connected to resilience indicators and data**. The selection of recommendations to be developed as Policy Letters was based on a structured prioritisation exercise carried out with CoP members and regional authorities. Each region was invited to select a maximum of ten recommendations from the full matrix, identifying those considered most relevant in their territorial context. The recommendations prioritised for Policy Letter production are those that attracted shared interest across multiple regions, reflecting a cross-regional consensus on the measures considered most urgent and transferable. This approach ensures that the Policy Letters produced represent not only locally significant outputs but also a common ground of priorities that can inform climate adaptation planning across different European territorial contexts.

6.1 Policy Uptake: from Recommendations to Policy Letters and Decision-Making

The resilience recommendations developed in ClimEmpower are designed to be both scientifically grounded and directly usable by the regional authorities, planners and practitioners who participated in the Communities of Practice. Policy Letters are the primary instrument through which this usability is realised at the level of policy communication. As illustrated in Figure 5, policy letters are designed as attractive and easy to read four-page briefs that can be handed out directly to policy makers and key stakeholders.



Figure 5: Example of a ClimEmpower policy letter (PL_48, cover and policy actions pages)

Each Policy Letter addresses a single prioritised recommendation, identified by the resilience indicator it responds to and by its field of application. The letters are traceable to the corresponding rows of the recommendations matrix in section 4.2. They are available for download from ClimEmpower web site (<https://climempower.eu/results/>) and from Zenodo (<https://zenodo.org/communities/climempower>).

Because selection followed cross-regional convergence rather than the structure of the framework, the resulting set is not evenly distributed across it. Five of the six resilience dimensions are represented: Health & Wellbeing, Population & Education, Economy & Labour Market, Governance, and Environment, Nature & Settlement Areas. The Infrastructure dimension is not covered by a Policy Letter; its recommendations remain available in the matrix in section 4.2 and in the published dataset. Annex A lists the full set.

The format of each Policy Letter is consistent across the full set and includes the following elements:

- an executive summary that frames the climate challenge the recommendation addresses;
- the field of application within the six-dimension resilience framework;
- the policy recommendation itself, stated as a clear and actionable directive;
- a set of key policy actions, articulated across governance, regulatory, technical and capacity-building dimensions;

- an implementation roadmap structured across four phases: assessment, policy deployment, scaling and monitoring, each corresponding to a different horizon of action;
- the expected co-benefits across environmental, social and economic domains;
- the relevant EU and national funding instruments through which the measure can be financed;
- references to scientific sources, EU frameworks and operational tools supporting implementation.

This structure ensures that each Policy Letter is self-contained and immediately usable, addressed primarily to regional and local authorities.

6.2 Climate Services and Resilience Recommendations in the Platform

In parallel with the Policy Letters, the resilience recommendations have been integrated into the ClimEmpower Decision Support platform (<https://m4d-operational.iti.gr/clim-empower/>), as illustrated in Figure 6.

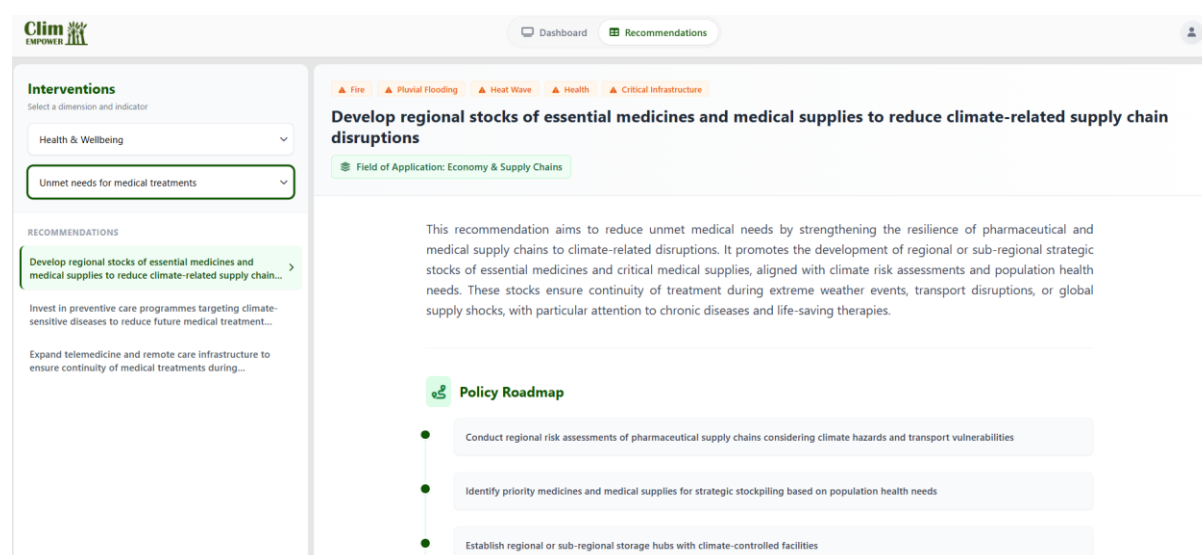


Figure 6: ClimEmpower resilience recommendations on DSS platform

This integration ensures that the recommendations are not only available as standalone documents but are embedded in an operational environment where they can be accessed alongside the resilience indicators, hazard and risk maps, and scenario simulations that informed their development.

Within the platform, recommendations are linked to the indicators they address, allowing users to move directly from a diagnosis of territorial vulnerability to the corresponding set of proposed actions. This connection between data, indicators and recommendations supports a more coherent and evidence-based approach to adaptation planning, making it possible for regional authorities and other end-users to explore options that are directly grounded in the conditions of their territory.

The integration of recommendations into the platform also reinforces their long-term accessibility. Rather than remaining static outputs tied to the project lifecycle, they become part of a living digital environment that can be updated, expanded and used by regional stakeholders beyond the project end, in line with the sustainability objectives of ClimEmpower.

6.3 Educational Manuals and Web Tools

To further support regional decision-makers, lead planners, and technical officers in operationalising the resilience recommendations and applying the **Hazard–Sector Translation Framework (HSTF)**, ClimEmpower team has developed a suite of practical educational resources, interactive web tools, and decision-support guides (Deliverable D4.2 “ClimEmpower Educational Library”).

ClimEmpower educational materials are available for download from ClimEmpower web site (<https://climempower.eu/>) and from the ClimEmpower Zenodo community feed (<https://zenodo.org/communities/climempower>).

Most relevant materials include:

6.3.1 HSTF learning manuals

- **Converting Climate Risks into Actionable Land-Use Plans**
 - Target Audience: Lead planners, technical officers, civil-protection authorities, and environmental managers.
 - Scope: An in-depth manual (87 pages, including a 16-page annex with practical planning exercises, worksheets, and readiness checklists) walking technical teams through the six-step HSTF sequence across five shared land-use domains (*Buildings, Agriculture, Blue-Green Infrastructure, Transportation, Protected-Area Conservation*). Includes governance-readiness checks, ethical/equity screens, and a case study of the Troodos mountain region in Cyprus.
- **Converting Climate Risks into Actionable Land-Use Plans: A Concise Guide for Regional Decision-Makers**
 - Target Audience: Mayors, senior policymakers, regional directors, and executive officials.
 - Scope: A condensed decision-maker edition (~60-minute reading time) retaining the principal HSTF methodology while focusing on executive oversight, governance readiness, legal competence, and funding pathways.

6.3.2 Complementary Courses and Guides:

- **Introduction to Climate Risk Assessment:** a high-level introduction in IPCC risk framework, risk mapping principles, and social equity considerations, targeting policy makers and high level decision makers that need to understand the what risk maps really represent and how they are made.
- **From Indicators to Action: Assessing Regional Climate Resilience:** A practical guide on evaluating 35 regional resilience indicators, bridging data gaps, and linking quantitative metrics with local Community of Practice feedback.

6.3.3 Discovery Frameworks & Multimodal AI Formats

- **Sectoral Recommendations Portal** (<https://climempower.eu/recommendations-presentation/>): An interactive, web-native interface where stakeholders can explore the full matrix of resilience recommendations filtered directly by sector (New and Existing Buildings, Agriculture, Blue and Green Infrastructures, Transportation, and Protected Areas Conservation).
- **Navigational Matrices** (Hazard–Sector Matrix: <https://climempower.eu/edu-hazard-sector-matrix>, User–Dimension Matrix: <https://climempower.eu/edu-user-dimension-matrix>): Interactive, grid-based filtering interfaces that map climate knowledge along specific thematic axes. The Hazard–Sector Matrix cross-references climate hazards (e.g., floods, droughts, heatwaves) with socio-economic sectors (e.g., agriculture, health, infrastructure), while the User–Dimension Matrix maps target audience roles (e.g., planners, decision-makers, educators) against climate resilience dimensions. Together, these matrices allow users to discover and filter a curated library of over 200 third-party educational materials and project resources tailored to their specific regional needs.
- **Multimodal AI Formats**: Alternative, AI-generated content representations—including mind maps, infographics, slide decks, video presentations, audio podcasts, flashcards, and quizzes that translate project deliverables (<https://climempower.eu/deliverables/>) and educational guides (<https://climempower.eu/education-about-results/>) into visual, auditory, and self-assessment formats to support different learning styles.
- **Conversational ClimEmpower AI Assistant** (<https://climempower.eu>): An interactive Large Language Model chatbot² pretrained on project knowledge and deliverables, allowing users to query project outputs and educational resources through natural language dialogue.

² AI-generated responses and summaries may contain inaccuracies, omissions, or hallucinations. Users are advised to double-check all information generated by the chatbot against source materials.

7 Conclusions

Deliverable D4.4 (v2.1) marks a critical evolution in the ClimEmpower framework, transitioning regional climate resilience from abstract risk assessments and generic inventories of adaptation measures into traceable, policy-ready, and spatially enforceable interventions. By combining quantitative indicator modelling with participatory Community of Practice (CoP) validation across five pilot territories, the deliverable establishes an operational blueprint designed to bridge the long-standing "translation gap" between climate science and everyday public administration.

The substantive meaning of this second deliverable version rests on the integration of its **three primary outputs**:

- 1) **Analytical Rigour and Systemic Scope (The Recommendations Matrix):** Reorganising the 90 co-designed recommendations across six systemic dimensions and seven fields of application grounds climate adaptation in the IPCC Climate Resilient Development paradigm. Rather than treating resilience as isolated technical fixes, each recommendation connects physical risk reduction with environmental, social, and economic co-benefits, structured across short-, medium-, and long-term policy horizons.
- 2) **Spatial Traceability and Governance Alignment (The HSTF):** The formalisation of the Hazard–Sector Translation Framework (Section 5) provides the missing methodological bridge connecting climate risk pathways to statutory spatial planning instruments. By requiring every recommendation to specify an affected territorial system, an active land-use domain, a legal authority, and an expected resilience function, the HSTF ensures that technical recommendations pass rigorous governance readiness, legal competence, and financial checks before implementation.
- 3) **Executive Policy Communication (The Policy Letters):** Distilling top regional priorities into ten self-contained, four-page Policy Letters (Section 6.1 and Annex A) transforms complex scientific evidence into direct regulatory and investment directives for mayors, regional directors, and policymakers.

To further increase the usability of these three primary outputs, Sections 6.2 and 6.3 connect them to an interactive operational environment: the online Decision Support System (DSS) platform and the step-by-step training manuals, discovery matrices, and conversational AI tools of the ClimEmpower Educational Library (Deliverable D4.2). Together, this ecosystem ensures that European regions possess both the empirical justification and the practical tools required to execute, fund, and monitor lasting climate resilience strategies

8 Beyond ClimEmpower

With the completion of the ClimEmpower project, the focus shifts from framework development and pilot testing to long-term policy impact, autonomous regional application, and widespread uptake across European territories.

8.1 Anticipated Long-Term Impacts

- **At Regional Level:** The primary impact is the empowerment of regional and local authorities to move beyond static climate hazard maps toward systemic, multi-sectoral adaptation. By adopting the 90-recommendations dataset, resilience recommendation letters and the Hazard–Sector Translation Framework (HSTF), municipal and regional planning bodies can integrate evidence-based climate resilience directly into statutory planning instruments, zoning regulations, building codes, and municipal capital budgets.
- **At European Level:** The project contributes a scalable, place-based methodology to the **EU Adaptation Strategy** and the **EU Mission on Adaptation to Climate Change**. The HSTF and Policy Letters demonstrate how participatory co-creation within regional Communities of Practice (CoPs) can produce adaptation strategies that are both locally legitimate and methodologically transferable across heterogeneous European regions.

8.2 Sustaining the Project Legacy

To ensure that project results remain active and accessible beyond the project lifetime, all primary outputs and supporting educational assets are permanently hosted on open-access platforms:

- **Open-Access Repositories:** All 90 recommendations, the ten Policy Letters, and technical deliverables are indexed and downloadable via the ClimEmpower Website (<https://climempower.eu/results/>) and the ClimEmpower Zenodo Community (<https://zenodo.org/communities/climempower>).
- **The ClimEmpower Educational Library** (Deliverable D4.2): Serves as a persistent digital learning environment. Regional actors can autonomously explore climate knowledge via the grid-based Hazard–Sector and User–Dimension matrices (<https://climempower.eu/edu/>).
- **AI-Supported Exploration:** The conversational ClimEmpower AI Assistant (<https://climempower.eu>) remains available to help non-specialist users, planners, and researchers query project documentation, digest complex deliverables, and extract tailored adaptation options through natural language dialogue.

8.3 Action Roadmap: What Regions Should Do Now

ClimEmpower pilot regions primarily need to focus on the continuation and statutory embedding of the workflows already established in the project. Other public authorities, spatial planners, and regional leaders looking to convert climate risk evidence into actionable land-use decisions will need to undertake a more comprehensive setup, following the seven-step implementation sequence established by the project

- 1) **Establish an Interdepartmental Team:** Form a small, cross-sectoral coordinating group bringing together spatial planning, civil protection, environmental management, water authorities, public health, and finance. Ideally, this team should be complemented by a fully-fledged regional Community of Practitioners.
- 2) **Select a Priority Hazard Pathway:** Identify a specific cause-and-consequence chain (e.g., heatwaves leading to urban overheating, or droughts causing agricultural soil-moisture loss) rather than acting on general hazard labels.
- 3) **Assemble Evidence:** Compile local hazard maps, historical disaster records, demographic vulnerability data, and municipal maintenance reports, documenting confidence levels and data gaps.
- 4) **Execute the Six-Step HSTF Sequence:** Trace the hazard pathway through the affected territorial system, select the primary land-use domain (*Buildings, Agriculture, Blue-Green Infrastructure, Transportation, Protected Areas*), assign a recommendation family, designate an active planning instrument, and define a measurable resilience function.
- 5) **Apply Governance Readiness & Equity Checks:** Verify legal competence, funding routes, and long-term maintenance responsibilities, while conducting an ethical screening to prevent maladaptation and protect vulnerable populations.
- 6) **Enact Policy Letters & Instruments:** Translate the ten co-designed Policy Letters into local development regulations, municipal bylaws, and public procurement requirements.
- 7) **Embed Continuous Monitoring:** Define quantitative baseline and target indicators (drawing on the 36 ClimEmpower indicators) and schedule formal review dates to adjust measures as local conditions evolve.

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Annex A — ClimEmpower Policy Letters

This annex lists the ten ClimEmpower Policy Letters that constitute the policy-oriented output of this deliverable. Each letter is a self-contained four-page brief built around a single prioritised recommendation and is identified below by the resilience indicator it responds to, its field of application and the resilience dimension to which that indicator belongs. The letters can therefore be traced directly to the corresponding rows of the recommendations matrix in section 4.2. An example of the layout and structure of a Policy Letter is shown in Figure 5, section 6.1.

The complete set is provided as PDF files accompanying this deliverable and is published on the ClimEmpower web site, under the Results section (<https://climempower.eu/results/>), and on the Zenodo community feed (<https://zenodo.org/communities/climempower>).

Table 10: The ten ClimEmpower Policy Letters and their position in the resilience framework

ID	Policy Letter	Indicator	Field application	of	Dimension
PL_03	Strengthening climate-resilient hospital bed capacity and emergency preparedness at community level	Number of hospital beds per 100,000 inhabitants	Governance		Health & Wellbeing
PL_18	Integrate nature-based solutions to enhance natural storage and water quality	Community water storage volume (cubic metres)	Planning & Finance		Health & Wellbeing
PL_20	Increase and diversify water storage for drought and service disruption resilience	Community water storage volume (cubic metres)	Preparedness		Health & Wellbeing
PL_30	Reduce population exposure through risk-informed land-use, protection and managed adaptation	Percentage of population at high risk from natural hazards	Governance, Planning & Finance		Population & Education
PL_48	Strengthening local agri-food supply chains to reduce dependence on food imports	Food import dependency	Economy & Supply Chains		Economy & Labour Market
PL_55	Climate-smart agriculture and seed diversity transition	Crop production & yield	Economy & Supply Chains		Economy & Labour Market
PL_81	Making hazard maps available and up to date	Percentage of municipalities with local flood risk management plans	Governance		Governance
PL_89	Enhancing climate resilience through the protection of natural areas	Percentage of natural areas	Planning & Finance		Environment, Nature & Settlement Areas

ID	Policy Letter	Indicator	Field application	of	Dimension
PL_90	Reducing groundwater overexploitation to strengthen water resilience	Percentage of groundwater bodies in poor condition due to overexploitation	Essential Services & Critical Infrastructure		Environment, Nature & Settlement Areas
PL_93	Reducing residential exposure in hazard-prone areas	Settlement areas in danger zones	Planning & Finance		Environment, Nature & Settlement Areas

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