FROM INDICATORS TO ACTION: ASSESSING REGIONAL CLIMATE RESILIENCE TO ENABLE TARGETED ACTION

Part of ClimEmpower educational library

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Revision history

Date	Version	Contributor/Reviewer	Description
21/08/2026	Initial release	Ausserdorfer Hannah	First version of the report

Legal Disclaimer

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List of Acronyms

CIC	Climate interaction context
CoP	Community of Practice
EUROSTAT	European Statistical Office
FAO	Food and Agriculture Organization of the United Nations
FWI	Fire Weather Index
IPCC	International Panel for Climate Change
OSM	OpenStreetMap
UNDRR	United Nations Office for Disaster Risk Reduction

Glossary

Climate impacts	The consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure (based on IPCC, 2018)
Climate 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.
Indicator	An indicator is a measurement or value which gives you an idea of what something is like.
NUTS 0 - 3	NUTS stands for Nomenclature of Units for Territorial Statistics. It's the European Union's standard for dividing up territories into regions for statistical purposes, with levels: • NUTS 0 – Countries • NUTS 1 – Major socio-economic regions • NUTS 2 – Basic regions for regional policies • NUTS 3 – Small regions for specific diagnoses

About this document

This material is part of the ClimEmpower educational library, related to Deliverable D4.2 and available at ClimEmpower web site and Zenodo: https://climempower.eu/, https://zenodo.org/communities/climempower .

*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.*

This educational unit helps regional and municipal decision makers, climate resilience practitioners, consultants, researchers, and data specialists understand how regional climate resilience can be assessed through a structured, indicator-based approach and enables them to develop or adapt a resilience assessment for their own region, identify suitable indicators and datasets, recognise data gaps, and use the results to support resilience planning and decision-making.

After reading this material, readers will be able to:

- **Understand** the key concepts, challenges, and principles related to regional climate resilience assessment, including resilience dimensions, indicator characteristics, data requirements, and the role of local knowledge.
- **Explain** how the ClimEmpower resilience assessment approach works and why it is relevant for regional planning and climate adaptation.
- **Apply** the indicator-based resilience assessment approach in their own context to select relevant resilience indicators, identify and evaluate suitable datasets, involve local stakeholders, identify data gaps, calculate indicators where possible, and use the results to identify priorities for strengthening regional resilience.

1 Introduction

1.1 Why should I read this document?

Climate resilience is the capacity of a system to anticipate, absorb, accommodate and recover from hazardous events while maintaining or improving its essential functions. Climate-risk assessment and resilience assessment are related but distinct:

- **Risk assessment** examines the interaction between hazard, exposure and vulnerability.
- **Resilience assessment** examines the capacities, resources and conditions that enable a region to prepare for, withstand, adapt to and recover from climate impacts.

Climate resilience is complex and depends on many different capacities and conditions within a region. Resilience indicators help translate this broad concept into information that can be assessed, discussed and monitored.

This document will help you understand how a climate resilience assessment is structured and how resilience indicators can be selected, supported with suitable data, validated with regional stakeholders and used to identify priorities and data gaps.

If you are a regional or municipal decision maker:
The approach can help you organize information about health, society, the economy, infrastructure, governance and the environment. It provides a basis for identifying weaknesses, setting target values and prioritizing investments or data-collection activities.

If you are a consultant, climate analyst or data scientist:
The framework provides a replicable process for reviewing indicators, matching them to datasets, calculating indicator values where possible, and documenting the data sources, proxies and limitations of the assessment.

If you are a researcher or innovation practitioner:
The approach demonstrates how scientific frameworks can be converted into indicators that are understandable and potentially useful to regional stakeholders. It also illustrates how Community of Practice feedback can be incorporated into indicator selection.

If you are a climate-service or software developer:
The indicator factsheets provide specifications for implementing indicators in a climate service, including calculation rules, variables, spatial resolution, update frequency and potential recommendations. Indicators that cannot yet be quantified can be addressed through qualitative explanations or storytelling until suitable data become available.

1.2 The Challenge

Regional climate resilience cannot be captured by a single indicator. A meaningful assessment therefore requires a set of complementary indicators that provides insights into different factors influencing a region's ability to prepare for, cope with and recover from climate impacts.

The challenge is to identify indicators that are both relevant and usable. Suitable data may not always be available at the spatial resolution needed for local decisions, while important local information may not be represented in European or national datasets.

A practical resilience assessment therefore needs to balance the relevance of an indicator with data availability and quality, while also incorporating regional knowledge and stakeholder input. Indicators should not be selected simply because they are easy to calculate, as this could leave important aspects of resilience unrepresented. And further, important indicators need to be acknowledged even if, at the current time, no suitable data exists to compute it.

1.3 What will I learn

After reading this document, you will:

- **understand** climate resilience and the role of indicators in a local climate resilience assessment;
- **know how** relevant European, national and local datasets can be used;
- **be able to involve** regional stakeholders in indicator selection;
- **be able to identify** important data gaps and appropriate proxy indicators;

2 Concepts, methods, and approaches

2.1 Regional Resilience Assessment

2.1.1 The 5-step workflow

How to build a resilience indicator list: The following table (Table 1) provides an overview of the five-step workflow. Each step is described in more detail in the subsequent sections.

Table 1: How to build a resilience indicator list

Step	What happens	Output
1. Literature and framework review	Review existing resilience frameworks, definitions (e.g. IPCC) and methodologies to identify what "resilience" means and how it has been measured before.	Shared definition of resilience; list of candidate dimensions/characteristics
2. Preliminary indicator list	Consortium experts select 3–6 candidate indicators per resilience dimension based on their relevance, measurability and applicability to different regional contexts.	Shortlist of ~35 candidate indicators
3. Gathering datasets	Identify open, EU-wide and national data sources (EUROSTAT, Copernicus, OSM, FAO, national statistics) that could feed each candidate indicator.	Inventory of usable datasets, mapped to indicators
4. Stakeholder feedback	Regional stakeholders (Communities of Practice) rate each indicator's relevance, state whether local data exists, and indicate whether spatial or temporal resolution matters more to them.	Priority ranking per indicator per region; local data leads
5. Final indicators, computation & recommendations	Highest-priority indicators are compiled into standardised "factsheets" (definition, dimension, characteristics, resilience impact, recommendations, calculation formula, datasets) and computed where data allows.	35 final resilience indicators with factsheets and, where possible, computed values

Why does it matter?

Climate risk assessment often results in climate risk maps, but it does not provide a complete picture of a region's capacity to prepare, respond and recover. Indicators broaden the assessment by considering healthcare, education, economic capacity, infrastructure, environmental conditions and governance. Further, increased resilience supports the regions regardless of a specific climate hazard.

2.1.1.1 Literature research

The starting point is a review of existing resilience frameworks and definitions to agree on a shared definition of resilience and a first set of candidate dimensions and characteristics. ClimEmpower adopted the IPCC (2022) definition and cross-checked it against established scorecards (e.g. UNDRR's city resilience scorecard) to understand their strengths (rich local nuance) and weaknesses (subjectivity, low comparability).

The following table (Table 2) shows how ClimEmpower organises resilience into six dimensions:

Table 2: Resilience organization of ClimEmpower

Health & Wellbeing	Population, Society & Education
Economy & Labour Market	Infrastructure
Environment & Settlement Areas	Governance, Strategy & Planning

Additionally, indicators are related to characteristics such as

- **Reflectiveness** (Learning from experience to inform decisions),
- **Resourcefulness** (Identifying alternative ways to use resources in a crisis),
- **Robustness** (System designed to withstand shocks without failure),
- **Flexibility** (Developing alternative strategies in response to crises) and
- **Inclusivity** (Board consultation and shared ownership, prioritizing vulnerable groups).

These characteristics help explain the aspect of resilience represented by each indicator, for example, whether it measures the durability of infrastructure, the availability of alternative resources or the inclusion of vulnerable groups.

EXERCISE
Which characteristics describe this indicator?

Indicator: 'Number of hospital beds per 100,000 inhabitants in the community'

Choose which of the five resilience characteristics (reflectiveness, resourcefulness, robustness, flexibility, inclusivity) that you think best describe the indicator.

Think about:

A. What does having sufficient hospital capacity allow a region to withstand?
B. How could additional capacity help the system react when demand changes during an emergency?

Answer:
In ClimEmpower, this indicator is associated with robustness and flexibility.

- **Robustness** applies because sufficient hospital capacity helps the health system withstand increased demand during an extreme event.
- **Flexibility** applies because available capacity can allow hospitals to accommodate additional patients, including patients from other affected areas.

2.1.1.2 Preliminary indicator list

For each of the six dimensions, the consortium selected 3-6 indicators. Maintaining coverage across all dimensions is important because resilience is systemic.

For each dimension, candidate indicators were selected according to the following criteria. Indicators should be:

- quantifiable where possible;
- tangible and understandable;
- relevant to urban, rural and agricultural regions;
- associated with a resilience characteristic;
- supported by an identifiable calculation method or proxy;
- potentially actionable through regional policy or investment.

This produced a shortlist of 35 candidate indicators, each linked to a tentative dataset (if available) and spatial resolution (e.g. NUTS2, NUTS3, or ~100m grid).

EXERCISE
Would you select this indicator?

You are part of the indicator-selection team.
Imagine that your team is considering the following indicator for the Health & Wellbeing dimension: 'Percentage of people with immediate access to first aid'

Would you include it in your preliminary indicator list?

Test it against the ClimEmpower selection considerations:

Question	Your Assessment
Is the indicator understandable and tangible?	Yes / No / Unsure
Is it relevant for different types of regions?	Yes / No / Unsure
Can you connect it to a resilience characteristic?	Yes / No / Unsure
Can it be calculated directly through a reasonable proxy?	Yes / No / Unsure
Could regional action potentially improve it?	Yes / No / Unsure

Make your decision: Include it, exclude it, or keep it provisionally while investigating the data?

Answer:
All stakeholders within ClimEmpower voted in favour of keeping the indicator and therefore it was retained even though direct data were difficult to obtain. The Deliverable D2.4 therefore explores proxies, such as combining healthcare-facility locations with popular data. This illustrates an important lesion: an indicator should not automatically be discarded dimply because the ideal dataset is unavailable.

2.1.1.3 Gathering datasets

For every candidate indicator, the team searched for open datasets that could compute it directly or serve as a proxy. Common sources used are for instance EUROSTAT and national statistics for socio-economic figures, Copernicus land-cover and hazard layers for environmental indicators, OSM for infrastructure and points of interest, and FAO data for agriculture.

Where possible, suitable datasets were identified for each indicator together with their available spatial resolution (e.g. NUTS2, NUTS3, or ~100m grid).

A dataset should not be selected simply because it is available. Its resolution and definition must correspond to the decision it is supposed to support. Country-level water-stress data, for example, may be unsuitable for municipal water planning.

2.1.1.4 Stakeholder feedback

Candidate indicators should be reviewed with stakeholders who understand regional planning, services, infrastructure, agriculture and local conditions.

ClimEmpower stakeholders were asked:

- How relevant is each indicator?
- Are local datasets available?
- Is spatial detail or temporal frequency more important?
- What geographic unit is most useful?
- Does the definition reflect regional realities?

The consultation methods differed between regions and included in-person questionnaires, online meetings, structured surveys, Excel forms and discussions with municipal leaders. Responses were converted into a low–medium–high relevance scale where appropriate.

Stakeholders generally considered spatial resolution more important than temporal frequency. Crop production, groundwater overexploitation and water stress were the main indicators for which temporal information was sometimes prioritised. Municipal, community, asset or hydrological-unit data were commonly preferred over national or broad NUTS-level statistics.

EXERCISE
Set regional priorities as part of the Community of Practice

You are participating in a Community of Practice and are asked to assess four possible resilience indicators.

In ClimEmpower, stakeholders could rank indicator relevance as **Low, Medium or High**. These responses were subsequently represented numerically as **1 = Low, 2 = Medium and 3 = High** to compare priorities.

Here are four indicators and the average relevance scores reported across the ClimEmpower regions:

Indicator	Average Relevance
Groundwater bodies in poor condition due to overexploitation	2.9
Water stress index	2.8
Population covered by multi-hazard early warning	2.7
Hospital beds per 100,000 inhabitants	2.6

Your task: You have resources to work on only two indicators first. Which ones would you prioritise?
The first answer appears easy: choose the two indicators with the highest stakeholder ratings.
Now comes the twist: the two highest-priority indicators also present important data gaps.

What would you do?

A. Drop them and use indicators for which data are readily available.
B. Keep them as priorities and investigate local data, new data collection or suitable proxies.
C. Replace them with indicators from another dimension.

Suggested answer: B
ClimEmopwer found that some highly prioritised indicators were also difficult to quantify. D2.4 therefore recommends that high relevance combined with poor data availability should help identify priorities for future data collection, rather than automatically causing an indicator to be excluded.

2.1.1.5 Final list of indicators and computation

After stakeholder review, indicators are retained with:

- their agreed definitions;
- calculation procedures;
- suitable datasets or proxies;
- spatial and temporal limitations;
- associated recommendations;
- preliminary visualisations where computation is possible.

This resulted in a final set of 35 resilience indicators across the six dimensions.

Note: Where direct calculation is impossible, a proxy can be used. For example, “immediate access to first aid” may be approximated by combining hospital locations from OpenStreetMap with population-density data and calculating the share of residents within a defined distance of a facility.

Because a rating methodology for individual indicator values was not identified, the project instead proposes to show a region's value plotted against the full range of values for all EU countries – regions should set their own improvement targets rather than imposing a fixed threshold.

What does a computed indicator look like?

Once a suitable indicator and dataset have been identified, the indicator can be computed and visualised. The following examples from ClimEmpower show how indicator values can be compared spatially across European regions. These visualisations should be interpreted as decision-support information rather than as resilience scores.

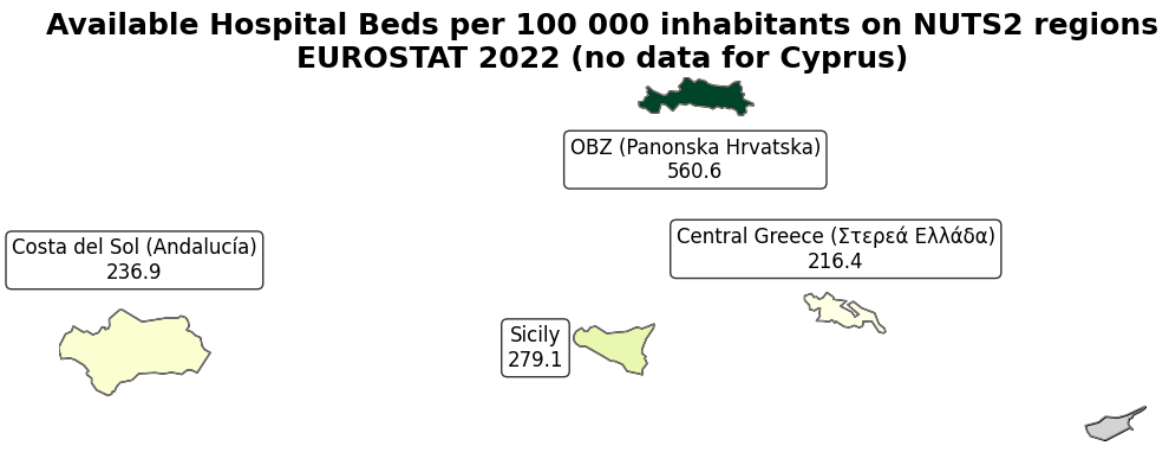

Figure 1: Number of hospital beds per 100 000 inhabitants based on EUROSTAT data

The graph compares healthcare capacity across European regions using the number of available hospital beds relative to population. This indicator provides an indication of the capacity of the healthcare system to respond to increased demand during extreme events.

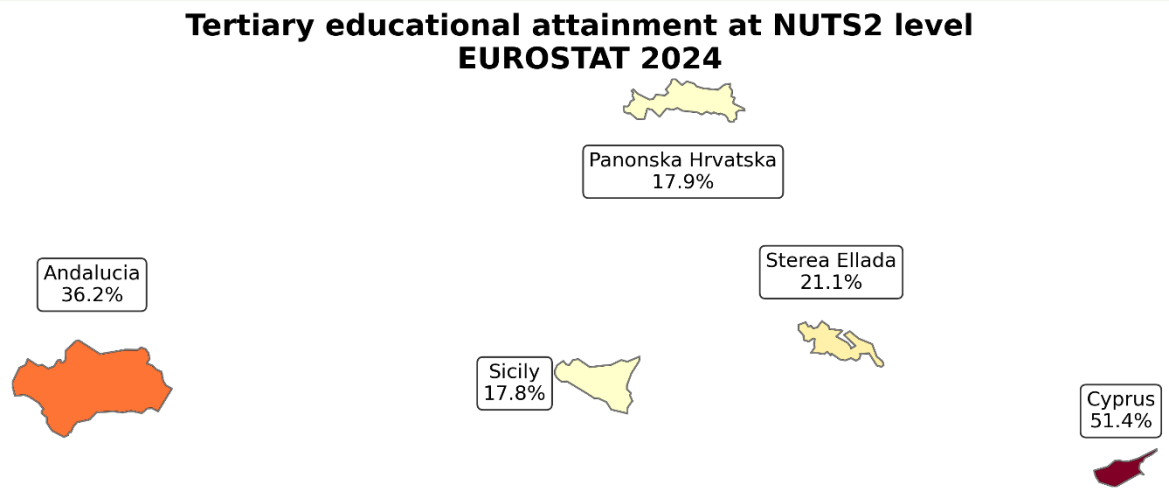

Figure 2: Tertiary education attainment based on EUROSTAT data

The graph shows regional differences in the proportion of the population with tertiary education. This indicator reflects the share of the population with higher education, which can contribute to knowledge, skills and adaptive capacity within a region.

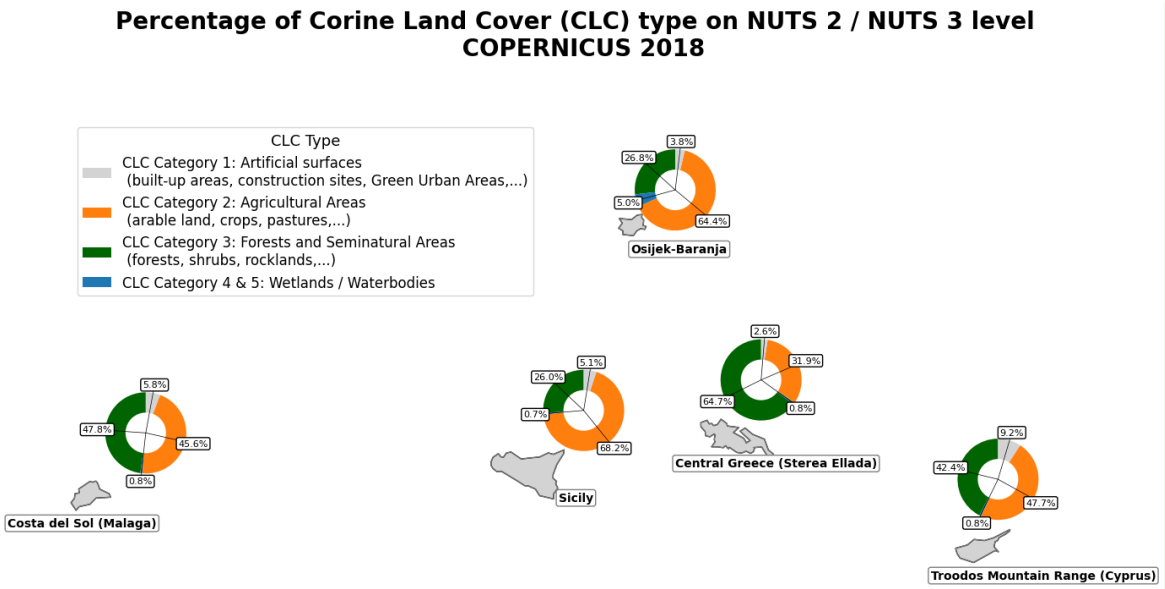

Figure 3: Percentage of Land Cover types according to CORINE data, different spatial resolutions possible

The graph illustrates differences in the proportion of natural and semi-natural land across regions. This indicator shows the share of natural and semi-natural land, which can contribute to resilience through ecosystem services and the buffering of environmental stress.

3 Practical considerations and lessons learnt

3.1 Data requirements and resources

A transferable assessment requires:

- GIS and statistical-analysis capacity;
- access to climate, population, land-use and administrative data;
- agreed geographic boundaries;
- expertise in climate hazards and local planning;
- stakeholder time for validation;
- procedures for updating indicators.

European data provide a consistent starting point, but municipal decisions usually require finer detail. ClimEmpower therefore recommends collecting missing information at municipality or community level wherever possible. Particular priority should be given to groundwater overexploitation, local water stress, early-warning coverage and governance-related preparedness data.

3.2 Quality, limitations and human oversight

Several issues must be addressed before operational implementation:

Resolution mismatch. National or NUTS-2 information can conceal substantial differences between municipalities, mountain areas, coastal zones and river basins.

Data gaps are not neutral. Some of the most highly prioritised indicators are also the least measurable. Excluding them would produce a dashboard driven by data availability rather than regional importance.

Proxy indicators need transparent interpretation. Distance to a hospital is not identical to access to first aid; firefighter employment does not fully represent emergency-response capacity.

Model results are decision support, not definitive risk. When incorporating hazard data and/or related risks, keep in mind: Global or European datasets may omit local protection measures, infrastructure conditions and behavioural factors.

Local expertise remains necessary. Stakeholders are needed to validate definitions, identify administrative datasets and interpret whether calculated differences are meaningful.

3.3 Adaptation to context and transferability

The overall workflow is transferable, but the inputs should be adapted.

A region applying the method should:

1) identify its priority hazards and assets;
2) review the ClimEmpower indicator list rather than adopting it automatically;
3) define the geographic scale required for each decision;
4) map available European and national data;
5) obtain local administrative and operational data;
6) validate indicators with local stakeholders;
7) document proxies and uncertainties;
8) set regional target values and timeframes;
9) connect each indicator to responsible institutions and feasible measures;
10) repeat the assessment to monitor progress.

The same indicator may require different scales in different regions. Water indicators may be best assessed by hydrological unit; infrastructure indicators may require asset-level information; social indicators may be useful at municipal or community level.

3.4 Ethical considerations

True resilience requires that the structural and economic shift toward climate safety is fair, inclusive, and prioritizes supporting the most vulnerable populations first.

Resilience indicators **reflect the systemic vulnerabilities, coping capacities, and environmental exposures of real regions.** To insure just transition, these indicators must not be treated as neutral data points, but as active tools to ensure that regional adaptation strategies do not exacerbate existing socio-economic disparities.

4 Key messages and next steps

4.1 Key messages

Remember:

- **Make resilience concrete and measurable** by using indicators to pinpoint regional strengths and weaknesses, compare with neighbouring regions, and monitor whether subsequent interventions actually improve the situation over time.
- Assess multiple dimensions, including health, economy, infrastructure, and environment, to ensure you do not get an incomplete, isolated picture.
- **Support real decisions** by directly connecting every indicator to practical regional targets, concrete measures, and responsible local institutions.
- **Combine diverse insights** by blending standardised quantitative data with local stakeholder knowledge and qualitative interpretation.
- **Prioritise spatial detail** over highly frequent but geographically coarse datasets to give regional planners the resolution they actually need.
- **Focus on policy importance**, not just data availability; use highly relevant but non-computable indicators to trigger new, targeted data collection.
- **Connect metrics to action** by linking every indicator to specific adaptation goals, designated owners, and continuous monitoring.
- **Communicate all assumptions**, proxies, and underlying uncertainties clearly whenever presenting risk maps or dashboard tools.

4.2 What can you do next?

A regional authority or organisation can begin with **reviewing the ClimEmpower indicators and factsheets and identifying those most relevant to the regional context**. If the existing indicators and factsheets sufficiently meet the region's needs, they can be used directly, and no further indicator development is needed. If indicators need to be adapted or additional indicators are required, continue with the following steps:

1) **Define dimensions and characteristics** when scoping the resilience indicator set.
2) **Create a local data inventory** covering climate, population, land use, health, infrastructure, emergency services and governance.
3) **Choose five to ten indicators** based on stakeholder feedback or pressing issues rather than implementing the complete list immediately.

4) **Prepare a factsheet for each indicator**, documenting its definition, calculation, data, limitations, improvement measures and responsible data owner.

5) **Run a stakeholder validation workshop** with municipal departments, emergency services, infrastructure operators, health services and community representatives.

6) **Prioritise missing data,** especially where an indicator is both highly relevant and currently not quantifiable.

7) **Set target values and review dates**, so the assessment becomes a monitoring process rather than a one-off study.

In both cases, relevant instruments, such as r**egional and local climate adaptation and emergency-planning frameworks** should be consulted when integrating indicators into existing planning and risk-management processes.

4.3 Further resources

Table 3 shows the recommended platforms for further reading and access to related ClimEmpower project resources.

Table 3: recommended platforms

Source platform	Short definition	Relevant materials
ClimEmpower Project Results — climempower.eu/results/	Official ClimEmpower platform for project results and outputs	Project deliverables; resilience recommendations; risk-map information; project tools and software; scenarios; data and knowledge assessments; stakeholder engagement results
ClimEmpower Educational Library — climempower.eu/knowledge-hubs/	ClimEmpower collection of educational materials and selected knowledge resources	Educational materials; reports and guidance; presentations; learning resources; climate-hazard and sector resources; target-group resources; external knowledge resources
CORDIS — cordis.europa.eu	European Commission platform for EU-funded research and innovation	Project descriptions; public deliverables and reports; publications; project partners; project results and outputs
Climate-ADAPT — climate-adapt.eea.europa.eu	European platform for climate change adaptation knowledge and practice	Adaptation strategies and policies; case studies; climate risks and impacts; adaptation options; tools; indicators; research and innovation projects
ClimEmpower Zenodo Community — zenodo.org/communities/climempower	Open repository for ClimEmpower research outputs and project materials	Datasets; journal publications; conference papers and posters; educational materials; other project outputs

Further materials of particular interest for this educational report include

IPCC Sixth Assessment Report (Working Group II):

- **What is it?** The definitive global scientific assessment focused on climate change impacts, systemic vulnerabilities, and regional adaptation options
- **Why is it highly relevant?** It establishes the foundational concepts of vulnerability, adaptive capacity, and systemic dimensions that underpin the ClimEmpower resilience indicator framework
- **Access:** https://www.ipcc.ch/report/ar6/wg2/

Climate Risk and Resilience: A Practical Introduction

- **What is it?** A ClimEmpower educational unit providing an accessible overview of climate risk and resilience concepts.
- **Why is it highly relevant?** It complements the methodology by reinforcing the IPCC framework for climate risk assessment and supporting the understanding of hazard, exposure, and vulnerability.

Using Climate Risk Maps for Regional Planning

- **What is it?** A ClimEmpower educational unit focused on the application of climate risk maps in regional planning contexts.
- **Why is it highly relevant?** It aligns with the methodology's emphasis on spatial resolution and stakeholder engagement, offering practical guidance on integrating risk maps into adaptation planning.

From Climate Risk Assessment to Adaptation Measures

- **What is it?** A ClimEmpower educational unit that bridges climate risk assessment and the design of concrete adaptation measures.
- **Why is it highly relevant?** It supports the methodology's focus on turning indicators into actionable policies, ensuring that assessments lead to measurable outcomes and institutional responsibility.

All ClimEmpower Courses and Guides are available for download from ClimEmpower web site (https://climempower.eu) and from ClimEmpower Zenodo community (https://zenodo.org/communities/climempower).

5 References

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