



MEASURES AND STRATEGIES FOR INCREASED CLIMATE CHANGE RESILIENCE

ClimEmpower Work Package 2, D2.4, v1



Project ClimEmpower: User Driven Climate Applications Empowering
Regional Resilience

Work package 2, Deliverable D2.4

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Coordinator:	Denis Havlik, Scientist AIT Austrian Institute of Technology Giefinggasse 4, 1210 Vienna, Austria
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Author(s):	Hochebner, A., Gazzaneo, P., Pöchersdorfer, P., Kozłowska, A., Tötzer, T., (AIT, Austria) Gamallo, I., Nieto, J.M (CETAQUA, Spain)

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List of Acronyms

AIT	Austrian Institute of Technology GmbH
ANDALUS	Consejería de Sostenibilidad, Medio ambiente y Economía Azul
CC	Climate Change
CDS	Climate Data Store
CERTH	Centre for Research and Technology Hellas
CIC	Climate interaction context
CLIMAAX	CLIMAt risk and vulnerability Assessment framework and toolboX (CLIMAAX-Project, 2025)
CLMS	Copernicus Land Monitoring Service
CoP	Community of Practice
CSF	Case Study Facilitator
CETAQUA	Centro Tecnológico del Agua (Water Technology Center)
DRR	Disaster Risk Reduction
EFFIS	European Forest Fire Information System
EU28	European Union with 28 member states (the composition before the United Kingdom left in 2020)
EUROSTAT	European Statistical Office
FAO	Food and Agricultural Organization of the United Nations
FWI	Fire Weather Index
GDP	Gross Domestic Product
GWL	Global Warming Level
IPCC	Intergovernmental Panel on Climate Change
LAU	Local municipality/village inside the Geopark (specific to Troodos Mountain Region)
LULC	Land use and land cover
NUTS	Nomenclature of Units for Territorial Statistics
OBZ	Osijek-Baranja county
P&C	Property and casualty (referring to insurance policies)
PLINIVS	PLINIVS - Centro Studi per l'Ingegneria Vulcanica Sismica e Idrogeologica
PPS	Purchasing Power Standard
PTSE	Periferia Sterias Elladas (Region of Central Greece)

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.
CLIMAAX	CLIMATE risk and vulnerability Assessment framework and toolboX (CLIMAAX) is a 4-year Horizon Europe project that will provide financial, analytical, and practical support to improve regional climate and emergency risk management plans. It offers a toolbox that integrates the components of risk (Hazard, Exposure, Vulnerability) into an integral risk assessment and visualizes risk information to develop regional risk profiles (CLIMAAX-Project, 2025).
Exposure	Exposure is the situation of people, infrastructure, housing, production capacities and other tangible (human) assets located in hazard-prone areas.
GWL	GWLs can be used to explore and compare regional changes in climate at specified levels of global warming, including the limits on global temperature increase committed to in the Paris Agreement . The GWL approach shifts the uncertainty in regional climate projections from the magnitude of the change associated with different emissions scenarios to the time when specific GWLs will be reached.
Hazard	Hazards have the potential to cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation.
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
Vulnerability	Vulnerability refers to the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards.

Executive summary (publishable)

The deliverable “D2.4 Measures and strategies for increased climate change resilience” is the last deliverable of WP2 “Addressing the Climate Change data and knowledge gaps” and brings together the information from D2.1, D2.2, D2.3 with the requirements of the regional stakeholders as well as the other WPs, specifically WP3 and WP4. Therefore, it provides the information on applicable risk assessment methods, comprehensive resilience indicators and measures on how to reduce the first and increase the latter.

Within ClimEmpower we focus on increasing the resilience of regions through providing quantitative and objective resilience assessment via climate services and education material. Resilience represents the ability to withstand, absorb and cope with any kind of hazard. In the case of ClimEmpower we focus on climate hazards and related risks. Therefore, the risk assessment approach is detailed within D2.4. The methodology on how to compute the heat induced risk to health, drought induced risk to society and agriculture, the flooding risk for buildings, critical infrastructure and the wildfire risk to different assets and people are specified. Regarding the resilience assessment - building upon the identified available resilience frameworks (D2.2) - six dimensions (health and wellbeing, population and education, economy and labour market, infrastructure, governance, environment/nature and settlement areas) and five characteristics (robustness, resourcefulness, flexibility, inclusivity, redundancy) were defined and are presented.

For each dimension up to 6 indicators were selected by the consortium and presented within fact sheets. Within the factsheets, the related dimension, the indicators relation to resilience, as well as suitable data sets for computation (D2.1) and recommendations (partly based on D4.3) on how to either direct or indirectly improve this indicator are given. This information is collected for all shortlisted indicators, within D2.4 six examples, one for each dimension, are displayed.

Further, the feedback from the CoPs to the specified indicators as well as their requirements with respect to spatial and temporal resolution are also presented, and the related data collection recommendations drawn.

Thus, this deliverable provides the information on quantifiable resilience indicators required for setting up the climate service (WP3), as well as the content that will be incorporated within WP4 with respect to resilience recommendations and learning material.

1. ClimEmpower summary

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

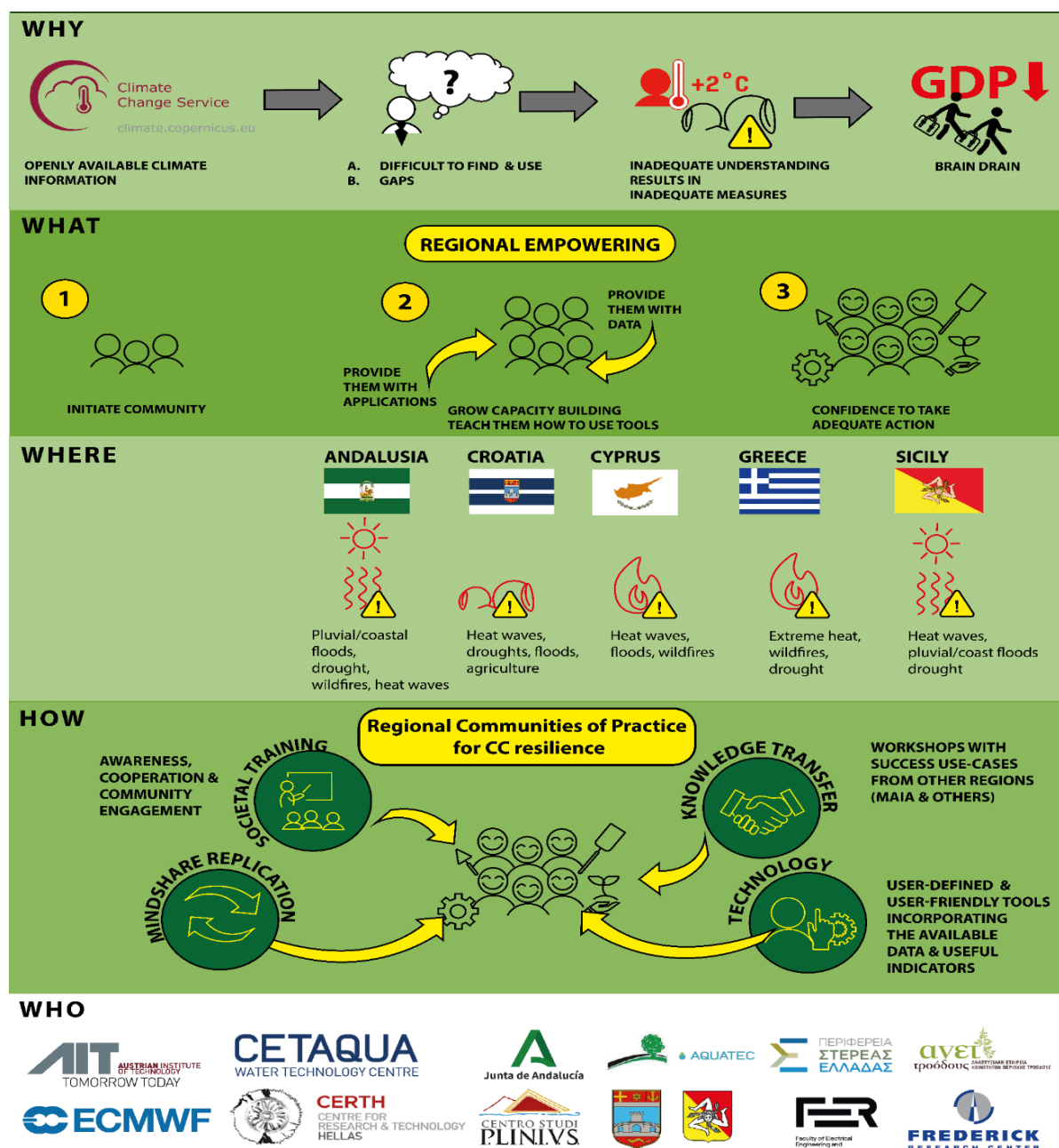


Figure 1: ClimEmpower at a glance: why, what, where, how and who.

1.1 Project Context

Climate risks results from a combination of a hazard, exposure, and vulnerability (IPCC, 2022). Addressing all three aspects is crucial for effective increase of regional resilience. However, exposure, vulnerability, and related aspects, such as adaptive capacity, strongly depend on available knowledge and climate literacy. Consequently, global climate crisis frequently has a higher impact on socioeconomically vulnerable regions, thanks to a higher human and economic potential for addressing the issue in more affluent regions. To maximize its impact, ClimEmpower has therefore chosen to address the EU regions featuring a combination of high potential CC impacts and low and/or stagnant regional GDP/capita. This is mainly the case for regions in South and Southeast Europe (Figure 2).

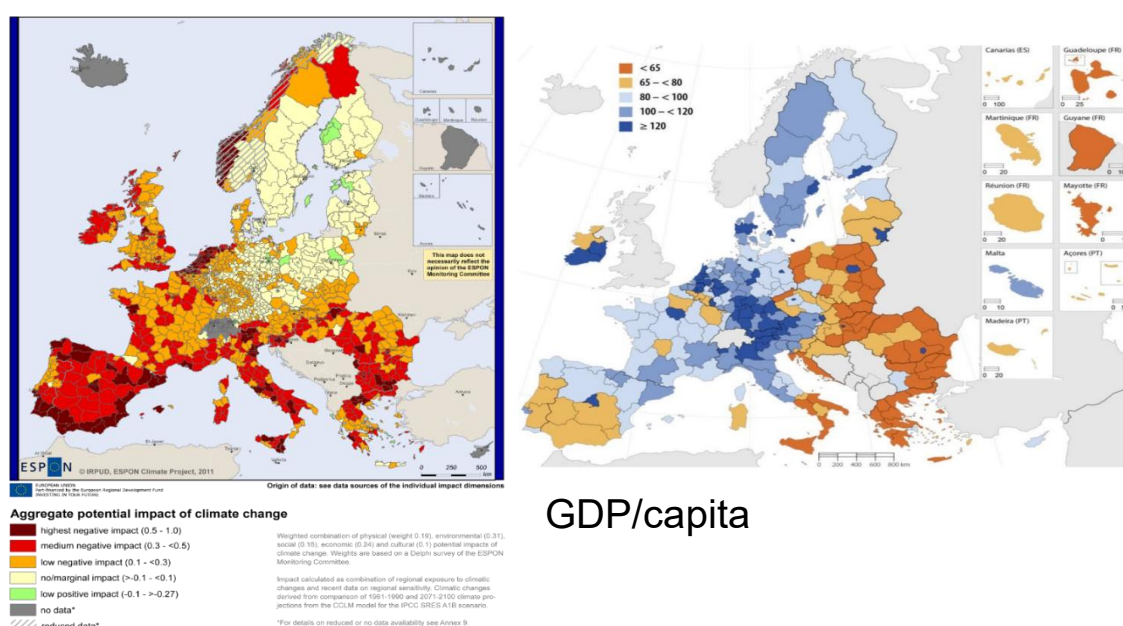


Figure 2: Aggregated potential impact of climate change (ESPON (European Spatial Planning Observation Network), 2012); GDP/capita (based on (Eurostat, 2019)).

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 SMART2 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.

² 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 “Measures and strategies for increased Climate Resilience” is the fourth and last one of the WP2 “Addressing the Climate Change data and knowledge Gaps” and therefore brings together the findings from the previous deliverables (D2.1, D2.2 and D2.3) that were more generic assessments of available data and climate services (D2.1), resilience frameworks and indicators (D2.2) and methodologies to close data gaps (D2.3).

Within this deliverable the resilience dimensions and characteristics as agreed on within ClimEmpower are displayed. Further, the hazards and especially risk computation chosen and consequently the main resilience indicators selected by the consortium and the regional partners are presented. The latter is done using fact sheets including:

- Name of the indicator
- Description
- Corresponding dimension
- Characteristics
- Impact on resilience
- Recommendations for improving the indicator (direct and indirect measures)
- Calculation
- Description and information on the underlying datasets.

Based on the selected indicators and available data sets, persisting data gaps are displayed and recommendations on which data sets should be collected are given.

This deliverable therefore provides important input to WP3 where the climate services are set-up as well as WP4, which focuses on learning material and useful resilience recommendations.

It is important to note that the resilience indicators presented here display a first attempt on providing quantifiable resilience information within a Climate Service for regions to improve their overall resilience, thereby being better prepared against climate extreme events and impacts. Thus, displaying a different approach then taken by resilience assessments so far, that mostly rely on experts answering predefined questions related to different resilience dimensions.

2.2 Results and expected impacts

The main result of D2.4 “Measures and strategies for increased Climate Change resilience” is a useful compilation of quantifiable resilience indicators applicable for any region. Additionally, a common understanding on how heat, drought, wildfire and flooding induced risk to different objects (people, infrastructure, natural areas) is computed, is presented.

D2.4 mainly contributes to **SO3.- Identification, definition, estimating, and communication of climate impact/resilience indicators suitable for local end-users**, but also to **SO5.- Empower the regions to activate and enhance their potential for addressing the climate change challenge**.

SO3 is targeted through providing the compiled list of quantifiable resilience indicators, based on the extensive review (D2.2), scientific expert opinion (consortium) and in-depth discussions with regional stakeholders (regional consortium partners, CoP meetings, questionnaires). Since the resilience indicators provide relevant information and the related recommendations actionable insights for the regions on how to increase their resilience, it also contributes to SP5.

With respect to the project impacts, this deliverable contributes to:

- **Society (short):** usable and quantifiable resilience indicators and related recommendations
- **Partners, regions, developers and scientists (medium):** increased understanding of climate risks and resilience, including actionable recommendations (EO1, regions, partners); set of indicators to be implemented within a Climate service (developers, scientists); resilience framework including dimensions, characteristics, risk assessment and resilience indicators based on available methodologies and feedback from regions (scientists, regions)
- **Consortium and regions (short):** increased understanding of climate resilience indicators, input to development of climate services and resilience recommendations training material

2.3 Relation to other work

As stated before, D2.4 builds upon D2.1, D2.2, D2.3 and extensive work done in WP4 with the CoPs as well as risk assessment approaches discussed within WP3 technical implementation.

The output of D2.4 provides critical input for WP3 (T3.2, T3.4) and WP4 (T4.1, T4.3, T4.4).

Additionally, the proposed resilience indicators present for the first time a selected set of indicators based on available data sets to be presented to any European region, providing the base for further discussions and implementations of recommended measures.

2.4 Data, security, and ethics

ClimEmpower observes the following three principles for data-related work:

- **KISS:** both the data management within the project and discovery, access, and reuse of data during and after the project will be made as simple and as transparent as possible.
- **FAIR:** data used in the project, as well as the data produced by the project should be easily Findable, Accessible, Interoperable and Reusable.
- **Societally Responsible:** data produced by the project will be made publicly available unless there is a compelling ethical or commercial reason against such publication. All project outputs (e.g. data, algorithms) will be explicitly checked for Ethics issues.

Related information pertinent to this deliverable is summarised hereafter.

2.4.1 Data interoperability

The data types used for this deliverable are XLSX files, selected and extracted from different sources. The biggest are the EUROSTAT and national databases, providing raw data which are directly used, or properly postprocessed, for the computation of the indicators in Sec. 6.1. The detailed description of the data, including spatial and temporal resolution, as well as data format and last update, is contained in the Indicator Factsheets.

2.4.2 Data accessibility and reuse

The used data are accessible without any restriction or limitation. As mentioned above, they have been extracted from for instance EUROSTAT and national databases, publicly available.

Table 1: Data used in preparation of ClimEmpower deliverable D2.4

Data set name	Format	Latest update	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
EUROSTAT: structural business statistics	CSV, TSV	2023	83 KB	EUROSTAT, open access	Assessment of economic resilience	https://ec.europa.eu/eurostat/web/structural-business-statistics/database
EUROSTAT: agriculture database	CSV, TSV	2023	203 KB	EUROSTAT, open access	Assessment of economic resilience	https://ec.europa.eu/eurostat/web/agriculture/database
STATISTA: GDP per sector	HTML, XLS (Pro)	2023	165 B	STATISTA, open access	Assessment of economic resilience	https://www.statista.com/statistics/271079/distribution-of-gross-domestic-product-gdp-across-economic-sectors-in-spain/
EUROSTAT: economic datasets	CSV	2023	55.1 KB	EUROSTAT, open access	Assessment of economic resilience	https://ec.europa.eu/eurostat/databrowser/view/tgs00006/default/table?lang=en&category=t_reg.t_reg_eco
EUROSTAT: population datasets	CSV	2024	960 KB	EUROSTAT, open access	Assessment of economic resilience	https://ec.europa.eu/eurostat/databrowser/explore/all/popul?lang=en&subtheme=demo&display=list&sort=category
Croatia: population statistics	XLS, HTML, PDF	2023	12 KB	Croatian Bureau of Statistics (DZS, open access)	Assessment of social resilience	https://web.dzs.hr/PXWeb/Menu.aspx?px_db=Stanovni%u0161tvo&px_language=en

Data set name	Format	Latest update	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Spain: Population age, sex	PC-Axis, CSV, XLS	2023	8 KB	INE (Spain)	Assessment of social resilience	https://www.ine.es/jaxiT3/Tabla.htm?t=56934
Sicily: Ageing Index Map	Web interactive, PNG, XLS	2025	32 KB	ISTAT / UrbiStat	Assessment of social resilience	https://ugeo.urbistat.com/AdminStat/en/it/demografia/eta/sicilia/19/2
EUROSTAT: Employment data	CSV, TSV, XLS	~2024	8 KB	EUROSTAT	Assessment of social resilience	https://ec.europa.eu/eurostat/databrowser/view/une_rt_m/default/table?lang=de&category=labour.employ.lfsi.une
Cyprus: Labor force survey	PDF, XLS	Q3 2024	240 KB	Government of Cyprus	Assessment of social resilience	https://www.gov.cy/en/economy-and-finance/labour-force-survey-lfs-3rd-quarter-2024/
Greece: employment statistics	XLS, PDF	Q1 2025	192 KB	ELSTAT (Hellenic Statistical Authority)	Assessment of social resilience	https://www.statistics.gr/en/statistics/-/publication/SJO01/-
Croatia: unemployment rate	HTML, PDF, XLS	Q1 2025	36 KB	Croatian Employment Service (HZZ)	Assessment of social resilience	https://statistika.hzz.hr/Statistika.aspx?tiplzvjestaja=1
EUROSTAT: education	CSV, TSV, XLS	2024	60 KB	EUROSTAT	Assessment of social resilience	https://ec.europa.eu/eurostat/databrowser/view/tgs00109/default/table?lang=en&category=t_reg.t_reg_educ
Croatia: population statistics	XLS, HTML, PDF	2023	872 KB	Croatian Bureau of Statistics (DZS)	Assessment of social resilience	https://podaci.dzs.hr/media/uwwdydgu/popis-2021-kucanstva-i-obitelji-pozupanijama.xlsx?utm_source=chatgpt.com
Spain: household statistics	PC-Axis, XLS, CSV	2020	16 KB	INE (Instituto Nacional de Estadística)	Assessment of social resilience	https://www.ine.es/dynt3/inebase/index.htm?type=pcaxis&path=/t20/p274/serie/prov/p01&file=pcaxis&L=1
Cyprus: population/housing data	XLS, CSV	2011	636 KB	Statistical Service of Cyprus	Assessment of social resilience	https://www.cystat.gov.cy/en/KeyFiguresList?s=46

Data set name	Format	Latest update	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Greece: household statistics	PDF, XLS	2021	872 KB	ELSTAT (Hellenic Statistical Authority)	Assessment of social resilience	https://www.statistics.gr/en/2021-census-res-pop-results?utm_source=chatgpt.com
ISTAT: household types	CSV, XLS, JSON	2024	16 KB	ISTAT (Italy)	Assessment of social resilience	https://esploradati.istat.it/databrowser/#/en/dw/categories/IT1.POP.1.0/POP_HOUSEHOLDS
LULC - Copernicus	Netcdf, GeoTIFF	2018	4 KB	Copernicus	Assessment of environmental resilience	https://land.copernicus.eu/en/products/corine-land-cover
Climate Data Store: Imperviousness data	GeoTIFF	2018	667 MB	Copernicus	Assessment of environmental resilience	https://land.copernicus.eu/en/products/high-resolution-layer-imperviousness
EUROSTAT: WEI	CSV	2022	24 KB	EUROSTAT	Assessment of environmental resilience	https://ec.europa.eu/eurostat/databrowser/view/SDG_06_60/default/table
EUROSTAT: Employment data	PDF	2022	12 KB	EUROSTAT	Assessment of governance resilience	https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230807-1
health care statistics	CSV, TSV, XLS	2024	32 KB	EUROSTAT	Assessment of health resilience	https://ec.europa.eu/eurostat/web/regions/database
Cyprus: Health statistics	XLS, PDF	2023	12 KB	Statistical Service of Cyprus	Assessment of health resilience	https://cystatdb.cystat.gov.cy/pxweb/en/8.CYSTAT-DB/8.CYSTAT-DB_Health
Italy: hospital beds per region	Article - HTML	2024			Assessment of health resilience	https://www.unimpresa.it/al-sud-pochi-posti-letto-in-ospedali-sotto-media-nazionale/62946
Greece: health statistics	PDF, XLS	2023	56 KB	ELSTAT (Hellenic Statistical Authority)	Assessment of health resilience	https://www.statistics.gr/en/statistics/-/publication/SHE06/

Data set name	Format	Latest update	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
EUROSTAT: hospital beds	CSV, TSV, XLS	2022	4 KB	EUROSTAT	Assessment of health resilience	https://ec.europa.eu/eurostat/databrowser/view/tgs00064/default/table?lang=de&category=t_reg.t_reg_hlth

Table 2: Other relevant outputs of ClimEmpower deliverable D2.4

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Factsheet percentage SME	DOCX	~KB	AIT, CA BY	Assessment of economic resilience	ZENODO ³
Factsheet crop production & yield	DOCX	~KB	AIT, CA BY	Assessment of economic resilience	ZENODO
Factsheet food import dependency	DOCX	~KB	AIT, CA BY	Assessment of economic resilience	ZENODO
Factsheet percentage of properties with insurance coverage for high-risk hazards	DOCX	~KB	AIT, CA BY	Assessment of economic resilience	ZENODO
Factsheet economic output for different sectors	DOCX	~KB	AIT, CA BY	Assessment of economic resilience	ZENODO
Factsheet potential market size expressed in GDP	DOCX	~KB	AIT, CA BY	Assessment of economic resilience	ZENODO
Factsheet population age	DOCX	~KB	AIT, CA BY	Assessment of social resilience	ZENODO
Factsheet employment rate of active population	DOCX	~KB	AIT, CA BY	Assessment of social resilience	ZENODO
Factsheet high education index	DOCX	~KB	AIT, CA BY	Assessment of social resilience	ZENODO
Factsheet percentage of city population covered by multi-hazard early warning system	DOCX	~KB	AIT, CA BY	Assessment of social resilience	ZENODO
Factsheet percentage of large families	DOCX	~KB	AIT, CA BY	Assessment of social resilience	ZENODO

³ ClimEmpower Zenodo community at <https://zenodo.org/communities/climempower>

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Factsheet percentage of population living in hazard zones	DOCX	~KB	AIT, CA BY	Assessment of social resilience	ZENODO
Factsheet percentage of population living within 1km of a grocery store	DOCX	~KB	AIT, CA BY	Assessment of social resilience	ZENODO
Factsheet "Settlement areas in danger zones": Proportion of residential buildings in a hazard zone	DOCX	~KB	AIT, CA BY	Assessment of environmental resilience	ZENODO
Factsheet percentage of groundwater bodies in poor condition due to overexploitation	DOCX	~KB	AIT, CA BY	Assessment of environmental resilience	ZENODO
Factsheet percentage of natural areas	DOCX	~KB	AIT, CA BY	Assessment of environmental resilience	ZENODO
Factsheet proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	DOCX	~KB	AIT, CA BY	Assessment of environmental resilience	ZENODO
Factsheet Surface impermeability (and related indices) (Annual soil impermeability index)	DOCX	~KB	AIT, CA BY	Assessment of environmental resilience	ZENODO
Factsheet water stress index	DOCX	~KB	AIT, CA BY	Assessment of environmental resilience	ZENODO
Factsheet percentage of population protected by structural disaster risk measures for flood/wildfire	DOCX	~KB	AIT, CA BY	Assessment of governance resilience	ZENODO

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Factsheet percentage of population who actively participate in a local organisation that aims to prepare for disasters	DOCX	~KB	AIT, CA BY	Assessment of governance resilience	ZENODO
Factsheet availability of hazard maps	DOCX	~KB	AIT, CA BY	Assessment of governance resilience	ZENODO
Factsheet Existence of emergency response organisation	DOCX	~KB	AIT, CA BY	Assessment of governance resilience	ZENODO
Factsheet Percentage of municipalities with local flood risk management plans	DOCX	~KB	AIT, CA BY	Assessment of governance resilience	ZENODO
Factsheet Percentage of people with immediate access to first aid	DOCX	~KB	AIT, CA BY	Assessment of health resilience	ZENODO
Factsheet Percentage of population with basic health insurance	DOCX	~KB	AIT, CA BY	Assessment of health resilience	ZENODO
Factsheet Community water storage volume (cubic metres)	DOCX	~KB	AIT, CA BY	Assessment of health resilience	ZENODO
Factsheet Number of hospital beds per 100000 inhabitants in the community	DOCX	~KB	AIT, CA BY	Assessment of health resilience	ZENODO
Factsheet Self-reported unmet needs for medical examination	DOCX	~KB	AIT, CA BY	Assessment of health resilience	ZENODO
Factsheet Investments in water cycle-related infrastructure	DOCX	~KB	AIT, CA BY	Assessment of infrastructural resilience	ZENODO
Factsheet Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget	DOCX	~KB	AIT, CA BY	Assessment of infrastructural resilience	ZENODO

Data set name	Format	Size	Owner & re-use conditions	Potential Utility within and outside	Unique ID
Factsheet Average age of infrastructure e.g. the water supply network, road network, electrical grid	DOCX	~KB	AIT, CA BY	Assessment of infrastructural resilience	ZENODO
Factsheet Number of land transport routes to enter/exit the community	DOCX	~KB	AIT, CA BY	Assessment of infrastructural resilience	ZENODO
Factsheet Percentage of critical facilities served by off-grid energy services	DOCX	~KB	AIT, CA BY	Assessment of infrastructural resilience	ZENODO
Factsheet Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event	DOCX	~KB	AIT, CA BY	Assessment of infrastructural resilience	ZENODO

2.5 Security and Ethics

The work performed in this deliverable and the data used or produced (if any) aren't considered sensitive in terms of ethics or security.

3 Climate Resilience

Within the deliverable D2.2 “Climate Change Resilience Indicators” a substantial review of different resilience frameworks and their approaches was given. Within the climate change mitigation and adaptation context, the Intergovernmental Panel on Climate Change (IPCC, 2022) defines resilience as:

“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.”

and notes that:

“The term describes not just the ability to maintain essential function, identity and structure, but also the capacity for transformation.” (IPCC, 2022)

Within the consortium we agreed on using this definition, as also stated in D2.2.

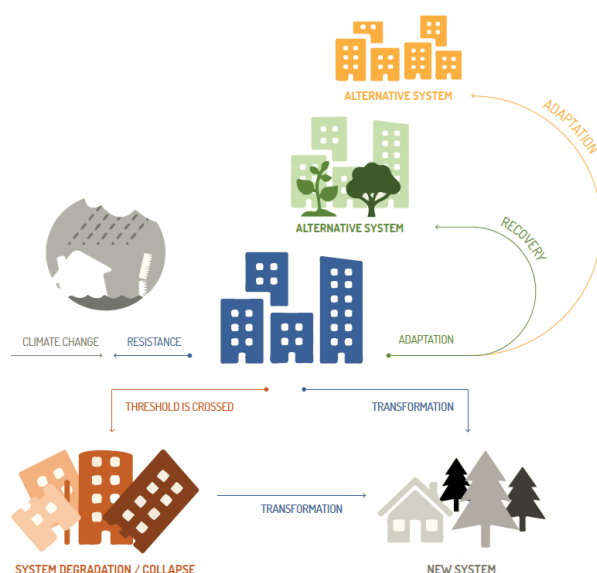


Figure 3: if a region is impacted by a climate event, it can lead to a total change and establishment of a new system, or through adaptation can become an alternative system (Tötzer, Loibl, Neubert, & Preiss, 2018) based on (Fuller & Quine, 2016).

This definition for resilience is independent of the climate hazardous event, but a sound knowledge of relevant climate hazards and their potential impacts and risks is needed nonetheless to empower regions to sustainably transform. Consequently, different hazard and risk computational methods for heat, flooding, drought and wildfire were investigated and the one chosen within ClimEmpower are depicted below (Figure 3).

3.1 Assessment of Climate Risks

The computation of risk depends on three components, the hazard, exposure and vulnerability of the object at state (IPCC, 2022), as also depicted in Figure 4 and depicted within D2.1.

In the IPCC context, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

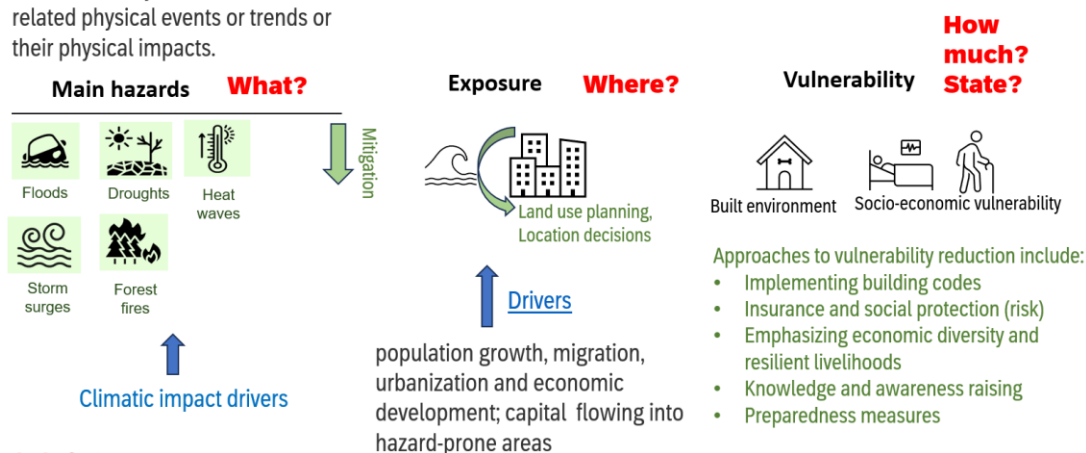


Figure 4: Overview of the three components of risk (source: D2.1)

Within ClimEmpower the regions stated the following hazards as most relevant (Table 3):

Table 3: Overview of relevant hazards by region

	Fire 	Drought 	Heatwaves 	Pluvial flooding 
Costa del Sol	X	X	X	X
Central Greece	X	X	X	X
Troodos Mountain	X	X	X	X
OBC		X	X	X
Sicily	X	X	X	X

Additionally, following aspects were identified as relevant (Table 4):

Table 4: Overview of important assets by region

	People / Health 	Tourism 	Critical Infrastructure 	Agriculture 	Natural Areas / Biodiversity 
Costa del Sol, Andalusia, Spain	X	X	X	X	X
Central Greece	X	X		X	X
Troodos Mountain		X		X	X
OBC				X	X
Sicily	X	X	X		X

Therefore, potential risk assessment computations are focused on the following hazards and impacts on sectors, independent of the regions (Figure 5).

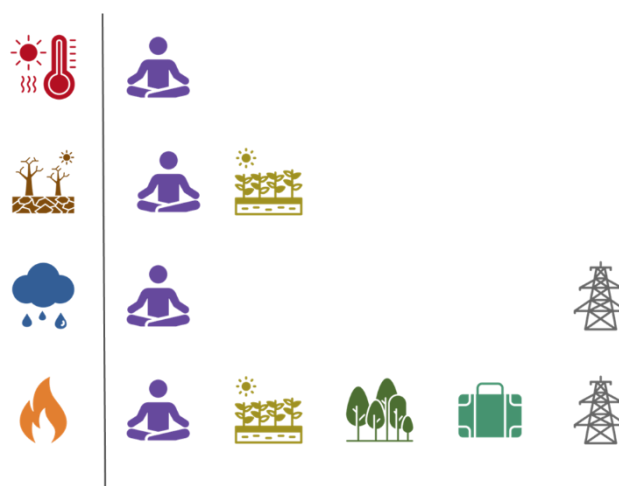


Figure 5: Overview of assets affected by specific hazards

3.1.1 Suggested risk calculation

There are different approaches available for the computation of risk and especially over the past years freely available and generally applicable risk assessment tools such as CLIMADA (Aznar-Siguan & Bresch, 2019) have gained importance and visibility. Within ClimEmpower, especially the toolbox for conducting risk assessment set-up within the CLIMAAX project (CLIMAAX-Project, 2025), incorporating jupyter notebooks to implement the workflow, provides comprehensive material. Apart from external resources, also internal risk assessment methods and workflows exist. The suggested risk calculations defined below build upon the internal and external resources and have been defined through expert discussions, a common understanding of best practice and the needs of ClimEmpower regions.

When calculating risk, it is common to weight the different components (hazard, exposure, vulnerability) to reflect their relative influence on the final outcome. A widely accepted default approach, recommended by UNDRR (UNDRR Risk Reduction, 2019) and IPCC (IPCC, 2022) is to apply equal weighting to each component, especially in the absence of strong evidence favouring an alternative. However, it is important to note that the way each layer is constructed—including data sources, resolution, and classification methods—often has greater impact on the final risk results than the choice of weighting scheme itself.

For the computation of risks depicted below the following approach is suggested: each layer is multiplied by 1/3 and added up to a final, normed risk score. If no vulnerability aspect was identified, a weighting of 1/2 for the remaining layers is applied.

For each risk assessment, key datasets were selected using contributions coming from experts and literature. These datasets were separated between the hazard, exposure and vulnerability components of the risk, and they were weighted over 1 inside them. This means that, for instance, two datasets comprised in the hazard component are weighted so the sum of their values is 1, to be further summed.

For drought risk assessment, for instance, data values of each dataset are standardized from 1 to 10, being distributed depending on the nature of the data. Final hazard, exposure and vulnerability values will be given between 1 and 10, while risk values will range between 1 and

1000 (as the result of multiplying hazard x exposure x vulnerability. Finally, risk will be classified depending on the value, resulting in:

Risk computed value	Risk definition
1-200	Very low
200-400	Low
400-600	Moderate
600-800	High
800-1000	Very high

3.1.2 Adaptation – measures to reduce identified risk

In case climate risks and impacts are either experienced or foreseen for a region, adaptation measures play a crucial role in decreasing the regions vulnerability and therefore risk. Thus, for each risk depicted below, potential adaptation measures based on D4.3, the ICARIA (Russo, et al., 2023) adaptation catalogue⁴ and the CoP feedback are provided. The adaptation measures stated below fall within the resilience dimensions (3.3) yet target a specific hazard and related impacts. It is important to note, that the resilience indicators and recommendations (3.2) are hazard (or shock) independent and focus on comprehensively ensuring the regions' resilience.

3.1.3 Heat induced risk to population

As recent years with increasing summer temperatures have shown, heat poses a substantial threat to (European) population. Also, within ClimEmpower it has been declared a priority by all regions, displaying that not only urban areas are affected.

However, cities are especially prone to heat risk as they intensify all three risk aspects: hazard (3.1.3.1), exposure (3.1.3.2) and vulnerability (3.1.3.3). The first is altered due to the prevailing materials in a built environment, reduced ventilation and blocked long-wave radiation (e.g. (Bügelmayer-Blaschek, Züger, & Tötzer, 2025) and references therein). The second relates to high population densities, prevailing in cities, and the third to the urban structure and population distribution (Figure 6).

Within ClimEmpower, the only „asset” we focus our heat induced risk on, is people.

⁴ <https://www.icariastrategies.eu>

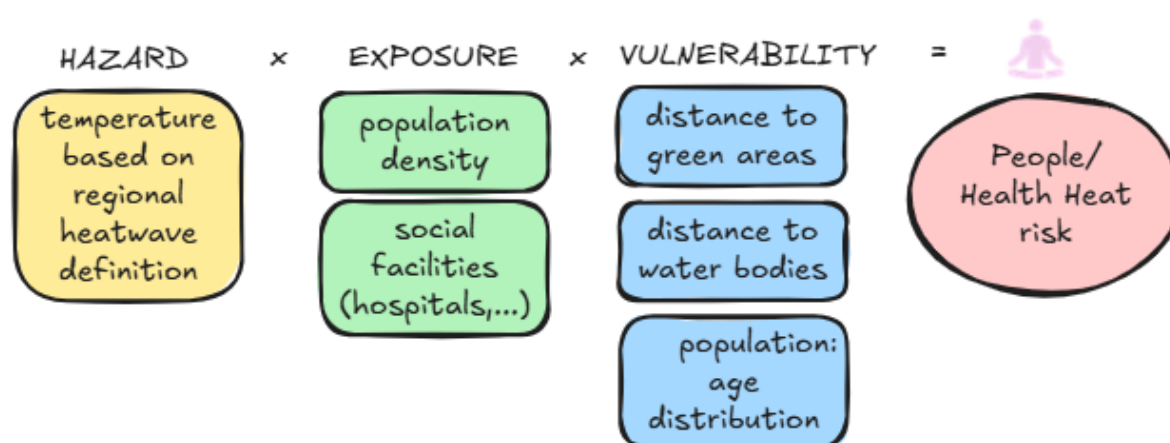


Figure 6: Suggested heat risk calculation workflow for assessing risk to people. Source: own presentation

3.1.3.1 Hazard

Heat presents a common hazard to an increasing number of regions and countries, however, there is no common definition on what meteorological conditions especially impact mortality or morbidity. The meteorological conditions investigated in most literature are maximum daily temperature, night time temperature, apparent temperature (e.g. (Ho, Knudby, Xu, Hodul, & Aminipouri, 2016), (Williams, et al., 2012)) or heatwaves, the latter being the most common (e.g. (Nitschke, Tucker, & Bi, 2007), (D'Ippoliti, et al., 2010), (Tong, Wang, & Guo, 2012)), although no common heatwave definition exists. This is due to the fact that countries and residents are used to different climate conditions and therefore also adapted to these, which requires region specific definitions.

Within ClimEmpower we follow the approach of using **regions specific heatwave definitions of our pilot regions** to be applied to climate data sets to assess the hazard. A heatwave definition often is: “3 consecutive days of $T_{max} > \text{threshold1}$ and $T_{min} > \text{threshold2}$ ”, thus for instance regional climate model data (e.g. **EURO-CORDEX ensemble** from the Copernicus data store) can be used as input data and analysed according to the definition given (Table 5). This analysis has to be done for different future conditions, and therefore emission scenarios, and time periods. The most common are: 2021 – 2050, 2041 – 2070 and 2071 – 2100, although there is a shift to move from time periods to global warming levels (GWL). GWL represent years when a specific global warming threshold is crossed within a certain global climate model (future) or observations (past). To shortly summarize they provide the following advantages⁵:

⁵ <https://climatedata.ca/resource/introduction-to-global-warming-levels/>

- GWLs can be used to explore and compare regional changes in climate at specified levels of global warming, including the limits on global temperature increase committed to in the [Paris Agreement](#).
- The GWL approach shifts the uncertainty in regional climate projections from the magnitude of the change associated with different emissions scenarios to the time when specific GWLs will be reached.

However, depending on the chosen global climate model, the global warming level is reached at a different model year, therefore, different time frames of 20 years are applicable for time aggregation, adding another difficulty in the automated hazard assessment approach.

Table 5: Suggested hazard datasets for heat risk calculation: Hazard layers

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Hazard	CORDEX regional climate model data on single levels	https://cds.climate.copernicus.eu/datasets/projections-cordex-domains-single-levels?tab=download	Tmin, Tmax	daily	0.11° x 0.11°	https://confluence.ecmwf.int/display/CKB/CORDEX%3A+Regional+climate+projections

3.1.3.2 Exposure

As we focus on population's risk to heat, exposure is represented by the population density, existence of tourist accommodation and social facilities, such as hospitals, kindergarten etc. that account for increased prevalence of people with higher vulnerabilities.

Regarding the treatment of layers, point locations such as tourist accommodation or social facilities are treated as 1 if available and 0 otherwise, while population density is normalized to the regions' distribution. The dataset is described in Table 6.

Table 6: Suggested hazard datasets for heat risk calculation: Exposure layers

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Exposure	population density	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	Total Population density	static, last update 2011	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/userguide.pdf
Exposure	Population density	https://data.jrc.ec.europa.eu/dataset/2ff68a52-5b5b-4a22-8f40-c41da8332cfe	Total population density	5 year interval, projection until 2030	3 arc seconds	https://doi.org/10.1080/17538947.2024.2390454

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Exposure	Building data	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [nursing_home,group_home,shelter,day_care,...]	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/
Exposure	Tourist accommodation	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [port,airport,hotel,motel,...]	static		For Costa del Sol, Golf course placements are also available;

3.1.3.3 Vulnerability

For heat, vulnerability of the population is altered by the possibility to access green areas and / or water bodies that represent cooler and relaxation zones for the population. Additionally, the population age strongly alters the vulnerability of people towards heat, with children and elderly being stronger negatively affected. Thus, the closer a person is from a surface water body and/or several types of green urban areas, will help to reduce heat induced risk. This reduction will be even higher on population under 15 years old and over 65 years old.

For the computation of the layers, a distance-based classification will be performed for the variables 'distance to green areas' and 'distance to water bodies' using 4 categories, where distances closer to the population indicate lower vulnerability compared to those that are farther away. Once classified by distances, the values will be normalized between 0 and 5, with 0 representing the least vulnerable and 5 representing the highest vulnerability. Regarding the variable 'population: age distribution', it will be normalized according to the population distribution in the region, following the same approach used for hazard assessment. The dataset is described in Table 7.

Table 7: Suggested hazard datasets for heat risk calculation: Vulnerability layers

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Vulnerability	Distance to surface water bodies	Corine Land Cover	Distance to surface water bodies	Static, last update 2018	100 x 100 m	https://land.copernicus.eu/en/products/corine-land-cover/clc2018#general_info
Vulnerability	Distance to green areas	a. Corine Land Cover b. Geofabrik Download Server c. GEOSTAT - Census grid 2021	Simultaneous proximity to green urban areas*	Static, last update 2021	100 x 100 m	https://land.copernicus.eu/en/products/corine-land-cover/clc2018#general_info

Vulnerability	Population <15 and >65 years	GEOSTAT - Census grid 2021	Population distribution	Static, last update 2021	1 x 1 km	https://ec.europa.eu/eurostat/web/gisco/geodata/population-distribution/population-grids
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*This indicator helps showing the access of population to green urban areas, depending on their surface and the distance they are from buildings. It is built computing layers comprising green urban areas, population distribution and buildings.

3.1.3.4 Adaptation measures

Based on the resilience recommendations (D4.3) and the ICARIA adaptation catalogue, the following adaptation measures for heat were selected and linked to the defined dimensions (Table 8).

Table 8: Suggested adaption measures for heat, sorted by dimension, expected impact and applicable region.

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Health & Wellbeing	Healthcare system preparedness	Strengthen health services and emergency response capacity for heat-related illnesses.	Reduces mortality and ensures effective treatment during heat waves.	Sicily
Health & Wellbeing	Improve health and safety policies considering CC	Protection from extreme temperatures. These plans and policies will include temperature hazard in future risk assessment of critical infrastructure.	protection of people through heat aware policies and strategies	Andalus
Health & Wellbeing	Strengthen the services for the most vulnerable people	Strengthen the services for the most vulnerable people at the Citizen Help and Information Offices (OACs) to help prevent the effects of heat and other extreme climate events		Andalus
Population, Society & Education	Community Gardens & Food Security	Promote community gardens as a means of fostering local food production, enhancing food security, and building community resilience.	Local food production is expected to be increased; green infrastructure decreases day- and especially night time temperatures	OBZ
Population, Society & Education	Public cooling centers	Provide accessible, air-conditioned spaces where people can find relief during extreme heat events.	Protects vulnerable groups (elderly, children, homeless) from health risks.	Sicily
Population, Society & Education	Public awareness campaigns	Educate communities about heat risks and promote protective behaviors (hydration, shading, avoiding outdoor activity at peak hours).	Knowledge and Behavioural change/ Information and Awareness Rising	Sicily

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Infrastructure	Green Roofs, Cool Roofs & Urban Vegetation	Integrate green roofs, green walls, vertical gardens, reflective/cool roofs, and other urban vegetation to enhance green coverage, improve building insulation, reduce heat absorption, and provide buffers against heat and flooding. Competitions or programs can engage residents and increase awareness.	Depending on measured: Expected to reduce urban heat island effect by up to 1–2°C (trees, urban vegetation), lower indoor temperatures by 2–5°C (green facades), decrease energy demand for cooling by 5–10% (facades, roof), improve air quality, and increase urban green coverage annually (vegetation, trees).	OBZ, Sicily
Infrastructure	Smart Energy Management	Incorporate smart energy management systems, including sensors and automation, to optimize energy use	Energy use in buildings is expected to be optimized	OBZ
Infrastructure	Climate-Resilient Building Design & Shading	Design and retrofit buildings to NZEB standards or with improved insulation, natural ventilation, and passive cooling techniques. Complement with shading structures and canopies in public spaces (bus stops, playgrounds, sidewalks) to reduce heat exposure.	Reduces building energy consumption for heating/cooling, lowers indoor heat stress, decreases energy costs, and reduces risk of heat stroke in vulnerable populations.	OBZ, Sicily, Troodos, Andalus
Infrastructure	Retrofit housing for adaptation	Renovate housing improving insulation to heat and flood, replacing obsolete electrical installations, etc.	through insulation and passive shading indoor temperatures can be decreased by 5-10°C	Andalus
Infrastructure	Energy system resilience	Upgrade energy infrastructure to cope with higher electricity demand for cooling during heat waves.	Reduces risk of blackouts and ensures reliable cooling access.	Sicily
Environment & Settlement Areas	Afforestation and Naturally Vegetated Land	Establish forests or stands of trees in areas without recent tree cover, including rural slopes. Manage species and fuel to enhance cooling, soil stability, and moisture retention while minimizing fire risk.	Enhances local carbon sequestration, biodiversity, cooling, and soil/moisture regulation. Natural areas store less heat than sealed areas and cool stronger during the night.	OBZ, Troodos
Environment & Settlement Areas	Soil Moisture Conservation	Use organic or synthetic mulch to reduce soil evaporation, moderate soil temperature, and suppress weed growth.	Soil moisture retention is expected to be increased	OBZ
Environment & Settlement Areas	Heat-Resilient Farming Systems	Introduce shade nets or agroforestry systems to protect crops and livestock from heat stress.	Heat stress in crops and livestock is expected to be reduced	OBZ

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Environment & Settlement Areas	Urban Green Parks and Tree Planting	Develop, expand, and maintain urban green parks, forests, gardens, and street tree cover to provide shade, cooling, improved air quality, and recreational spaces for communities.	Urban temperatures are expected to decrease by 1–3°C, improving thermal comfort, reducing heat-related illnesses, and enhancing overall urban livability.	OBZ, Sicily, Troodos
Environment & Settlement Areas	Water features and misting systems	Introduce fountains, ponds, and misting systems in public areas to increase evaporative cooling.	Can reduce local ambient temperature by 1–2°C and improve comfort in urban spaces.	Sicily
Environment & Settlement Areas	Lawns and green areas	Lawn Lawns and green areas are permeable surfaces that perform some important functions in an urban environment, such as heat and run-off control, space for recreational and sport uses, biodiversity hubs and carbon storage components. There are several typologies of lawn suitable for urban areas, such as: - rustic lawns, which ask for less maintenance and are mainly used for river/canal banks and floodable public places; - ornamental lawn, used in public and private gardens; - sports lawns, formed by species that allow a high trampling; - flowery lawns, formed by a mix of herbaceous flowering plants, annual or perennial. Depending on the types, they may or not require a regular irrigation and mowing. The use of spontaneous species and the support of symbiotic behaviours (between different plant types and/or fungi), when carefully designed, can greatly enhance the quality of green areas, reducing maintenance and irrigation costs, as well as providing improved resistance during droughts.	decreased heat storage during the day, cooling effect during the night. Magnitude of cooling dependent on size of lawns	Andalus

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Governance, Strategy & Planning	Actions for public awareness, information, education and communication	Inform local citizens and visitors about the major hazards through public meetings, flyers, website, training, collaborative platforms, brochures, public presentations, internet portals, etc.	People are more aware of climate changes and danger, adapt measures and recommendations for resilience	OBZ, Andalus
Governance, Strategy & Planning	Assessment of thermoregulatory vegetation in the city	Decide which zones need more thermoregulatory vegetation, those where it is not necessary and where xerophile vegetation is already sufficient	Priority zones for vegetation are expected to be identified, leading to a 1-2°C local temperature reduction in targeted areas.	OBZ, Troodos
Governance, Strategy & Planning	Implementation of climate shelters	Climate shelter spaces (identify & equip cool refuges; parks/gardens, public buildings opened during heat alerts).		Troodos
Governance, Strategy & Planning	Early warning systems for heat waves	Develop heat alert systems that provide forecasts and guidance to citizens and institutions.	Improves preparedness and reduces mortality and morbidity from extreme heat.	Sicily

3.1.4 Drought induced risk to agriculture and population

A detailed assessment of the risks associated to droughts, as well as the analysis of their history is crucial to reduce, manage and adapt to the impact of future events. This assessment could be done from the information coming from past and forecasted climate impacts, to i) identify factors defining a specific type of drought risk, ii) how do they interact, and iii) estimate the current risk levels for different sectors and systems (Rossi, et al., 2023). In this project, the focus of the drought risk assessment implies the affectation to population and agriculture (Figure 7).

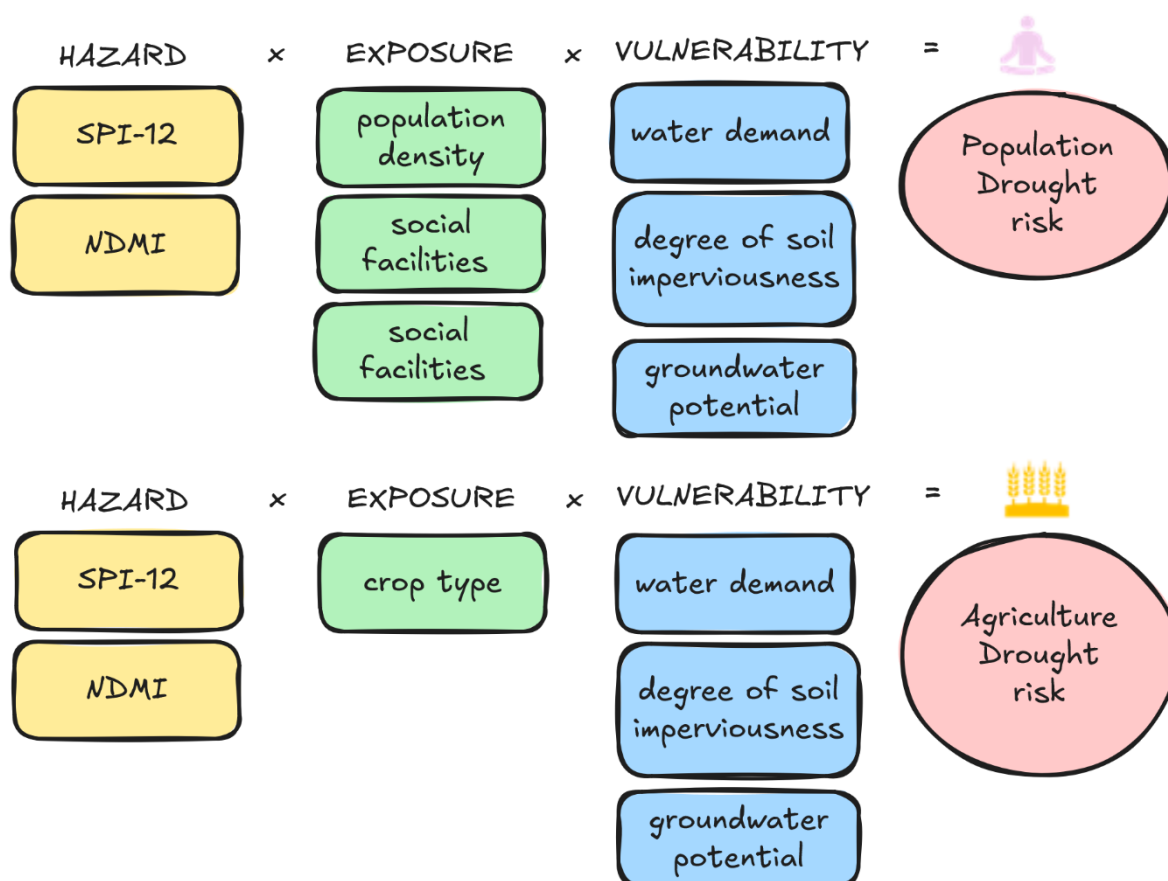


Figure 7: Suggested drought risk calculation workflow for assessing risk to people and agriculture.
Source: own presentation.

3.1.4.1 Hazard

Hazard of droughts refers to factors causing water scarcity that can affect a determined system, mainly linked to the existence of a rainfall deficit. However, the appearance of “water scarcity” situations also depend on human activities and the associated water demand. In this project, the hazard component has been linked to the natural component of drought, taking into consideration two variables as the Standardized precipitation index for 12 months (SPI-12) and the Normalized Difference Moisture Index (NDMI).

The dataset is described in Table 9.

Table 9: Suggested hazard datasets for drought risk calculation: Hazard layers

Asset	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
All	Standardized Precipitation Index (SPI-12)	SPI-12 JRC	SPI-12	10-daily or monthly	Data dependent	https://drought.emergency.copernicus.eu/data/factsheets/factsheet_spi.pdf
All	CORDEX climate projection data	https://cds.climate.copernicus.eu/datasets/projections-cordex-domains-single-levels?tab=overview&utm_source=chatgpt.com	Pr (precipitation)	Daily to seasonal mean	Data dependent	https://euro-cordex.net/060378/index.php.en?utm_source=chatgpt.com
All	Sentinel-2 L2A	Copernicus Browser	Normalized Difference Moisture Index (NDMI)	5-daily	10 x 10 m	https://documentation.dataspace.copernicus.eu/Data/SentinelMissions/Sentinel2.html

3.1.4.2 Exposure

Exposure refers to the “presence of people, ways of life, species or ecosystems, environmental functions, services and resources, infrastructures, and/or economic, social or cultural goods that could be negatively affected” (IPCC, 2022). Therefore, here some variables as population density and social facilities have been considered, in order to measure the impact on population, but also tourist accommodation or the location of golf courses have been taken into account, as tourism is an important economic asset in some specific regions (specially in coastal Mediterranean areas). To assess drought exposure for agriculture, the type of crop was used as water demand is different among the different type of crops. For vulnerability, water demand, degree of soil imperviousness and groundwater potential have been used for assessing general risk to drought (all assets). The dataset is described in Table 10.

Table 10: Suggested exposure datasets for drought risk calculation: Exposure layers

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Population	Census grid 2021	GEOSTAT - Census grid 2021	Population density	Not specified	1x1 km	GEOSTAT - Census grid 2021
Population	Basic services	https://ec.europa.eu/eurostat/web/gisco/geodata/basic-services#Education	Social facilities (hospitals, schools, nursing homes, etc.)	2020, 2023	Vectorial, data dependent	https://gisco-services.ec.europa.eu/public/education/metadata.pdf

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Population	Tourist accommodation	Geofabrik Download Server	Tourist accommodation	Not specified	Vectorial, data dependent	https://download.geofabrik.de/osm-data-in-gis-formats-free.pdf
Population	Golf courses location	Corine Land Cover	Golf courses location	6-yearly	100x100 m	https://land.copernicus.eu/en/products/corine-land-cover/clc2018#download
Agriculture	Crop types	Copernicus – Land Monitoring Service	Crop type	1 year	10 m	https://sdi.eea.europa.eu/catalogue/srv/api/records/9db29b07-5968-4ce0-8351-1e356b3d7d47/formatters/xsl-view?output=pdf&language=eng&approved=true

3.1.4.3 Vulnerability

Vulnerability component refers to the different levels of fragility of the exposed elements to drought events, which imply higher or lower sensitivity of ecosystems (e.g.: soil and vegetation characteristics, capacity of aquifers to storage groundwater for long periods, etc.) and population potentially affected (e.g.: activities or sectors strongly dependents of water). Besides, other factors related with the adaptation capacity of the system can play different roles (Rossi, et al., 2023), as the existence of local emergency plans for droughts, or the current status of hydraulic infrastructures (e.g.: percentage of non-registered water in the network system). The dataset is described in Table 11.

Table 11: Suggested hazard datasets for drought risk calculation: Vulnerability layers

Asset	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
All	CORINE Land Cover 2018	Corine Land Cover	Water demand (agriculture and urban)	6-yearly	100x100 m	https://land.copernicus.eu/en/products/corine-land-cover/clc2018#download
All	Imperviousness Density 2018	Copernicus Land Monitoring Service	Degree of soil imperviousness	3-yearly	10x10 m / 100x100 m	https://land.copernicus.eu/en/products/high-resolution-layer-imperviousness/imperviousness-density-2018
All	International Hydrogeological Map of Europe 1:1,500,000 (IHME1500)	Hydrogeological map of Europe	Groundwater potential (hydraulic conductivity of aquifers)	Static	Vector / 1:1,500,000	Hydrogeological map of Europe

3.1.4.4 Adaptation measures

Based on the resilience recommendations (D4.3) and the ICARIA adaptation catalogue, the following adaptation measures for drought were selected and linked to the defined dimensions (Table 12).

Table 12: Suggested adaption measures for drought, sorted by dimension, expected impact and applicable region.

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Population, Society & Education	Climate-Resilient Crop Varieties	Promote crop diversification with drought-resistant, flood-tolerant, and heat-resilient varieties to adapt to variable climate conditions.	Increased crop yield stability	OBZ
Population, Society & Education	Climate-Aligned Crop Scheduling	Adjust planting and harvesting schedules based on seasonal climate forecasts to optimize crop yields and reduce exposure to extreme weather.	Reduced yield losses from extreme climate events	OBZ
Population, Society & Education	Public campaigns to encourage watersaving at a domestic level	Raise awareness and inform households about simple measures to reduce water use (e.g., efficient appliances, behavioral changes).	Promotes widespread water conservation, significantly lowering domestic water demand.	Sicily, Andalus
Population, Society & Education	Actions for public awareness, information, education and communication	Inform local citizens and visitors about the major hazards through public meetings, flyers, website, training, collaborative platforms, brochures, public presentations, internet portals, etc	Knowledge and Behavioural change/ Information and Awareness Rising	Sicily
Infrastructure	Assessment of energy impact of supplying water	Study the energy impact of supplying water (desalination plant, regenerated water plants, etc.)	Energy consumption associated with water supply is expected to be quantified, enabling optimization and reduction	OBZ, Troodos, Sicily

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Infrastructure	Adaptation of intake infrastructure to handle low flows	Water abstraction structures are often designed to tackle a given range of water height at receiving water bodies, thus not allowing abstraction of water when flows are at lower levels. To increase the flexibility of abstraction structures it is of interest to face meteorological conditions conducting to drought.	Reliability of water abstraction during drought conditions	OBZ, Troodos
Infrastructure	Foster water saving on a municipal level	Foster water saving on a municipal level in irrigating parks and gardens, fountains, street cleaning and municipal buildings; Build recharging pools at high points & install rainwater capture systems for reuse (village scale).	Municipal water consumption for public services (parks, fountains, cleaning, buildings) is expected to be decreased.	OBZ, Troodos
Infrastructure	Integrated Rainwater and Greywater Harvesting	Collect, store, and reuse rainwater and greywater from rooftops, paved areas, and domestic/industrial sources for irrigation, cooling, and non-drinking purposes.	Dependence on potable water supply is expected to be reduced by 10–40%, increasing water availability during droughts and supporting farm and urban water self-sufficiency.	OBZ, Sicily, Andalus
Infrastructure	Efficient Irrigation Systems	Retrofit irrigation systems with water-saving technologies such as drip or micro-sprinkler irrigation to optimize water use and reduce evaporation losses.	Agricultural water use is expected to be decreased through efficient irrigation systems.	OBZ
Infrastructure	Precision Water Management	Utilize precision farming technologies, such as soil moisture sensors and satellite monitoring, to manage water and nutrient application more effectively.	Efficiency of water and nutrient use is expected to be improved	OBZ

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Infrastructure	Urban Rainwater Harvesting	Implement rainwater harvesting systems for buildings, public spaces, and roads to reduce stormwater runoff and conserve water resources. These systems can store water for irrigation, cooling, or domestic use, helping mitigate the impacts of droughts and heatwaves.	Urban stormwater runoff is expected to be reduced, while harvested rainwater can supply non-potable water demand.	OBZ
Infrastructure	Bypass/diversion channels at sub-basin scale for seasonal flow management & drought support.		ensure water supply through diversified channels.	Troodos
Infrastructure	Hydropower: Improved turbine efficiency and reservoir management	Improve turbine efficiency and optimize water reservoir management to reduce evaporation losses and improve water storage.	Maintains renewable energy production and secures water storage capacity during droughts.	Sicily
Infrastructure	Optimize desalinization plant	Improve efficiency of desalination plants with advanced processes to minimize costs and environmental impacts	Provides a reliable alternative water source during drought while reducing energy use and emissions.	Sicily, Andalus
Infrastructure	Reduction of leakages in water distribution networks	Modernize and maintain distribution systems to minimize water loss through leaks	Saves large volumes of water, improving efficiency and extending supply during droughts.	Sicily
Infrastructure	Interbasin connections	Interbasin connection to offer redundancies for water supply	increased resilience of region	Andalus
Infrastructure	Reduction of leakages in water distribution networks	Perform monitoring, preventive and corrective actions to avoid leakage problems in water distribution networks	saving water that is lost due to leakages, therefore reducing water consumption	Andalus

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Infrastructure	Smart local irrigation system	Design the municipal irrigation system for watering trees to be able to adapt to different needs of evapotranspiration and cooling services	reduced water consumption due to targeted irrigation system	Andalus
Environment & Settlement Areas	Water Storage & Recharge Systems	Construct reservoirs, retention ponds, underground storage, and recharging pools to capture rainwater and enhance aquifer recharge, securing water availability for irrigation and urban use.	Water availability during droughts is expected to be increased, supporting irrigation needs, urban water supply, and reducing stormwater runoff.	OBZ, Sicily
Environment & Settlement Areas	Canopies	Install shaded canopy structures in public areas and over urban infrastructure.	Reduces water loss from evaporation in soil and public spaces; lowers heat stress in cities during droughts.	Sicily
Environment & Settlement Areas	Restoration of natural infiltration to groundwater	Restoration of natural infiltration to groundwater , also known as "Artificial Groundwater Recharge" has a significant impact on runoff storage.	ensures higher groundwater levels needed during drought	Andalus
Governance, Strategy & Planning	Drought-Tolerant Landscaping	Design landscaping with xerophytic (drought-tolerant) plants to reduce water consumption and ensure resilience during prolonged dry periods	Irrigation water demand is expected to be reduced by up to 20%, increasing resilience during prolonged drought periods.	OBZ
Governance, Strategy & Planning	Adapt the necessary current urban planning regulations	Adapt urban planning regulations to integrate climate change adaptation and mitigation targets, with a focus on water efficiency and drought resilience.	Ensures that future developments reduce water demand and are resilient to drought impacts.	Sicily, Andalus
Governance, Strategy & Planning	Foster water saving on a municipal level	Promote water efficiency in municipal services such as irrigation of parks, fountains, street cleaning, and public buildings.	Reduces overall municipal water demand, setting an example for citizens and saving significant volumes of water.	Sicily, Andalus

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region
Governance, Strategy & Planning	Increase water cost for specific uses	Increase water cost (to reduce water consumption) through different actions: tax for water overconsumption in industry processes, incentives to modern irrigation systems development or to a change in agricultural production (promoting more sustainable farming)	water is understood as valuable resource and is used more sustainably	Andalus
Governance, Strategy & Planning	Monitoring drinking water and groundwater quality	Assess and continuously monitor the quality of drinking water and groundwater under drought conditions.	Ensures safe water supply, prevents contamination from salinity or pollutants concentrated by low water levels.	Sicily, Andalus
Governance, Strategy & Planning	Update the drought protocol with climate projections	Incorporate up-to-date climate projections in future editions of the Drought Protocol	enables long-term planning	Andalus
Governance, Strategy & Planning	Build water-network flow & quality modelling tools (plan for interruptions/quality shifts in drought).		allows effective planning and preparedness for drought	Troodos

3.1.5 Flood induced risk to buildings, population and critical infrastructure

Flooding proves to be the most common, frequent and most costly natural disaster in Europe (European Commission (Directorate-General for Environment), 2025), with climate change further intensifying the hazard, and the development of our society the exposure and vulnerability. Within ClimEmpower we focus on the flood induced risk to buildings (damage), population (displacement) and critical infrastructure (affected). The suggested workflow is seen in Figure 8.

Further, we focus on assessing the impact of fluvial and coastal flooding based on the CLIMADA river and coastal flooding risk assessment approach (CLIMAAX-Project, 2025). Regarding extreme precipitation only the changes in precipitation intensities are displayed, as local and asset specific thresholds would be needed for risk assessment.

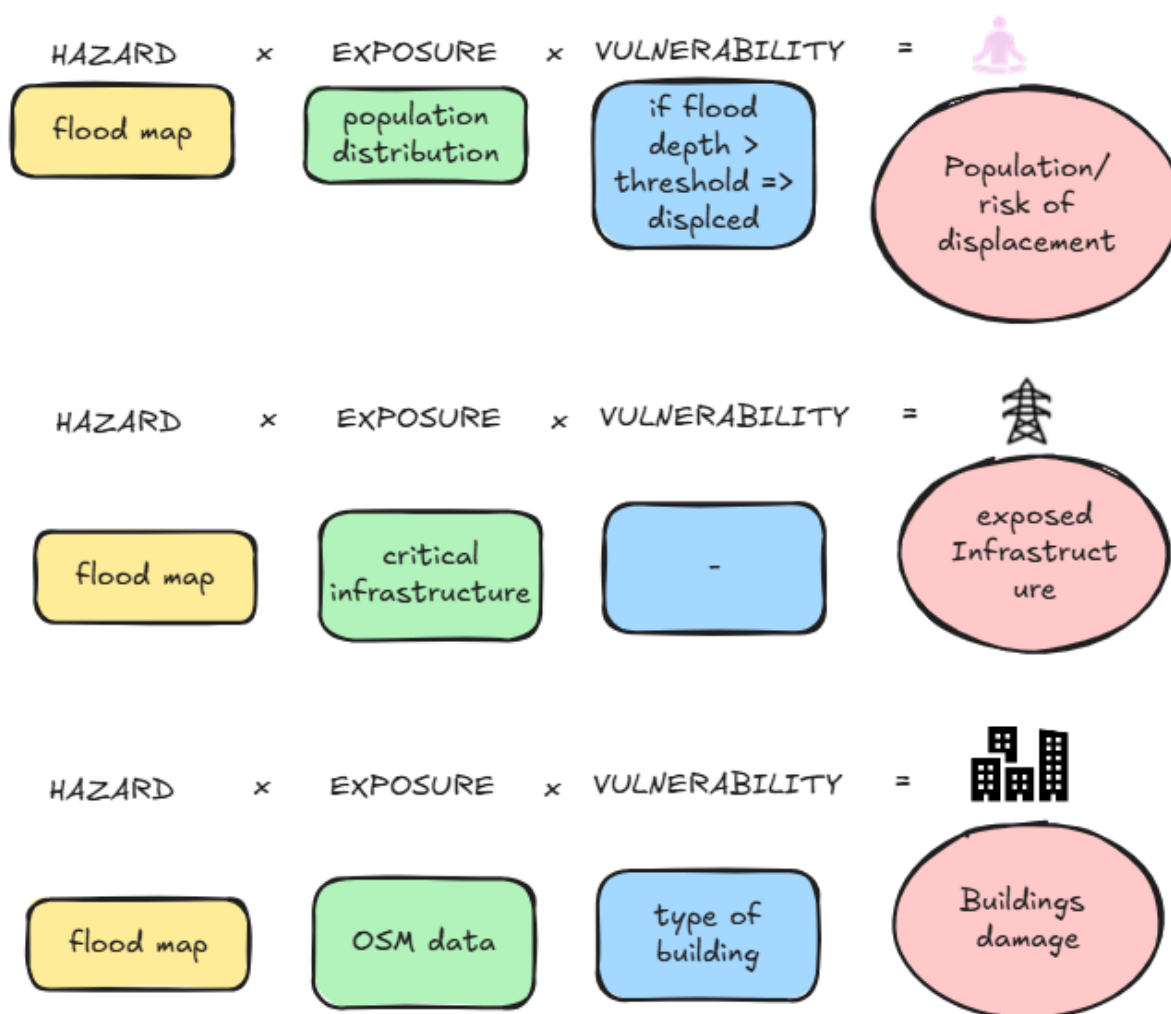


Figure 8: Suggested flood risk calculation workflow for assessing risk to people, critical infrastructure and buildings. Source: own presentation

3.1.5.1 Hazard

Computing the flood hazard of a region displays a different complexity than heat or drought, as flooding might stem from strong precipitation (pluvial), river (fluvial), or coastal flooding. Even though they all relate to strong precipitation events (also mostly in the case of coastal flooding), flood maps can't be derived from precipitation observations or projections directly. Yet, hydrological models are needed to translate precipitation intensities to flooded area and depth.

For river flooding, the hydrological model computes the flooding based on the inflow of water within the whole river basin, the rivers bathymetry and surroundings. To correctly assess pluvial flooding, mainly relevant in built-up areas, the information on land use and canal system are needed as additional input to the model, with especially the latter posing significant complexity. Coastal flooding can be assessed based on sea level (including wave height) and the bathymetry of the sea as well as its surrounding.

In case no regional flood maps are available for river and coastal flooding, global flood data sets at very high resolution exist. However, they don't account for already implemented protective measures such as retention areas or dams. Therefore, flooding might be strongly overestimated. Overall, it is important to consider that the suggested data provide a first estimate, not a detailed analysis of potential flooding extent!

Regarding extreme precipitation, we state the data set useful for assessing changes in intensities and duration. Thus, using this data, the annual maximum precipitation (3h / 6h / 12h / daily) can be computed and displayed, as well as for instance the maximum daily precipitation within a certain time period (e.g. RX1day 1991-2020, 2021-2050, 2041-2070, 2071-2100) or within different global warming levels. For better understanding of changes in extreme precipitation, the expected range of RX1day within a certain time period is a common indicator (example as in Figure 9).

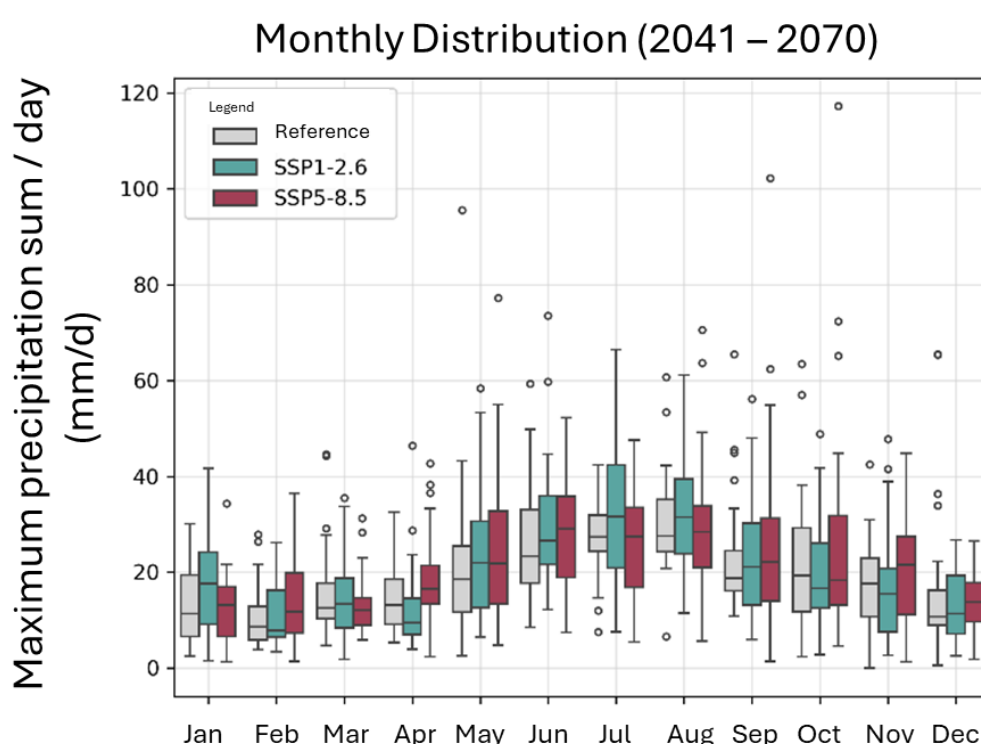


Figure 9: example of the distribution of RX1day for a specific region (regional mean) over all months within the climate period 2041-2070 for a low (SSP1-2.6) and high (SSP5-8.5) emission scenario

The list of hazard datasets for flooding risk calculation is in Table 13.

Table 13: Suggested hazard datasets for flooding risk calculation: Hazard layers

Type of flooding	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
River	Aqueduct Flood Hazards Maps	https://www.wri.org/data/aqueduct-floods-hazard-maps	Flood map for extreme flood events	Extreme events representative for baseline (~1980) and future periods (2030, 2050, 2080)	300 – 750m	https://www.wri.org/research/aqueduct-floods-methodology
Coastal	Aqueduct Flood Hazards Maps	https://planetarycomputer.microsoft.com/dataset/deltares-floods	Global Coastal flood maps	Present day climate (~2018), 2050 under RCP scenario	30-75m	https://ai4edatasetspublicassets.blob.core.windows.net/assets/aod_docs/11206409-003-ZWS-0003_v0.1-Planetary-Computer-Deltares-global-flood-docs.pdf
Extreme precipitation	CORDEX regional climate model data on single levels	https://cds.climate.copernicus.eu/datasets/projections-cordex-domains-single-levels?tab=download	Pr, mean precipitation flux	3h	0.11° x 0.11°	https://confluence.ecmwf.int/display/CKB/CORDEX%3A+Regional+climate+projections

3.1.5.2 Exposure

The assets at risk incorporated within ClimEmpower are people, critical infrastructure and buildings. To assess the impact on buildings, the availability and – if available – building type information is used as exposure. To account for population, the population density is considered and for critical infrastructure its location as stated within the OSM data set.

By combining the flood map (flood depth) with the exposure layer, the flood depth at the location of people/buildings or critical infrastructure is identified. For the critical infrastructure the risk assessment stops here, as no vulnerability information exists. The dataset is described in Table 14.

Table 14: Suggested hazard datasets for flooding risk calculation: Exposure layers

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Exposure	Population density	https://data.jrc.ec.europa.eu/dataset/2ff68a52-5b5b-4a22-8f40-c41da8332cfe	Total population density	5 year interval, projection until 2030	3 arc seconds	https://doi.org/10.1080/17538947.2024.2390454
Exposure	Building data	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [residential, commercial and industrial]	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/
Exposure	Critical infrastructure data	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [critical infrastructure]	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/

3.1.5.3 Vulnerability

For assessing the damage to buildings due to different flood depth, vulnerability curves set-up by JRC are commonly used if no local dataset on vulnerability curves exists, as seen in Figure 10.

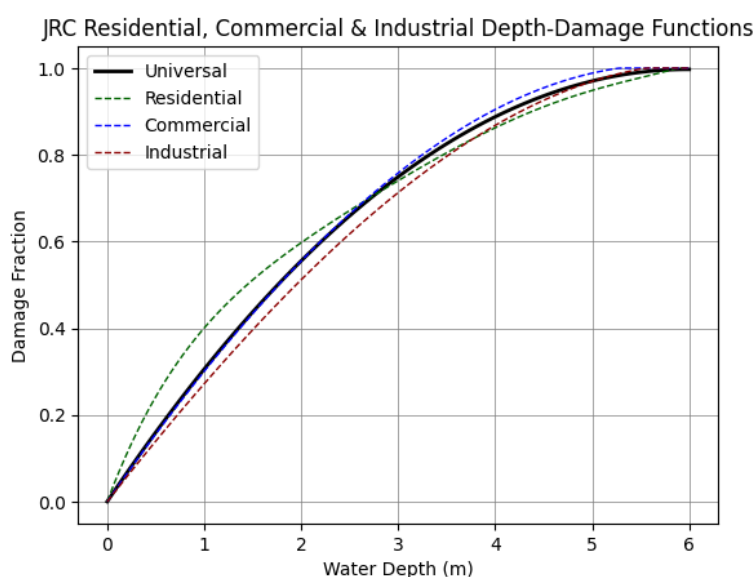


Figure 10: vulnerability curves linking water depth to damage fraction of different building (Huizinga, de Moel, & Szewczyk, 2017).

Based on the damage fraction and information on building reconstruction costs per square meters as well as building content replacement value per square meter, the monetary damage can be assessed (2010 represents base year). The assessment can be performed for specific return periods of the flooding.

To quantify the number of people displaced by flooding, a threshold of flood depth needs to be defined (e.g. above 1m) that is then used to assess how many of the affected population (combining population density with flood map) is displaced (combining population density with flood depth greater than 1m). Therefore, no additional data set is needed. The dataset is described in Table 15.

Table 15: Suggested hazard datasets for flooding risk calculation: Vulnerability layers

Layer	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Buildings	Global flood depth-damage functions	https://publications.jrc.ec.europa.eu/repository/handle/JRC105688	Depth-damage functions	Static, 2017		https://publications.jrc.ec.europa.eu/repository/handle/JRC105688
Buildings	Consumer Price Index	https://data.worldbank.org/indicator/FP.CPI.TOTL	Reconstruction and refurbishment costs	yearly	national	https://data.worldbank.org/indicator/FP.CPI.TOTL

3.1.5.4 Adaptation measures

Based on the resilience recommendations (D4.3) and the ICARIA adaptation catalogue, the following adaptation measures for flooding were selected and linked to the defined dimensions (Table 16).

Table 16: Suggested adaption measures for flooding, sorted by dimension, expected impact and applicable region.

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
Population, Society & Education	Actions for public awareness, information, education and communication	Inform local citizens and visitors about the major hazards through public meetings, flyers, website, training, collaborative platforms, brochures, public presentations, internet portals, etc	Knowledge and Behavioural change/ Information and Awareness Rising	Sicily
Population, Society & Education	Analyse social perception of climate change effects on the coast	Social research on perceptions and attitudes towards coastal flood risks and acceptance of adaptation measures.	Improves citizen participation, facilitates implementation of measures, and strengthens community resilience.	Central Greece
Economy & Labour Market	Green Stormwater Infrastructure	Invest in green infrastructure systems like bioswales, vegetated swales, and rain gardens that manage stormwater naturally, enhancing water infiltration and providing filtration of	Stormwater infiltration rates are expected to be increased by at least 5%, while pollutant loads entering water bodies are reduced.	OBZ

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
		pollutants before they enter water bodies.		
Infrastructure	Engineered Flood Protection	Implement flood barriers, retention basins, and water diversion systems around the site to minimize flood damage.	Flood damage in surrounding areas will be minimized as excess water is retained, diverted, or blocked during heavy rainfall or storm surges.	OBZ, Andalus
Infrastructure	Construction of anti-flood retention tanks	Retention or detention tanks designed to temporarily store stormwater during heavy rainfall events.	Cuts peak flows and gradually releases water back into the network, reducing overflow incidents.	Central Greece
Infrastructure	Water-Resistant Materials	Use materials resistant to water damage for lower building levels, and design spaces that can be easily restored after flooding (e.g., raised electrical systems, floodproof finishes).	Post-flood recovery time and repair costs will be reduced by ensuring that exposed areas suffer less permanent damage and can be restored more quickly.	OBZ
Infrastructure	Agricultural Drainage	Establish effective drainage networks to prevent waterlogging and root rot in flood-prone areas.	Flood duration and crop losses in flood-prone areas are expected to be reduced by up to 20%.	OBZ
Infrastructure	Resilient Transport Assets	Upgrade and Maintain Critical Transport Assets: Invest in high-quality roads, bridges, railways, and public transport fleets resistant to climate and operational stress.	Transport disruptions due to extreme weather are expected to be reduced by up to 20%, ensuring higher reliability of mobility networks.	OBZ
Infrastructure	Build water squares (only if a larger settlement has a suitable central space).		Cuts peak flows and gradually releases water back into the network, reducing overflow incidents.	Troodos
Infrastructure	Flood-Resilient Buildings	Elevate building foundations or critical infrastructure in flood-prone areas to reduce vulnerability to storm surges or riverine flooding.	Vulnerability to storm surges and riverine flooding will be reduced by ensuring that essential structures remain operational during flood events.	OBZ, Sicily
Infrastructure	Build water network flow and quality modelling tools for assessing	Development of modelling tools for water supply and sewerage networks to assess	Quantifies risks (damage, service interruptions, water quality deterioration) and supports targeted	Central Greece

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
	responses to damage, supply interruptions, and changing water quality.	vulnerabilities under flood conditions.	investments and emergency planning.	
Infrastructure	Bypass/diversion channels	Construction of bypass or diversion channels to redirect part of the flow away from densely built-up areas.	Reduces flood levels in main channels within cities and increases the hydraulic capacity of the system.	Central Greece
Infrastructure	Filter drain	Subsurface drain with pipe and gravel that collects and conveys stormwater from roads or paved areas.	Reduces ponding and local flooding, improving road safety and drainage efficiency.	Central Greece
Infrastructure	Increase pumping capacity	Upgrading pumping stations and deploying mobile pumps to rapidly remove stormwater from critical locations.	Reduces inundation duration, drains low-lying areas faster, and limits flood damage.	Central Greece
Infrastructure	Increase the capacity of sewer-drainage system	Upgrading sewer and drainage pipe capacity, adding bypasses and balancing tanks to prevent overflows.	Increases hydraulic capacity, reduces backflows, and prevents road flooding.	Central Greece
Infrastructure	Increase the network of waterways	Restoring and expanding waterways and stream networks to re-establish natural hydraulic continuity.	Increases flood conveyance and provides ecological co-benefits through river restoration.	Central Greece
Infrastructure	Inspection and cleaning of drains or sewer pipes	Regular inspection and cleaning of drains and sewers to remove debris, sediments, and roots.	Restores hydraulic capacity and reduces blockages, lowering the frequency of local floods.	Central Greece, Andalus
Infrastructure	Municipal reclaimed water for industrial use and aquifer recharge	Reuse of treated wastewater for industrial applications and aquifer recharge.	Releases capacity in the sewer system and improves water balance, indirectly reducing flood pressures.	Central Greece
Infrastructure	Rainwater first flush diversion system	Diverts and stores the first flush of stormwater from roofs before it enters drainage systems.	Reduces load on sewer networks during storms and improves water quality.	Sicily
Infrastructure	Integrated urban water management	Design water systems to manage both excess stormwater and scarcity, using efficient infrastructure	Reduces risk of urban flooding while ensuring reliable water supply	Sicily
Environment & Settlement Areas	Nature-Based Water Management	Utilize blue infrastructure, such as rain gardens, bioswales, and permeable pavements, to manage stormwater and reduce the risk of	Stormwater runoff is reduced, and urban flood risks are mitigated while providing additional environmental and social co-benefits.	OBZ

Dimension	Name of Adaptation Measure	Description	Exptected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
		flooding from heavy rainfall		
Environment & Settlement Areas	Enhancing Flood Resilience	Implement terraced farming or raised planting beds to protect crops from flooding and improve water drainage.	Crop survival rates during flood events are expected to be increased by at least 20%.	OBZ
Environment & Settlement Areas	Permeable Pavement & Surfaces	Use permeable or semi-permeable materials (e.g., porous asphalt, permeable concrete, paving stones) in streets, driveways, and pavements to allow water infiltration, reduce surface runoff, and support stormwater management.	Surface runoff is expected to be reduced by up to 10%, decreasing peak runoff during heavy rainfall, lowering the frequency of urban flooding events, reducing pressure on drainage systems, and improving groundwater recharge.	OBZ, Sicily, Andalus
Environment & Settlement Areas	Ecosystem Waterways & Wetlands	Design and restore natural waterways, such as rivers, lakes, wetlands, and ponds, to absorb excess rainfall and reduce flood risks. Construct wetlands and swales to filter stormwater, improve water quality, and provide flood storage capacity.	Peak flood volumes are expected to be reduced by up to 5%, while water quality is improved through natural filtration.	OBZ
Environment & Settlement Areas	Floodplain Restoration & Control Infrastructure	Restore floodplains and implement flood control infrastructure (such as levees, dams, retention basins, or flood detention systems) to protect urban areas from extreme rainfall and rising water levels while restoring natural water retention capacity.	Flood risk in urban areas is expected to be reduced by up to 20% during extreme rainfall events, providing large-scale flood protection and enhancing natural water storage.	OBZ, Sicily, Andalus
Environment & Settlement Areas	Buffer Strips & Bioswales	Vegetated strips along rivers, streams, or fields, combined with bioswales and small-scale bioretention areas, to trap sediments, filter pollutants, slow surface runoff, and attenuate local flood peaks.	Reduces erosion and pollutant loads, improves water quality, and provides small-scale flood peak attenuation in both urban and rural areas.	Central Creece, Troodos

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
Environment & Settlement Areas	Constructed Semi-Natural / Artificial Wetlands & Retention Tanks	Design and construct semi-natural or artificial wetlands in small valleys or river reaches, combined with anti-flood retention tanks in areas with flash-runoff issues. These systems reduce flood risks, enhance stormwater retention, and can additionally treat wastewater.	Flood risk is reduced, stormwater is naturally retained and filtered, and water quality is improved while providing ecological co-benefits.	Troodos, OBZ, Andalus
Environment & Settlement Areas	Afforestation & Naturally Vegetated Land	Reforestation and preservation of natural vegetation in hydrologically sensitive catchments. Planting and maintaining forests and other vegetation increases surface roughness, slows runoff, stabilizes soils, enhances infiltration, and improves natural flood regulation.	Reduces peak flood flows and volumes, mitigates erosion, improves water quality, and increases groundwater recharge.	Central Greece, Sicily, Andalus
Environment & Settlement Areas	Alkborough flats	Example of managed realignment where low-lying land is intentionally flooded to create tidal wetlands.	Provides natural flood storage and reduces tidal surge heights, while enhancing wetland biodiversity.	Central Greece
Environment & Settlement Areas	Bioretention area	Shallow vegetated basins or depressions (LID/SuDS) designed to capture, filter, and slowly release stormwater using engineered soil and vegetation.	Reduces peak runoff, delays flooding, improves stormwater quality, and increases local infiltration.	Central Greece, Sicily
Environment & Settlement Areas	Infiltration basin/surface	Basins or surfaces designed to temporarily store stormwater and infiltrate it into the ground.	Reduces runoff, recharges groundwater, and prevents surface water flooding during storms.	Central Greece
Environment & Settlement Areas	Install filter strip	Vegetated strips between urban surfaces and water bodies designed to intercept runoff and pollutants.	Traps sediments, slows runoff, reduces pollution, and slightly attenuates peak flows.	Central Greece
Environment & Settlement Areas	Install filter trenches	Gravel-filled trenches with geotextile that collect and infiltrate stormwater before entering the drainage network.	Locally reduces flood runoff and improves water quality through infiltration and storage.	Central Greece
Environment & Settlement Areas	Natural coastal protection	Protect cities from rising sea levels and storm surges through natural coastal protection (mangroves, coral reefs, dunes).	reduces intensity of flood	Andalus

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
Environment & Settlement Areas	Build and promote urban forest and park	Increase green areas in cities to absorb rainwater, delay runoff, and reduce impermeable surfaces.	Lowers flood risk in urban areas by enhancing infiltration and storage.	Sicily
Environment & Settlement Areas	Build water network flow and quality modelling tools for assessing responses to damage, supply interruptions, and changing water quality	Create modelling tools to assess flood-related disruptions to water networks and supply.	Strengthens resilience of urban water services during and after floods.	Sicily
Governance, Strategy & Planning	Emergency response plans and procedures	Establish/update/operation emergency plans with close cooperation of emergency entities, decision makers, enterprises and citizens. Include related new developments of climate change knowledge.	Emergency preparedness and response capacity are strengthened, coordination among actors is improved, and climate-related risks are managed more effectively.	OBZ
Governance, Strategy & Planning	Emergency Transport Systems	Develop Emergency Backup Systems: Ensure alternative routes, backup fuel supplies, and emergency transit plans are in place for disruptions.	Recovery times during climate-related disruptions are expected to be shortened by at least 20%, maintaining continuity of essential services.	OBZ
Governance, Strategy & Planning	Climate-conscious land-use planning	Land-use planning that considers flood risk, including zoning, building restrictions in floodplains, and river setbacks.	Reduces long-term exposure of people and assets and improves effectiveness of other measures.	Central Greece, Sicily, OBZ
Governance, Strategy & Planning	Data collection for flood recovery	Systematic post-flood data collection on flood extent, damages, recovery times, and high-water marks.	Improves impact assessment, prioritization of recovery measures, and feeds into flood risk mapping and modelling.	Central Greece, Sicily, Andalus
Governance, Strategy & Planning	Develop a rescue plan	Dedicated flood rescue plan outlining roles, procedures, equipment, safe routes, and assembly points.	Reduces fatalities and injuries, ensures faster response, and improves coordination across agencies.	Central Greece, Sicily, OBZ
Governance, Strategy & Planning	Develop community flood plans	Community-level flood preparedness plans involving residents, volunteers, and local authorities.	Enhances local readiness, self-protection, and faster recovery after flood events.	Central Greece, Sicily, Andalus
Governance, Strategy & Planning	Emergency response plans and procedures	Civil protection plans and protocols (operational procedures, ICS, crisis communication, evacuations).	Enables faster mobilization and reduces losses in lives and property during floods.	Central Greece

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
Governance, Strategy & Planning	Flood Risk Mapping & Modelling Studies	conduct hydrological, hydraulic, and pollutant transport modelling studies to identify high-risk flood zones, vulnerabilities, and exposures under different scenarios.	Supports prioritization of projects, development of updated hazard maps, risk-based investments, and more effective, cost-efficient interventions.	Central Greece, Andalus
Governance, Strategy & Planning	Implement multi-hazard early warning systems	Integrated early warning systems that combine monitoring, forecasting, communication, and response protocols.	Provide timely alerts to populations and authorities, improving preparedness and reducing losses.	Central Greece, Andalus
Governance, Strategy & Planning	Improve flood forecasting	Upgrading flood forecasting systems with denser monitoring networks, radar/nowcasting, and coupled models.	Delivers more accurate and timely warnings, providing crucial lead time for protective actions.	Central Greece
Governance, Strategy & Planning	Provide climate information through online platforms	Online platforms providing climate and weather data, warnings, and self-protection guidelines.	Improves public access to reliable information and supports faster decision-making during floods.	Central Greece
Governance, Strategy & Planning	Resilience Action Plan	Comprehensive action plan coordinating prevention, preparedness, response, and recovery measures.	Ensures policy coherence, prioritizes investments, and strengthens resilience indicators over time.	Central Greece
Governance, Strategy & Planning	Set or update flood hazard maps	Preparation or updating of flood hazard maps based on new data, climate scenarios, and implemented measures.	Provides accurate spatial planning, informed permitting, and better communication of flood risks.	Central Greece, Andalus
Governance, Strategy & Planning	Amend staff insurance policies to fit CC adaptation strategy	Adjust insurance to include flood-related risks and support institutional flood preparedness.	Improves financial resilience of staff and organizations to flood events.	Sicily
Governance, Strategy & Planning	Adapt the necessary current urban planning regulations	Adapt the necessary current urban planning regulations so they help to achieve the climate change mitigation and adaptation goals and targets	Urban plans are updated	OBZ

3.1.6 Wildfire induced Risk to population, agricultural and natural areas, infrastructure and tourism

Wildfire risk is an increasingly severe threat across Europe due to climate change, land-use changes, and population pressure. Numerous institutions and projects—such as EFFIS, CETH, CETAQUA, and CLIMAAX (CLIMAAX-Project, 2025)—have developed approaches for integral wildfire risk assessment, each contributing valuable methodologies. As stated in

3.1, the risk will be calculated based on hazard, vulnerability and exposure data. Risk calculation is asset dependent and for the wildfire risk it is suggested to create individual assessments for different relevant assets: critical infrastructure, people and health, tourism, agriculture and natural areas / biodiversity.

The suggested construction of the individual layers for each asset can be seen in Figure 11. The individual construction of the layers is described in 3.1.6.1, 3.1.6.2 and 3.1.6.3..

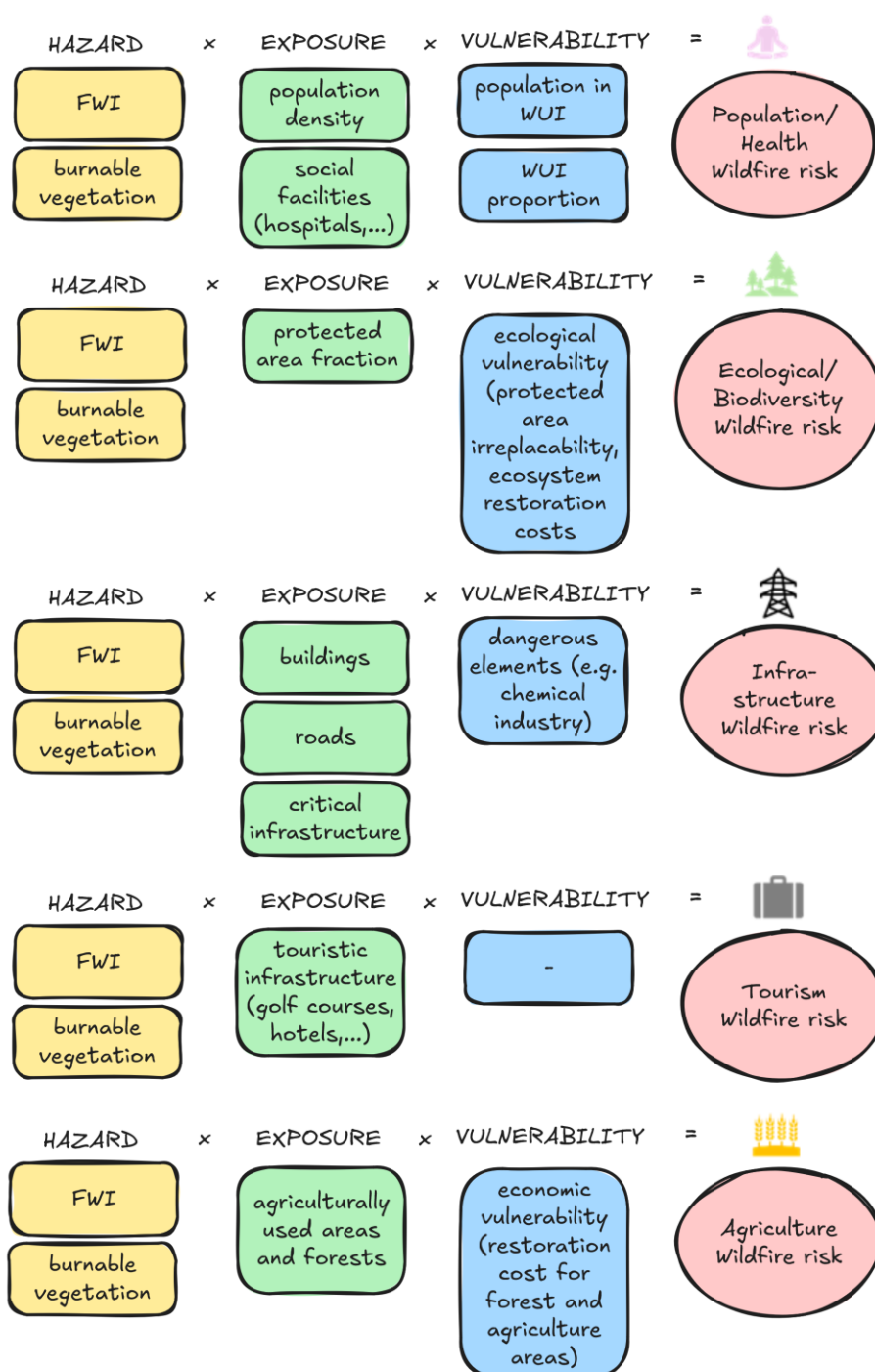


Figure 11: Suggested wildfire risk calculation workflow for different assets. FWI stands for Fire weather index and WUI is the wildland urban interface. Source: own presentation

3.1.6.1 Hazard

The European Forest Fire Information System (EFFIS) provides comprehensive monitoring and forecasting of wildfire danger across Europe. One of its core components is the Fire Weather Index (FWI), a widely used meteorological index that estimates fire danger based on temperature, humidity, wind speed, and precipitation. The FWI system enables daily assessment of ignition potential and fire spread conditions (German Meteorological Service (DWD), 2023), serving as a key input for early warning systems and risk assessments across multiple projects and institutions (Canadian Forest Fire Information System (CWFIS) - Natural Resources Canada, 2024). FWI is particularly valuable for climate risk analysis as it is available in high-resolution historical datasets and has been projected for future climate scenarios across Europe. This makes it well-suited for assessing both current and future wildfire risk within the ClimEmpower framework. In this case, the seasonal FWI mean is applied. The dataset is described in Table 17.

As FWI itself is not wildfire hazard itself but represents favourable meteorological conditions for wildfire, it is combined with another essential component, the burnable vegetation layer. It represents the current state of vegetation prone to burning and is derived from CORINE Land Cover classifications. Combining the two layers allows a simple quantification of wildfire hazard.

The hazard layer is constructed by masking out all non-burnable vegetation parts and multiplying the burnable vegetation score with the FWI. The hazard layer is then rescaled from 0-1.

Table 17: Suggested hazard datasets for wildfire risk calculation: Hazard layers.

Asset	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
All	FWI	https://climate.copernicus.eu/fire-weather-index	Seasonal fire weather index	yearly	0.11° x 0.11°	https://cwfis.cfs.nrcan.gc.ca/background/summary/fwi
All	burnable vegetation	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	Burnable land proportion	static, last update 2021	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/effis.fire.risk.viewer.user.guide.pdf

3.1.6.2 Exposure

In wildfire risk assessment, the exposure layer is asset-dependent and tailored to the elements at risk within a specific context. Asset-specific layers are incorporated depending on the focus of the assessment.

Depending on the type of dataset – an overview is found in Table 18 - different layer constructions need to be applied. For asset location datasets such as location of facilities, buildings, touristic or critical infrastructure, roads, agriculturally used areas and forests, a simple Boolean structure is applied: 1 if asset is present, 0 if not. If datasets are upscaled, it is suggested to use a fraction approach. For the population density, it is recommended to norm it based on the real values found in the respective region, as rural areas might not have high

densities at all. All exposure layers listed in Table 18 of the respective assets (see also column 'asset' in Table 18) are added up and capped at 1. If only one exposure layer is used, as it is for the risk calculation related to agriculture and tourism the case, the layer can be used directly.

Table 18: Suggested datasets for wildfire risk calculation: Exposure layers.

Asset	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Population	Population density	https://data.jrc.ec.europa.eu/dataset/2ff68a52-5b5b-4a22-8f40-c41da8332cfe	Total population density	5 year interval, projection until 2030	3 arc seconds	https://doi.org/10.1080/17538947.2024.2390454
Population	social facilities	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [nursing_home, group_home, shelter, day_care,...]	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/
Biodiversity	protected area fraction	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	Protected Area fraction	static, last updated 2021	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/effis.fire.risk.viewer.userguide.pdf
Infrastructure	buildings	https://www.openstreetmap.org/#map=7/47.714/13.349	building footprints	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/
Infrastructure	roads	https://www.openstreetmap.org/#map=7/47.714/13.349	road maps	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/
Infrastructure	critical infrastructure	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [hospital, clinic, doctors, pharmacy, police, fire_station,...]	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/
Tourism	touristic infrastructure	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [port, airport, hotel, motel,...]	static		For Costa del Sol, Golf course placements should also be used (dataset already available at CETAQUA)
Agriculture	agriculturaly used areas	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	CLC2: agricultural areas	static, last update 2021	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/effis.fire.risk.viewer.userguide.pdf

3.1.6.3 Vulnerability

Vulnerability is often the most challenging component of wildfire risk to assess, as it depends heavily on the specific characteristics and sensitivities of the exposed assets. Nevertheless, institutions like EFFIS and the Joint Research Centre (JRC) provide valuable proxies that support structured vulnerability estimation with predefined layers such as Ecological vulnerability, Economic vulnerability, and Ecological-economic vulnerability (EFFIS (European Forest Fire Information System) & JRC (Joint Research Centre), 2022).

The underlying data to create this vulnerability layers is as well available, including WUI (wildland urban interface) proportion, population density in WUI, protected area irreplaceability, and protected area fraction.

The construction of the vulnerability layer depends on the asset. Layer components that are already normed, such as the WUI fraction, are taken as is, location datasets are again taken as Boolean values and datasets containing a wide range of values are normed between 0-1 with 0 relating to the minimum and 1 to the maximum value. The suggested datasets are listed in Table 19. All respective vulnerability components are added up and capped at 1 (see layer 'asset' in Table 19). If only one dataset is given, as for example with wildfire risk related to infrastructure, it can be taken as is.

Table 19: Suggested datasets for wildfire risk calculation: Vulnerability datasets.

Asset	Dataset name	Download / source link	Variable name	Temporal resolution	Spatial resolution	Documentation / Additional information
Population	WUI proportion	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	WUI proportion	static, last updated 2021	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/effis.fire.risk.viewer.user.guide.pdf
Biodiversity	ecological vulnerability	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	ecological vulnerability	static, last updated 2021	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/effis.fire.risk.viewer.user.guide.pdf
Infrastructure	dangerous elements	https://www.openstreetmap.org/#map=7/47.714/13.349	Suggested tags [industrial, chemical, oil, gas, refinery,...]	static		https://welcome.openstreetmap.org/working-with-osm-data/downloading-and-using/
Agriculture	economic vulnerability	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	economic vulnerability	static, last update 2021	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/effis.fire.risk.viewer.user.guide.pdf
Population	population in WUI	https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/	Population density in vulnerable WUI	static, last updated 2021	0.11° x 0.11°	https://data.effis.emergency.copernicus.eu/apps/fire.risk.viewer/effis.fire.risk.viewer.user.guide.pdf

3.1.6.4 Adaptation measures

Based on the resilience recommendations (D4.3) and the ICARIA adaptation catalogue, the following adaptation measures for wildfire were selected and linked to the defined dimensions (Table 20).

Table 20: Suggested adaption measures for wildfire risks, sorted by Dimension, expected impact and applicable region.

Dimension	Name of Adaptation Measure	Description	Exptected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
Population, Society & Education	Inclusive Conservation Practices	Involve local and Indigenous communities in conservation efforts, incorporating traditional ecological practices (e.g., fire management or sustainable hunting).		OBZ
Population, Society & Education	Actions for public awareness, information, education and communication	Inform local citizens and visitors about wildfire hazards through public meetings, flyers, websites, training, collaborative platforms, brochures, public presentations, internet portals, etc.	Knowledge and behavioural change / Increased awareness of wildfire risks	Sicily, Troodos, Andalus
Population, Society & Education	Community and Indigenous Engagement	Involve local and Indigenous communities in fire prevention and management, incorporating traditional ecological practices.	Supports community-led conservation and wildfire risk reduction, enhances resilience of local populations	Sicily
Infrastructure	Building Codes and Land Use Planning	Develop and enforce building codes and land use plans that minimize fire vulnerability (e.g., fire-resistant materials, safe distances from forested areas).	Reduces structural damage and risk to human life during wildfires	Sicily
Infrastructure	Water Resource Management and Firefighting Infrastructure	Ensure water supply, reservoirs, and firefighting equipment are available in fire-prone areas.	Enhances effectiveness of firefighting operations, limits fire spread, and protects communities	Sicily
Environment & Settlement Areas	Reforestation and forest conservation	Planting trees, or sowing seeds, in a barren land devoid of any trees to create a forest	Reduced wildfire intensity and spread	OBZ, Andalus

Dimension	Name of Adaptation Measure	Description	Expected Impact	applicable region (Sicily, Troodos, Andalus, Central Greece, OBZ)
Governance, Strategy & Planning	Adaptive Ecosystem Management	Continuously update management plans based on monitoring results and emerging environmental data, such as changes in wildfire risk or vegetation health	Improved wildfire preparedness and resilience	OBZ, Sicily
Governance, Strategy & Planning	Firebreaks & Fuel Management	Create and maintain firebreaks, tracks, and water points, combined with fuel management practices such as vegetation thinning, controlled burns, and early wildfire detection (in line with EU wildfire prevention guidance for Mediterranean mountain regions). These measures reduce available fuel loads and facilitate firefighting access.	Reduces wildfire intensity, slows fire spread, and increases preparedness, protecting human settlements, ecosystems, and infrastructure.	Troodos, Sicily
Governance, Strategy & Planning	Early Warning Systems and Forecasting	Implement real-time fire detection systems, weather monitoring, and predictive models.	Allows timely evacuation and firefighting response, reducing property damage and fatalities	Sicily
Governance, Strategy & Planning	Emergency Preparedness and Response Plans	Develop evacuation routes, emergency shelters, and response protocols for wildfire events.	Reduces casualties, ensures rapid response, and improves coordination during emergencies	Sicily

As stated above, identifying and quantifying the risk of specific hazard types is just one part of resilience. It is therefore important to keep in mind that resilience indicates the ability of a system to “anticipate, absorb, accommodate, or recover from the effects of a hazardous event

in a timely and efficient manner” (IPCC, 2022). Thus, the description of the resilience framework and the chosen resilience indicators are presented below.

3.2 ClimEmpower Resilience Framework

The review of resilience frameworks (D2.2) revealed that most use a mix of qualitative-quantitative approach. For instance, within the UNDRR_Disaster resilience scorecard for cities (cities_Detailed_Excel tool_English_Jan2021), as well as the Costa del Sol resilience framework, questions are asked to local experts and the answers are related to numbers, that are then evaluated to provide a quantitative resilience score. It is important to note that simply asking respondents to provide numerical answers does not automatically constitute a combination of qualitative and quantitative approaches. Rather, this practice reflects a primarily qualitative approach, where numbers are used as a tool to ‘normalize’ or standardize diverse perspectives in advance. While this can facilitate comparison and synthesis, it should not be mistaken for a fully quantitative methodology, as the analysis still fundamentally relies on subjective interpretation and contextual understanding. Overall, with the most common approach, the information can’t be received automatically or objectively, based on available data sets, as is the approach within ClimEmpower. Both approaches have their reasoning as well as advantages and disadvantages.

The first one enables a more detailed analysis of specific local context based on experience, knowledge and available (local) data that might not be reflected in openly available data sets, but it is also subjective and may be influenced by the personal biases of the individuals answering the questionnaire. The second approach relies purely on available data, therefore, is objective and can be applied to any region. However, spatial and temporal shortcomings of the data sets as well as missing data sets might hinder the implementation of specific indicators.

Therefore, a combination of qualitative (guiding questions, WP4) and quantitative approach (climate service, WP3) is envisioned.

Apart from focusing on quantitative indicators, the relevant dimensions and characteristics were adapted from existing resilience frameworks to better represent the needs and understanding of the ClimEmpower CoPs and are depicted below.

3.3 Relevant Dimensions

Building upon the work on the resilience framework and indicators presented in Deliverable D2.2 and the feedback from the CoPs and project consortium, the following dimensions have been defined as they cover the most relevant thematic areas for assessing regional resilience. By focusing on these key areas, the project ensures a structured and practical approach to evaluating and enhancing regional climate resilience.



3.3.1 Health & Wellbeing

This dimension emphasizes the ability of individuals, communities, and healthcare systems to adapt to and recover from the health impacts of climate change. The goal is to safeguard and promote both physical and mental health in the long term.

A key aspect is strengthening healthcare services to effectively address climate-related risks such as heat stress, emerging diseases, and the consequences of extreme weather events. Equally important is providing access to resources that support mental and emotional well-being, since psychological burdens linked to climate change are becoming increasingly significant.

Special attention must also be given to protecting vulnerable populations, who are disproportionately affected by climate-related challenges.

Ultimately, this dimension requires building resilient systems that ensure the long-term health and well-being of people in the face of a changing climate.



3.3.2 Population, Society & Education

The resilience of a society to climate change is strongly shaped by its social structure, demographic characteristics, and educational preparedness. These elements determine how effectively a community can respond to and recover from climate-related events.

Important factors include the composition of the population, with particular consideration for vulnerable groups, as well as the general level of education within the society. In addition, the proportion of the population trained in emergency preparedness and disaster response plays a critical role. Efforts in disaster risk reduction further enhance a community's overall ability to manage crises.

These factors help assess a society's readiness to respond to and recover from climate-related events by examining the percentage of the population trained in disaster response, the vulnerability of certain populations, and the overall state of societal awareness and preparedness.



3.3.3 Economy & Labour Market

This dimension highlights the economic resilience of a region in the face of climate change and related challenges. It examines the ability of economic systems to remain stable, adapt to disruptions, and recover effectively.

Key aspects include assessing the strength, flexibility, and stability of economic sectors, financial systems, and the labour market. Understanding how well the economy can withstand shocks—such as climate-related disruptions—and adapt to changing conditions is essential for long-term resilience.

This dimension also emphasizes the promotion of sustainable growth and the creation of secure, future-oriented job opportunities. By integrating economic preparedness with climate adaptation strategies, regions can ensure that their economies not only recover from adverse impacts but also evolve in a way that supports resilience and sustainability.



3.3.4 Infrastructure

The Infrastructure dimension covers all critical sectors that are essential for the functionality of a region and its resilience in the face of climate change and other disasters. These sectors include transportation, telecommunications, energy, water supply, and safety systems.

Central to this dimension is the assessment of the robustness and adaptability of infrastructure. This involves evaluating the extent to which critical systems can withstand disruptions, recover quickly, and continue to provide essential services during times of crisis.

In addition, this dimension highlights the role of infrastructure in supporting communities before, during, and after climate-related or emergency events. Reliable and adaptable infrastructure is fundamental to reducing risks, safeguarding populations, and ensuring the long-term resilience of regions under changing climatic conditions.



3.3.5 Environment & Settlement areas

The Environment & Settlement Areas dimension focuses on spatial and land use aspects that shape both current and future conditions of a region. It considers the interaction between natural environments and human-made developments, which together determine how well a region is prepared for the impacts of climate change.

Key indicators include the characteristics of built environments, such as the percentage of sealed surfaces, as well as man-made features like irrigated land. At the same time, natural elements—such as the extent of forested areas—play an equally important role in resilience.

By examining these spatial patterns and land use factors, it becomes possible to better understand how human activity and natural systems interact in influencing a region's ability to cope with and adapt to extreme climate events.



3.3.6 Governance, Strategy & Planning

The Governance, Strategy & Planning dimension addresses the policies, planning processes, and institutional frameworks that determine a region's resilience to climate change and disasters. Effective governance plays a central role in coordinating actions, setting priorities, and ensuring that resilience measures are implemented efficiently and sustainably.

Key aspects include the effectiveness of governance structures, the degree to which resilience strategies are developed and executed, and the availability of critical resources to support adaptation and response.

This dimension ultimately evaluates how well a region is able to anticipate, prepare for, and respond to climate-related risks through proactive planning, regulatory measures, and coordinated action across institutions and stakeholders. Strong governance not only strengthens immediate disaster response but also lays the foundation for long-term resilience.

3.4 Characteristics of Indicators

In addition to defining key dimensions, it is also important to specify the characteristics of indicators. These characteristics are important because they clarify what aspects of resilience

an indicator captures and guide the selection and interpretation of indicators to ensure they effectively support regional climate resilience. Building on the research on the qualities of resilient systems presented in Deliverable D2.2, characteristics were examined that make indicators meaningful for assessing resilience. The following characteristics have been defined as suitable for the ClimEmpower project.

3.4.1 Reflectiveness

Involves learning from past experiences to inform future decisions, adapting standards, behaviours, and policies as circumstances evolve. Indicators with reflectiveness capture trends over time and highlight the effectiveness of past interventions. Example: Updating hazard or risk plans regularly based on new data and experiences.

3.4.2 Resourcefulness

Represents the ability to identify and provide alternative ways to utilize or supply resources during crises to meet needs or achieve goals. Indicators reflecting resourcefulness show how well a system can mobilize available assets under stress. Example: Ensuring access to emergency water resources for citizens.

3.4.3 Robustness

Ensures systems are well-designed, constructed, and managed to withstand shocks without catastrophic failure. Indicators measuring robustness can reveal infrastructure or system durability under extreme events. Example: Building infrastructure that accounts for current and projected future conditions and climate impacts.

3.4.4 Flexibility

Emphasizes the need to develop alternative strategies that can be applied in response to crises. Indicators capturing flexibility reveal the adaptability of institutions, communities, or infrastructure. Example: Assigning schools as temporary shelters during emergencies.

3.4.5 Inclusivity

Ensures broad consultation and shared ownership in decision-making, prioritizing the needs of vulnerable groups. Indicators demonstrating inclusivity help identify whether systems are equitable and whether all stakeholders are considered in resilience planning. Example: Implementing inclusive early warning systems so that everyone at risk receives timely information to minimize harm.

3.5 Information per Indicator

To provide all relevant information for the chosen indicators, so-called fact sheets were set-up that encompass the following aspects:

- Name of the indicator
- Description
- Corresponding dimension

- Characteristics
- Impact on resilience
- Recommendations for improving the indicator (direct and indirect measures)
- Calculation
- Description and information on the underlying datasets.

3.5.1 Rating of indicators

It was initially foreseen that indicators can and will be rated to support regions in finding the areas where actions are most needed. However, there was no applicable methodology identified on how to rate an indicator. To address this, we propose displaying the full range of indicator values across all EU countries included in the dataset, while highlighting the specific position of each region. As a next step, the regional representatives can determine target value for each indicator over a specific time frame and select the recommendations that are most appropriate for improving those indicators.

3.6 Potential indicators per Dimension

For each dimension mentioned in 3.4, 3-6 indicators were chosen that are quantifiable, tangible and relevant to all types of regions (agriculture, rural and urban). This selection (Table 21) was done by the consortium and used as basis to gather feedback and a final selection by the CoPs (0

Feedback from CoPs).

Table 21: Shortlist of indicators based on D2.2

Dimension	Name of indicator	Characteristics	Dataset	spatial resolution
Health & Wellbeing 	Number of hospital beds per 100.000 inhabitants in the community	robustness, flexibility	EUROSTAT, national data sources	Nuts 2, national
	unmet needs for medical treatments	robustness, inclusivity	EUROSTAT, national data sources	Nuts2 / Nuts3, National, regional
	life expectancy	robustness, integration, inclusivity	EUROSTAT	Nuts2
	% of people with immediate access to first aid	robustness, redundancy	different approaches feasible: * EUROSTAT nr. of physician/1000 inhabitants * linking OSM data (medical facilities) with population data	Nuts2
	Community water storage volume (cubic metres)	redundancy, robustness	EUROSTAT (e.g. total renewable water resources)	National
Population & Education 	Age groups	robustness	EUROSTAT	Nuts2 / Nuts3
	Employment rate - % of active population	robustness, inclusivity	EUROSTAT, national data sources	down to Nuts3
	Percentage of population at high risk from natural hazards	robustness, reflectiveness	merge hazard & population data	down to ~100m (in classes) - worldpop
	percentage of large families (>= 3 people per family unit)	robustness	EUROSTAT	Nuts2/Nuts3
	percentage of city population covered by multi-hazard early warning	robustness, reflectiveness, inclusivity		
	high education index	flexibility	EUROSTAT	Nuts2
	percentage of schools teaching DRR	robustness, inclusivity		
	Percentage of population living within 1km of a grocery store	redundancy, robustness	OSM, WorldPop	Nuts2/Nuts3
Economy & Labour Market 	% of economic output attributed to different sectors.	robustness, flexibility	STATISTA, EUROSTAT	National
	Crop Production & Yield (Total production, yield per hectare, seed variety performance)	flexibility, resourcefulness, robustness	FAO crop yield, EUROSTAT per product, national	~10km grid or national

Dimension	Name of indicator	Characteristics	Dataset	spatial resolution
	Percentage of SME businesses relative to total number of businesses	robustness, flexibility	EUROSTAT, national data sources	Nuts2/3, national
	Percentage of properties with insurance coverage for high-risk hazards	robustness, resourcefulness		
	Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values	flexibility, resourcefulness	EUROSTAT	Nuts2
	Food import dependency	robustness, redundancy	AgriData, EUROSTAT	EU-level
Infrastructure 	Number of land transport routes to enter / exit the community	redundancy	OSM	high resolution
	Average age of infrastructure e.g the water supply network, road network, electrical grid	robustness, flexibility		
	Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event	resourcefulness, robustness		
	Percentage of critical facilities served by off-grid energy services	redundancy		
	Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget	resourcefulness, robustness, reflectiveness		
Governance 	Percentage of municipalities with local flood risk management plans	integration, reflectiveness		
	Availability of hazard maps	reflectiveness	risk methodology	high resolution
	% of population who actively participate in a local organisation that aims to prepare for disasters.	integration, flexibility		
	Existence of emergency response organisation	robustness, redundancy	EUROSTAT	Nuts1
	% of population protected by structural disaster risk measures for hazards	robustness, inclusivity, reflectiveness	if local data on measures exist, this can be combined with hazard maps	km

Dimension	Name of indicator	Characteristics	Dataset	spatial resolution
	Surface impermeability (and related indices) (Annual soil impermeability index)	resourcefulness, flexibility	Copernicus, regional / national data	10 m to regional
	Percentage of natural areas	flexibility, resourcefulness, robustness	Copernicus, regional / national data	10 m to regional
	Percentage of groundwater bodies in poor condition due to overexploitation	resourcefulness, robustness, flexibility	EUROSTAT, FAO on available water resources, regional data	Country, 10km
	water stress index	robustness	EUROSTAT	National
	Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	resourcefulness	Copernicus, hazard maps	km
	'Settlement areas in danger zones': Proportion of residential buildings in a hazard zone	robustness, inclusivity	OSM, hazard maps	km

4 Feedback from CoPs

The list of indicators, together with additional information in from of a description, the characteristics and its impact on resilience were given to the participants of the regional CoP meetings.

- How do you perceive the relevance of this indicator?
- Feedback regarding the following questions have been collected: Are there local data sets or sources of information that could support these indicators?
- When thinking about data quality, what matters more to you: Spatial resolution or temporal accuracy? What level of granularity and spatial extent is most useful for your context?

The stakeholders of all regions were asked to provide feedback, however the setup, questionnaire and methods varied for the regions.

Croatia: The Community of Practice (CoP) meeting in Osijek was held on July 3, 2025, from 10:00 to 12:00 with 15 participants. The main purpose of the meeting was to prioritize selected indicators and to gather ideas on available datasets or potential sources for them. Since the meeting was organized face-to-face, participants received paper questionnaires after a short introduction, and facilitators explained each indicator in detail, providing additional clarification when necessary. All participants completed the questionnaires, and the collected responses were later analyzed by the CSF team.

Greece: The Community of Practice (CoP) meeting was held online on Wednesday, July 9, 2025, from 12:00 to 14:00, due to the prevailing heatwave. A total of six stakeholders participated, representing different sectors, including public services, organizations, and private companies. During the meeting, following a presentation on the program's progress, participants were requested to carry out the prioritization of the indicators using the 'Mural' application. Each stakeholder submitted their input by selecting among predefined options for the designated Excel columns provided, while also offering clarifications where necessary.

Sicily: The first step involved a preliminary discussion between CSF (Plinius) and RA, carried out through an online meeting. During this meeting, we reviewed the full list of indicators and created a shortlist of those that best matched the interests of the region. The decision to prepare a shortlist was driven by the need to make the CoP interaction more efficient and to remain aligned with the topics previously discussed in CoP meetings. For each of the indicators selected, we added information on available datasets or potential data sources. Once the shortlist was prepared, it was presented during the CoP meeting, along with the ClimEmpower methodology for indicators. The shortlist was shared with participants, who provided comments to validate the choices. The discussion also offered an opportunity to add further details about data sources and the perceived importance about spatial and temporal resolution. For the sake of clarity and completeness, the full list of indicators was later shared via email, with a request for additional feedback, although no further responses were received.

Andalucía: To advance the prioritization of indicators, the team first identified and selected relevant stakeholders, primarily local authorities. A structured survey was then prepared, organized into the selected dimensions. Each dimension included a brief explanation of its

scope, followed by questions about the associated indicators. For every indicator, participants were asked to assess its priority (High / Medium / Low), indicate the required level of detail, and provide feedback on whether the indicator was more relevant at the spatial or temporal scale. Additionally, for each indicator, known datasets were presented, and respondents were invited to suggest any complementary local data sources. The collected responses were analyzed and they will be presented during the next Community of Practice (CoP) meeting in the Region, where stakeholders will have the opportunity to review, discuss, and refine the results.

Troodos Mountains: To prioritize the project's indicators, targeted feedback was collected from local decision-makers already familiar with the project through prior participation in the second Community of Practice (CoP) meeting. Thirteen (13) mayors representing the communities of the Troodos Geopark were invited to provide input. This group was selected because they (i) hold responsibility for local policy and implementation, and (ii) had prior exposure to some of the indicators and project objectives during the 2nd CoP, ensuring informed responses. An Excel file was used. For each candidate indicator, respondents were asked to rate its importance on a three-point ordinal scale—High / Medium / Low—for their own municipality considering it as part of the Geopark on the Troodos Mountains. Each indicator was accompanied by a short definition to support consistent interpretation. The instrument comprised only closed questions to facilitate aggregation and comparison.

Procedure:

- 1. Recruitment:** Each mayor was contacted by telephone to confirm availability, explain the purpose of the exercise (prioritization of indicators), and address any immediate questions.
- 2. Administration:** Immediately following the call, participants received an email containing: (i) the questionnaire (list of indicators with rating fields and instructions), and (ii) guidance on how to return the completed form.
- 3. Submission:** Respondents completed the questionnaire independently and returned it by email. Clarifications, where requested, were provided individually by phone or email to avoid influencing other responses.

4.1.1 Perceived relevance of the indicators

The feedback regarding the perceived relevance of each indicator has been gathered for all ClimEmpower regions. Stakeholders could rate the relevance of the individual indicator as low, medium or high and the corresponding lists were provided for Greece, OBZ and Costa del Sol. Sicily did not use the scoring of low, medium and high but provided a list of chosen, highly prioritized indicators.

To evaluate the final score for each indicator, the mean of the answers per regions is taken by assigning the numerical values to the qualitative answers. Low relevance is given the value 1, medium the value 2 and high the value 3. For Sicily, as there are no medium or low ratings, 0 for no rating and 3 for a high rating is used. The results are presented in Table 22.

As the results show, the perceived relevance varies. However, each indicator is rated at least medium relevant for at least one region. There is no dimension receiving exceptionally low or high ratings averaged across regions. However, two of the three indicators perceived as most

important are part of the dimension Environment/Nature & Settlement areas, while two of the three as least important ranked indicators are part of Population & Education.

The suggested list of indicators seems therefore to cover the respective needs of each region well.

Table 22: Feedback from the CoPs: Perceived importance of the indicators, sorted by highest average across regions: 1 is low priority, 2 medium and 3 high priority, also depicted in the color-coding from no (white) to low (yellow) and high priority (light orange). The mean answer value of all respective stakeholder answers is shown. Source: own presentation.

Dimension	Name of indicator	Average	COSTA DEL SOL	GREECE	SICILY	OBZ	TROODOS
Environment/ Nature & Settlement Areas	Percentage of groundwater bodies in poor condition due to overexploitation	2.9	3.0	3.0	3.0	2.7	3.0
Environment/ Nature & Settlement Areas	water stress index	2.8	2.8	2.8	3.0	2.6	3.0
Population & Education	percentage of city population covered by multi-hazard early warning	2.7	3.0	2.5	3.0	2.2	3.0
Environment/ Nature & Settlement Areas	Surface impermeability (and related indices) (Annual soil impermeability index)	2.7	2.8	2.0	3.0	2.7	3.0
Health & Wellbeing	Number of hospital beds per 100.000 inhabitants in the community	2.6	3.0	2.8	3.0	2.4	2.0
Population & Education	Percentage of population at high risk from natural hazards	2.6	3.0	3.0	3.0	2.1	2.0
Governance	% of population who actively participate in a local organisation that aims to prepare for disasters.	2.6	2.5	2.8	3.0	2.6	2.0
Infrastructure	Number of land transport routes to enter / exit the community	2.5	3.0	2.3	3.0	2.4	2.0
Health & Wellbeing	% of people with immediate access to first aid	2.5	3.0	2.0	3.0	2.5	2.0
Environment/ Nature & Settlement Areas	Percentage of natural areas	2.5	2.8	2.0	3.0	2.7	2.0
Governance	Percentage of municipalities with local flood risk management plans	2.5	3.0	2.8	3.0	2.6	1.0
Governance	Existence of emergency response organisation	2.4	3.0	2.5	3.0	2.5	1.0
Infrastructure	Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event	2.4	3.0	2.5	3.0	2.3	1.0

Dimension	Name of indicator	Average	COSTA DEL SOL	GREECE	SICILY	OBZ	TROODOS
Environment/ Nature & Settlement Areas	'Settlement areas in danger zones': Proportion of residential buildings in a hazard zone	2.3	3.0	3.0	0.0	2.7	3.0
Economy & Labour Market	Percentage of properties with insurance coverage for high-risk hazards	2.3	2.5	2.3	3.0	2.7	1.0
Health & Wellbeing	life expectancy	2.2	2.0	1.8	3.0	2.5	2.0
Health & Wellbeing	Community water storage volume (cubic metres)	2.2	3.0	2.5	0.0	2.6	3.0
Environment/ Nature & Settlement Areas	Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	2.2	2.8	2.5	0.0	2.7	3.0
Governance	% of population protected by structural disaster risk measures for hazards	2.1	3.0	3.0	0.0	2.6	2.0
Economy & Labour Market	Food import dependency	2.1	3.0	2.8	0.0	2.8	2.0
Population & Education	high education index	2.1	2.0	1.3	3.0	2.1	2.0
Economy & Labour Market	% of economic output attributed to different sectors.	2.0	3.0	2.0	0.0	2.9	2.0
Population & Education	percentage of large families (>= 3 people per family unit)	2.0	1.5	1.3	3.0	2.1	2.0
Economy & Labour Market	Crop Production & Yield (Total production, yield per hectare, seed variety performance)	1.9	2.5	2.5	0.0	2.7	2.0
Governance	Availability of hazard maps	1.9	3.0	3.0	0.0	2.6	1.0
Infrastructure	Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget	1.9	3.0	2.3	0.0	2.3	2.0
Infrastructure	Average age of infrastructure e.g the water supply network, road network, electrical grid	1.9	2.8	2.5	0.0	2.3	2.0
Infrastructure	Percentage of critical facilities served by off-grid energy services	1.9	3.0	2.3	0.0	2.2	2.0
Population & Education	Employment rate - % of active population	1.9	3.0	2.3	0.0	2.2	2.0
Health & Wellbeing	unmet needs for medical treatments	1.9	2.8	2.3	0.0	2.3	2.0
Economy & Labour Market	Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values	1.8	2.5	2.0	0.0	2.7	2.0

Dimension	Name of indicator	Average	COSTA DEL SOL	GREECE	SICILY	OBZ	TROODOS
Population & Education	percentage of schools teaching DRR	1.8	3.0	2.0	0.0	2.1	2.0
Population & Education	Age groups	1.8	2.8	2.0	0.0	2.3	2.0
Population & Education	Percentage of population living within 1km of a grocery store	1.6	2.0	2.0	0.0	1.9	2.0
Economy & Labour Market	Percentage of SME businesses relative to total number of businesses	1.5	2.0	1.0	0.0	2.5	2.0

4.1.2 Perceived importance of spatial vs. temporal resolution and most useful granularity

During the CoPs, stakeholders were also asked to indicate the perceived importance of high spatial and low temporal vs. low spatial and high temporal resolution for each indicator. Stakeholders were additionally asked to indicate the spatial resolution they perceived as most useful for each listed indicator. Sicilian stakeholders only gave feedback to indicators with a perceived high priority (see section 4.1.1).

Regarding the perceived higher importance of spatial or temporal resolution, stakeholders in every CoP were given those two options to choose from. To arrive at a final answer on the preference or spatial resolution versus temporal accuracy, the majority answer of each respective region (majority vote of stakeholders) was taken. Spanish stakeholders answered uniformly with a preference for spatial resolution, which was also most answered for all other regions.

However, for three indicators temporal resolution was chosen to be more important than the spatial one:

- Crop Production & Yield
- Percentage of groundwater bodies in danger of overexploitation
- Water stress index

The feedback on the most useful granularity of the indicators, however, was provided in different forms for each ClimEmpower region.

The Greek stakeholders were presented a set of options for spatial granularity to choose from:

- Regional (Region of Central Greece)
- Regional unit (The Region of Central Greece consists of 5 Regional Units (Evrytania, Euboea, Phocis, and Phthiotis), each of which has distinct characteristics and different needs)
- Municipality level or
- Local level.

The Costa del Sol feedback was given as a free text answer. To present the responses in a meaningful way, they are clustered into 8 categories:

- national,
- local or regional (municipality level or Costa del Sol level),
- 1 - 10 m grid,
- 1-10 km grid,
- higher resolution than NUTS 3 (higher resolution than Malaga province. Equivalent to “regional”),

- NUTS 2/3 (the minimum resolution available in NUTS level, depending on the indicator),
- Europe,
- Spatial scale not relevant

The response “Classification in less than 100 m linked to WorldPop (minimum available)” is attributed to “higher resolution than NUTS 3”, all other answers fit the above-mentioned categories well.

Croatian stakeholders were presented a set of options for spatial granularity to choose from:

- National
- Regional (Osijek-Baranja County)
- Local (specific city, municipality, ...)

The feedback given by stakeholders from Cyprus was also given as a free text answer. The original answers have been aggregated to responses and are also displayed in Table 23.

- 10m grid
- 10-100m grid
- Asset level: depending on the indicator referring to buildings, schools, polygons,...
- Community: “Community” means LAU (local municipality/village inside the Geopark)
- District (NUTS3): very large areas that extend far beyond the Geopark. For Troodos, NUTS-3 mainly means the Limassol, Nicosia, and Paphos districts, which include big lowland/coastal areas that aren’t part of the mountain system—so district stats can dilute the Troodos
- Municipality
- Hydrological unit: refers to the respective hydrological unit (water body, river basin,...)
- National

The feedback for the regions Costa del Sol, PTSE and Troodos regarding the most useful granularity of each resilient indicator is provided in Table 23. For OBZ and Sicily, the answers were uniform for each indicator, ‘regional’ and ‘municipal/local’, respectively. Those answers are therefore not presented in the table.

Table 23: Feedback from the CoPs: Preferred spatial granularity for Greece, Costa del Sol and Troodos regions. OBZ and Sicily answered uniformly 'regional' and 'municipal/local', respectively, and are not displayed. Source: own representation.

Indicator	Response COSTA DEL SOL	Response GREECE	Responses TROODOS
% of economic output attributed to different sectors.	REGIONAL/LOCAL	REGIONAL UNIT	DISTRICT (NUTS3)
Crop Production & Yield (Total production, yield per hectare, seed variety performance)	REGIONAL/LOCAL	MUNICIPALITY	COMMUNITY
Food import dependency	REGIONAL/LOCAL	MUNICIPALITY	NATIONAL
Percentage of properties with insurance coverage for high-risk hazards	SCALE NOT RELEVANT	REGIONAL UNIT	COMMUNITY
Percentage of SME businesses relative to total number of businesses	REGIONAL/LOCAL	MUNICIPALITY	COMMUNITY
Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values	NUTS 2-3	REGIONAL UNIT	NATIONAL
'Settlement areas in danger zones': Proportion of residential buildings in a hazard zone	1-10 km GRID	MUNICIPALITY	ASSET-LEVEL , COMMUNITY
Percentage of groundwater bodies in poor condition due to overexploitation	1-10 km GRID	REGIONAL UNIT	HYDROLOGICAL UNIT
Percentage of natural areas	1-10 m GRID	MUNICIPALITY	ASSET-LEVEL, COMMUNITY
Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	1-10 km GRID, NUTS 2-3	REGIONAL, REGIONAL UNIT	COMMUNITY
Surface impermeability (and related indices) (Annual soil impermeability index)	REGIONAL/LOCAL, 1-10 m GRID	MUNICIPALITY	10m GRID, COMMUNITY
water stress index	REGIONAL/LOCAL	REGIONAL UNIT	HYDROLOGICAL UNIT, COMMUNITY
% of population protected by structural disaster risk measures for hazards	REGIONAL/LOCAL	MUNICIPALITY	ASSET-LEVEL , COMMUNITY
% of population who actively participate in a local organisation that aims to prepare for disasters.	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY
Availability of hazard maps	REGIONAL/LOCAL	LOCAL	MUNICIPALITY
Existence of emergency response organisation	REGIONAL/LOCAL, NUTS 2-3	REGIONAL UNIT	COMMUNITY
Percentage of municipalities with local flood risk management plans	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	MUNICIPALITY, HYDROLOGICAL UNIT
% of people with immediate access to first aid	NUTS 2-3	MUNICIPALITY	MUNICIPALITY

Indicator	Response COSTA DEL SOL	Response GREECE	Responses TROODOS
Community water storage volume (cubic metres)	REGIONAL/LOCAL, NUTS 2-3	LOCAL	COMMUNITY, ASSET LEVEL
life expectancy	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	DISTRICT (NUTS 3), MUNICIPALITY
Number of hospital beds per 100.000 inhabitants in the community	REGIONAL/LOCAL, NUTS 2-3	REGIONAL UNIT, MUNICIPALITY	COMMUNITY, MUNICIPALITY
unmet needs for medical treatments	REGIONAL/LOCAL	LOCAL	COMMUNITY, MUNICIPALITY
Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget	REGIONAL/LOCAL, NUTS 2-3, SCALE NOT RELEVANT	MUNICIPALITY	COMMUNITY
Average age of infrastructure e.g the water supply network, road network, electrical grid	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY, ASSET LEVEL
Number of land transport routes to enter / exit the community	REGIONAL/LOCAL	LOCAL	COMMUNITY, MUNICIPALITY
Percentage of critical facilities served by off-grid energy services	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY
Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY
Age groups	NUTS 2-3	REGIONAL, REGIONAL UNIT, MUNICIPALITY, LOCAL	COMMUNITY
Employment rate - % of active population	HIGHER THAN NUTS3	MUNICIPALITY	COMMUNITY
high education index	SCALE NOT RELEVANT	MUNICIPALITY	COMMUNITY
percentage of city population covered by multi-hazard early warning	NUTS 2-3	MUNICIPALITY, LOCAL	COMMUNITY
percentage of large families (≥ 3 people per family unit)	NUTS 2-3	MUNICIPALITY	COMMUNITY
Percentage of population at high risk from natural hazards	REGIONAL/LOCAL, HIGHER THAN NUTS3	REGIONAL UNIT, MUNICIPALITY	10-100m GRID, COMMUNITY
Percentage of population living within 1km of a grocery store	NUTS 2-3	MUNICIPALITY, LOCAL	ASSET-LEVEL, COMMUNITY
percentage of schools teaching DRR	NUTS 2-3	MUNICIPALITY	COMMUNITY

4.1.3 Awareness of local data that can support the indicators

Additionally, the stakeholders were asked to state, if they know of any local datasets that can be used to support the listed indicators and if yes, to name them. The given answers as well as the formats of the answers varied substantially between the regions. To give a better overview, the results are split into ClimEmpower regions.

4.1.3.1 Sicily

Regarding local datasets to support the indicators, Sicily provided a list of potential dataset sources for the indicators they ranked as highly relevant, which is presented in Table 24. Answers stating ‘No datasets found so far’ are excluded in the table.

Table 24: Feedback from the CoPs: Sicilian stakeholder suggestions for local datasets supporting the resilience indicators. Source: own presentation.

Indicator	Suggestion for datasets /comments
Number of hospital beds per 100.000 inhabitants in the community	Assistenza local network plan https://www.unimpresa.it/al-sud-pochi-posti-letto-in-ospedali-sotto-media-nazionale/62946
life expectancy	Istat dataset
Age groups	https://esploradati.istat.it/databrowser/#/it/dw/categories/IT1,Z0500LAB,1.0/LAB_OFFER/LAB_OFF_EMPLOY/DCCV_TAXOCCU1/IT1,150_915_DF_DCCV_TAXOCCU1_1,1.0
Percentage of population at high risk from natural hazards	ISPRA Report e MOSAICATURA OPENDATA (https://idrogeo.isprambiente.it/app/page/open-data)
percentage of large families (>= 3 people per family unit)	https://esploradati.istat.it/databrowser/#/it/dw/categories/IT1,POP,1.0/POP_HOUSEHOLDS/POP_HOUS_COUPLES/IT1,82_87_DF_DCCV_AVQ_FAMIGLIE_2,1.0
high education index	https://esploradati.istat.it/databrowser/#/it/dw/categories/IT1,Z0820EDU,1.0/DCCV_POPTIT1_UNT2020/IT1,52_1194_DF_DCCV_POPTIT1_UNT2020_2,1.0
Number of land transport routes to enter / exit the community	Civil Protection municipal plans
Percentage of municipalities with local flood risk management plans	Civil Protection municipal plans
% of population who actively participate in a local organisation that aims to prepare for disasters.	National register of Third Sector organizations
Existence of emergency response organisation	National register of Third Sector organizations
Surface impermeability (and related indices) (Annual soil impermeability index)	Elaborazioni Plinvs
Percentage of natural areas	Elaborazioni Plinvs
Percentage of groundwater bodies in poor condition due to overexploitation	Water management Plan (Autorità di Bacino)
water stress index	Water management Plan (Autorità di Bacino)

4.1.3.2 Costa del Sol

In the questionnaire for the Spanish region, a free text answer was allowed. For most of the indicators the response was ‘No known local data sets or sources of information that can support them, only the suggested’. For a handful of indicators, some suggestion and ideas of local datasets are given and presented in Table 25.

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Table 25: Feedback from the CoPs: Costa del Sol stakeholder suggestions for local datasets supporting the resilience indicators. Source: own presentation.

Indicator	Suggestion for datasets /comments
Average age of infrastructure e.g the water supply network, road network, electrical grid	Perhaps more than the age of the infrastructure, it would be interesting to know its materials, or better yet, a categorization of the materials, although this type of information may be even more difficult to obtain. Request data from management entities, for sanitation and water supply on the Costa del Sol.
Percentage of municipalities with local flood risk management plans	The municipalities themselves and their local emergency plans (this answer comes from a person that works in local government. Potential source: https://www.juntadeandalucia.es/sites/default/files/inline-files/2024/09/792-MEMORIA-PGRI-CMA.pdf)
Availability of hazard maps	Local emergency plans of each municipality. This indicator could be included within the previous one [referring to 'Percentage of municipalities with local flood risk management plans'], since if a municipality has a local risk management plan, it may include a risk map. Potential source: https://sig.miteco.gob.es/snczi/
Existence of emergency response organisation	Civil Protection (Government Delegation of the Andalusian Regional Government). This variable could also be included in local risk management plans.
water stress index	The Ministry of Sustainability and Environment of Andalucía has made these calculations.
Community water storage volume (cubic metres)	EUROSTAT data is not representative here, but no other sources are known

4.1.3.3 OBZ

The stakeholders in OBZ were asked to provide any possible source of data sets. The answers are presented in Table 26.

Table 26: Feedback from the CoPs: Croatian stakeholder suggestions for local datasets supporting the resilience indicators. Source: own presentation.

Indicator	Suggestion for datasets /comments
Number of hospital beds per 100.000 inhabitants in the community	Croatian Medical Chamber https://www.hlk.hr/rad-bolnica-u-2015-u-bolnickom-krevet-u-na-godinu-lijece-32-pacijenta.aspx?utm_source=chatgpt.com https://www.hzjz.hr/wp-content/uploads/2024/12/Bilten-Rad-bolnica-2023_final.pdf
unmet needs for medical treatments	https://www.ombudsman.hr/hr/pravo-na-zdravlje-2023/ https://www.ombudsman.hr/hr/pravo-na-zdravlje-2023/ Ombudsman's reports for Croatia
life expectancy	https://podaci.dzs.hr/2021/hr/9931 https://podaci.dzs.hr/en/statistics/population/
% of people with immediate access to first aid	https://health.ec.europa.eu/system/files/2024-01/2023_chp_hr_croatian.pdf
Community water storage volume (cubic metres)	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Water_statistics
Age groups	https://podaci.dzs.hr/2021/hr/9931 https://podaci.dzs.hr/en/statistics/population/
Employment rate - % of active population	https://podaci.dzs.hr/2025/en/96922

Indicator	Suggestion for datasets /comments
Percentage of population at high risk from natural hazards	https://hgk.hr/documents/official-croatia-report5cef87495aaec.pdf https://www.preventionweb.net/publication/disaster-risk-profile-croatia
percentage of large families (>= 3 people per family unit)	https://dzs.gov.hr/news/decrease-in-the-number-of-households-with-three-or-more-members-increase-in-the-number-of-one-and-two-person-households/1567
high education index	https://www.azvo.hr/images/stories/visoko/croatia_review_of_higher_education.pdf
% of economic output attributed to different sectors.	https://economy-finance.ec.europa.eu/economic-surveillance-eu-economies/croatia/economic-forecast-croatia_en
Crop Production & Yield (Total production, yield per hectare, seed variety performance)	https://podaci.dzs.hr/2024/en/77191 https://podaci.dzs.hr/media/so5f4ybf/polj-2023-2-6-areas-and-production-of-cereals-and-other-crops-2023-provisional-data.pdf https://ruralnirazvoj.hr/files/Program-ruralnog-razvoja-Republike-Hrvatske-za-razdoblje-2014.-2020.-ver.-13.0.pdf
Percentage of SME businesses relative to total number of businesses	https://podaci.dzs.hr/2022/en/29181 https://podaci.dzs.hr/media/0bdj0c1k/posl-2023-1-2_1-number-and-structure-of-business-entities-2023-by-counties.pdf
Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values	https://podaci.dzs.hr/2025/en/97200
Food import dependency	https://www.hapih.hr/osijski-centre-for-transfer-of-food-safety-knowledge-to-neighbouring-countries/ https://www.efos.unios.hr/repec/osi/bulimm/PDF/BusinessLogisticsinModernManagement15/blimm1507.pdf https://podaci.dzs.hr/media/icieduuz/vt-2025-1-2-foreign-trade-in-goods-of-the-republic-of-croatia-2024.pdf https://podaci.dzs.hr/media/v1ebjxaa/vt-2024-1-1_7-foreign-trade-in-goods-of-the-republic-of-croatia-provisional-data-january-july-2024-and-january-august-2024.pdf
Average age of infrastructure e.g the water supply network, road network, electrical grid	https://economy-finance.ec.europa.eu/system/files/2023-05/HR_SWD_2023_611_en.pdf
Percentage of municipalities with local flood risk management plans	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019SC0069&from=sl https://www.researchgate.net/publication/378331091_Pluvial_Flood_Susceptibility_in_the_Local_Community_of_the_City_of_Gospic_Croatia https://www.osijek.hr/wp-content/uploads/2022/02/Deliverable-T2.1.2_LOCAL-FLOOD-HAZARD-VULNERABILITY-AND-RISK-MAPS_REPORT_Drava-river-basin_Executive-summary-in-English.signed.pdf
Availability of hazard maps	https://www.mdpi.com/2071-1050/12/5/1796
Existence of emergency response organisation	https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/national-disaster-management-system/republic-croatia_en

Indicator	Suggestion for datasets /comments
water stress index	https://neuron.mefst.hr/docs/CMJ/issues/2002/43/4/12187529.pdf http://geofizika-journal.gfz.hr/vol_41/No1/41-1_Loncar-Petrinjak_et_al.pdf https://repozitorij.gfz.hr/islandora/object/gfos%3A2741/datastream/FILE0/view https://hrcak.srce.hr/file/178637 https://meteo.hr/DMCSEE/dokumenti/Report_DMCSEE_external_experts_May_2012.pdf https://jcea.agr.hr/articles/771492_Portable_spectrometer_based_cold_stress_detection_in_C3_and_C4_plants_en.pdf
Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	https://mpgi.gov.hr/UserDocImages/Zavod/Publikacije/Spaltial.Development.Strategy.pdf https://efi.int/sites/default/files/files/publication-bank/projects/croatia.pdf https://mingo.gov.hr/UserDocImages/KLIMA/SZKAIZOS/NFAP_Croatia.pdf

4.1.3.4 PSTE

For the Central Greece region, stakeholders were asked: ‘Are there local data sets or information sources that could support these indicators?’ and given the option of 3 possible answers:

- Yes (information)
- No
- Do not know

Although 10 indicators were given at least once a ‘Yes’ response, only seven answers included the asked additional information, as is shown in Table 27.

Table 27: Feedback from the CoPs: Greek stakeholder suggestions for local datasets supporting the resilience indicators. Source: own presentation.

Indicators given at least once a ‘Yes’ response	Additionally provided information
Number of hospital beds per 100.000 inhabitants in the community	Local Hospitals
Community water storage volume (cubic metres)	Municipal Water Supply and Sewerage Company
Age groups	https://www.statistics.gr/el/statistics/-/publication/SAM03/-
High education index	https://www.statistics.gr/el/statistics/-/publication/SAM03/-
Percentage of properties with insurance coverage for high-risk hazards	Insurance Companies
Availability of hazard maps	https://meteo.gr/ (fire risk) https://gis.floods.ypeka.gr/ (floods) CORINE 2018 https://gis.ktimanet.gr/gis/forestsuspension https://oikoskopio.geodiv.page/map

4.1.3.5 Troodos

Cypriot stakeholders were to answer two questions, one related to possible sources for the indicators and one related to available local datasets. The answers are provided in Table 28.

Table 28: Feedback from the CoPs: Cypriot stakeholder suggestions for local datasets supporting the resilience indicators. Source: own presentation.

Name of indicator	Local datasets	Possible sources
% of economic output attributed to different sectors.		CYSTAT – Labour Force Survey, Business Register; Registrar of Companies – active enterprises (by community)
Crop Production & Yield (Total production, yield per hectare, seed variety performance)		Dept. of Agriculture & CAPO (IACS/LPIS) – crops, parcels, yields; FAOSTAT/Eurostat – national yields
Food import dependency	Provided for NUTS2 in PDF	CYSTAT; DLS; relevant line ministries; EEA/Copernicus
Percentage of properties with insurance coverage for high-risk hazards		Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover; Insurance Association of Cyprus; EIOPA catastrophe protection gap survey
Percentage of SME businesses relative to total number of businesses		CYSTAT – Labour Force Survey, Business Register; Registrar of Companies – active enterprises (by community)
Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values		CYSTAT; DLS; relevant line ministries; EEA/Copernicus
'Settlement areas in danger zones': Proportion of residential buildings in a hazard zone	Shape files/ Census Data/Layers of Copernicus	Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover; DLS Buildings (INSPIRE BU); Microsoft Global ML Building Footprints; OSM tags
Percentage of groundwater bodies in poor condition due to overexploitation	Provided in PDF	Water Development Department (WDD) – reservoirs, aquifers, hydrology; Department of Meteorology – precipitation/temperature; Local community councils – tank/reservoir volumes
Percentage of natural areas	Shape files/ Census Data/Layers of Copernicus	EEA/Copernicus; Natura 2000; Department of Forests; WDPA
Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	Shape files/ Census Data/Layers of Copernicus	Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover; EEA/Copernicus; Natura 2000; Department of Forests; WDPA
Surface impermeability (and related indices) (Annual soil impermeability index)	Shape files/ Census Data/Layers of Copernicus	EEA/Copernicus; Natura 2000; Department of Forests; WDPA
water stress index		Water Development Department (WDD) – reservoirs, aquifers, hydrology; Department of Meteorology – precipitation/temperature; Local community councils – tank/reservoir volumes

Name of indicator	Local datasets	Possible sources
% of population protected by structural disaster risk measures for hazards		Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover
% of population who actively participate in a local organisation that aims to prepare for disasters.		CYSTAT; DLS; relevant line ministries; EEA/Copernicus
Availability of hazard maps	Provided plenty of PDFs	Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover
Existence of emergency response organisation		CYSTAT; DLS; relevant line ministries; EEA/Copernicus
Percentage of municipalities with local flood risk management plans	Interactive maps by WDD	Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover
% of people with immediate access to first aid	Provided in Word as also as a figure	Ministry of Health (MoH), Health Monitoring Unit/Hospitals; Cyprus Statistical Service (CYSTAT) – Health & EU-SILC; Civil Defence & Ambulance Service (response times)
Community water storage volume (cubic metres)	(For some communities) Provided in Excel	Water Development Department (WDD) – reservoirs, aquifers, hydrology; Department of Meteorology – precipitation/temperature; Local community councils – tank/reservoir volumes
life expectancy	Provided in Excel	Ministry of Health (MoH), Health Monitoring Unit/Hospitals; Cyprus Statistical Service (CYSTAT) – Health & EU-SILC
Number of hospital beds per 100.000 inhabitants in the community		Ministry of Health (MoH), Health Monitoring Unit/Hospitals; Cyprus Statistical Service (CYSTAT) – Health & EU-SILC
unmet needs for medical treatments		Ministry of Health (MoH), Health Monitoring Unit/Hospitals; Cyprus Statistical Service (CYSTAT) – Health & EU-SILC
Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget		CYSTAT; DLS; relevant line ministries; EEA/Copernicus
Average age of infrastructure e.g the water supply network, road network, electrical grid		Water Development Department (WDD) – reservoirs, aquifers, hydrology; Department of Meteorology – precipitation/temperature; Local community councils – tank/reservoir volumes
Number of land transport routes to enter / exit the community	Provided in Word as also as a shape file	Public Works Department & DLS roads; community asset registers
Percentage of critical facilities served by off-grid energy services		EAC (Electricity Authority of Cyprus); facility operators
Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event		CYSTAT; DLS; relevant line ministries; EEA/Copernicus
Age groups	Provided in Excel	CYSTAT; DLS; relevant line ministries; EEA/Copernicus

Name of indicator	Local datasets	Possible sources
Employment rate - % of active population	Provided for NUTS2 in PDF	CYSTAT; DLS; relevant line ministries; EEA/Copernicus
high education index		CYSTAT; DLS; relevant line ministries; EEA/Copernicus
percentage of city population covered by multi-hazard early warning	(For some communities) Provided in PDF	Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover
percentage of large families (≥ 3 people per family unit)	Provided for NUTS2 in PDF	CYSTAT; DLS; relevant line ministries; EEA/Copernicus
Percentage of population at high risk from natural hazards	Shape files/ Census Data/Layers of wildfires Copernicus	Civil Defence & Department of Forests – wildfire risk & response; WDD – Floods Directive maps (risk/hazard); EFEHR/ESHM20 – seismic hazard; EEA/Copernicus – HRL Imperviousness, land cover
Percentage of population living within 1km of a grocery store	(For some communities) Provided in Excel	DLS geoportal POIs; OpenStreetMap shops; local business registries
percentage of schools teaching DRR		CYSTAT; DLS; relevant line ministries; EEA/Copernicus

Additionally, a preliminary computation of all indicators was provided by the CSF.

5 Final selection of indicators

The following are exemplary Resilience Indicator Factsheets, with one factsheet provided per dimension. Each factsheet follows a consistent structure:

- Name of the indicator
- Description
- Corresponding dimension
- Characteristics
- Impact on resilience
- Recommendations for improving the indicator (direct and indirect measures)
- Calculation
- Description and information on the underlying datasets.
- A figure depicting the preliminary calculation results (see Figure 12, Figure 13, Figure 14, Figure 15, and Figure 16 for each respective indicator)

NAME OF THE INDICATOR	DESCRIPTION
NUMBER OF HOSPITAL BEDS PER 100.000 INHABITANTS IN THE COMMUNITY	This indicator displays how many hospital beds are available per 100.000 inhabitants in the community.

CORRESPONDING DIMENSION
HEALTH & WELLBEING

CHARACTERISTICS
ROBUSTNESS: The more beds exist per inhabitant, the more robust the system is towards increased need during an extreme event. FLEXIBILITY: By having more beds available within the community, hospitals can take over patients from other areas within the area.

IMPACT ON RESILIENCE
During extreme events, an increased demand of medical support and hospital beds is often the case. If a region has very limited capacities, this enhances the negative impacts of the extreme event on the people's health and might even lead to cascading negative effects such as outbreaks of diseases that have long term effects on the region and its recovery.

RECOMMENDATIONS
Direct • Expand capacity through temporary hospital units or spaces that can be deployed during emergencies. • Promote equitable distribution of hospital capacity between areas, especially urban and rural, to reduce vulnerability gaps. Indirect • Invest in climate-resilient health facilities that are energy efficient and disaster-proof.

CALCULATION
Directly from Datasets $(\text{Total Hospital Beds} / \text{Population}) * 100,000$

REGION-SPECIFIC DATASETS	GENERAL DATASETS
• CYSTAT: health and hospital statistics (Health care functions) • INE: Health statistics • ISTAT: hospital beds • Greece: health statistics	• EUROSTAT: hospital beds • OECD: hospital beds (not covering Cyprus)

Name	Source	Link	Spatial resolution	Temporal resolution	Last updated	Data format	Variable	Used for computation (Y/N)
Cyprus: Health statistics	Statistical Service of Cyprus	https://cystatdb.cystat.gov.cy/pxweb/en/8.CYSTAT-DB/8.CYSTAT-DB_Health_	National, regional	Annual	2023	XLS, PDF	Private Clinics, Number of Hospital Beds and Personnel by District, Beds by Public Hospital	Y
Italy: hospital beds	ISTAT (Italy)	https://esploradati.istat.it/databrowser/#/en/dw/categories/IT1,Z0810HEA,1.0/HEA_SERV_ICES	National / regional	Annual	2021	HTML, XLS	Hospital beds and activities by clinical speciality	N
Italy: hospital beds per region	Article	https://www.unimpresa.it/al-sud-pochi-posti-letto-in-ospedali-sotto-media-nazionale/62946	National/regional		2024		Hospital beds per 10000 inhabitants	Y
Greece: health statistics	ELSTAT (Hellenic Statistical Authority)	https://www.statistics.gr/en/statistics/-/publication/SHE06/-	National	Annual	2023	PDF, XLS	Hospitals and beds by speciality and region	Y
Spain: Health statistics	INE (Spain)	https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736176779&menu=resultados&idp=1254735573175	National	Annual	2005	CSV, XLS, HTML	Distribution of available beds in hospital according to purpose	N
EUROSTAT: hospital beds	EUROSTAT	https://ec.europa.eu/eurostat/databrowser/view/tgs00064/default/table?lang=de&category=t_reg.t_reg_hlth	Country / NUTS 2	Annual	2022	CSV, TSV, XLS	Available beds in hospitals	Y
OECD: hospital beds	OECD	https://www.oecd.org/en/data/indicators/hospital-beds.html	National	Annual	2022	Web interactive, XLS, CSV	Hospital beds	N

Available Hospital Beds per 100 000 inhabitants on NUTS2 regions EUROSTAT 2022 (no data for Cyprus)

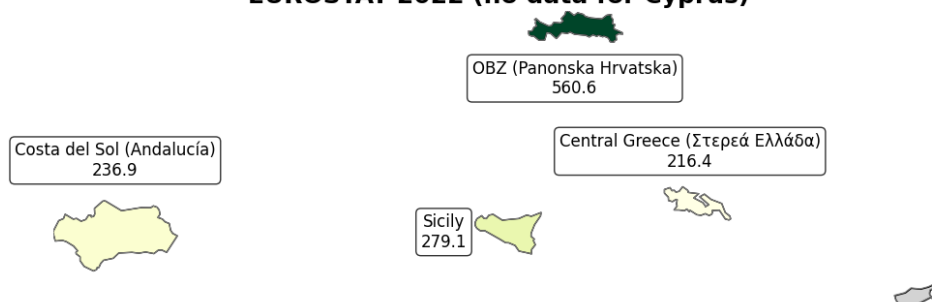


Figure 12: number of hospital beds per 100 000 inhabitants based on EUROSTAT data

NAME OF THE INDICATOR	DESCRIPTION
HIGH EDUCATION INDEX	This indicator measures the proportion of the population that has attained a high level of education, such as tertiary education (university degrees or equivalent). It reflects the educational attainment and skill level within a community.
CORRESPONDING DIMENSION	
POPULATION & EDUCATION	
CHARACTERISTICS	
FLEXIBILITY: A well-educated population tends to have greater cognitive flexibility, problem-solving skills, and the ability to innovate. This facilitates adaptation to new challenges, supports alternative strategies in crises, and enables learning from past experiences.	
IMPACT ON RESILIENCE	
Higher education levels enhance resilience by empowering individuals and communities to respond effectively to change, access diverse employment opportunities, and participate actively in governance and recovery processes.	
RECOMMENDATIONS	
Direct - Promote the incorporation of disaster risk knowledge—covering prevention, mitigation, preparedness, response, recovery, and rehabilitation—into formal and non-formal education, civic education at all levels, and professional education and training. - Promote vocational and technical training for green and climate-resilient jobs. Indirect - Foster knowledge-sharing platforms that link science, policy, and community needs to strengthen awareness and adaptive capacity.	
CALCULATION	
Tertiary educational attainment - Percentage of the population aged 25-64 who have successfully completed tertiary studies (e.g. university, higher technical institution, etc.)	
REGION-SPECIFIC DATASETS	GENERAL DATASETS
Italy: population per educational attainment and region	EUROSTAT: education

Name	Source	Link	Spatial resolution	Temporal resolution	Last updated	Data format	Variable	Reasons for adding	Used for computation (Y/N)
EUROSTAT: education	EUROSTAT	https://ec.europa.eu/eurostat/databrowser/view/tgs00109/default/table?lang=en&category=t_reg.t_reg_educ	NUTS 2	Annual	2024	CSV, TSV, XLS	Tertiary educational attainment		Y
ISTAT: population per educational attainment and region	ISTAT	https://esploradati.istat.it/databrowser/#/it/dw/categories/IT1,Z0820EDU,1.0/DCCV_POPTIT1_UNT2020/IT1,52_1194_DF_DCCV_POPTIT1_UNT2020_2,1.0	NUTS2	Annual	2020	CSV, XLS, JSON	Tertiary educational attainment		N

Tertiary educational attainment at NUTS2 level EUROSTAT 2024

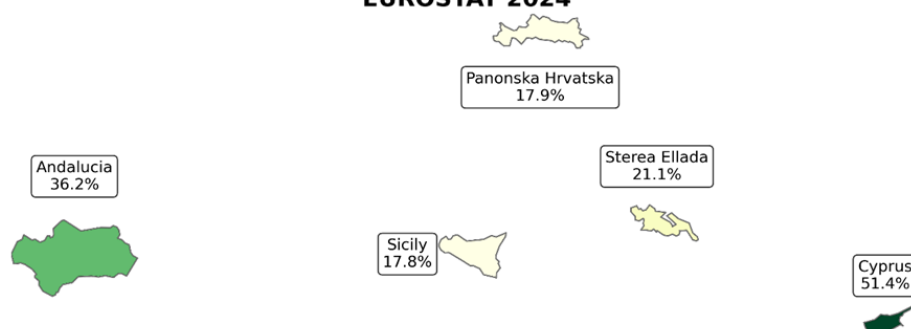


Figure 13: tertiary educational attainment based on EUROSTAT data

NAME OF THE INDICATOR	DESCRIPTION
POTENTIAL MARKET SIZE EXPRESSED IN GDP: INDEX GDP (PPS) EU27=100 - EU27 AVERAGE COMPUTED AS POPULATION WEIGHTED AVERAGE OF THE NUTS2 VALUES	This indicator measures the economic potential of a region by comparing its Gross Domestic Product (GDP) per capita, adjusted for purchasing power standards (PPS), against the EU28 average. It reflects the relative market size and economic capacity of a region within the European context.

CORRESPONDING DIMENSION
ECONOMY, LABOUR MARKET

CHARACTERISTICS
FLEXIBILITY: Regions with higher GDP levels tend to have greater institutional and financial capacity to reallocate resources and adapt strategies in response to economic or environmental crises. RESOURCEFULNESS: A larger potential market size often implies better access to capital, infrastructure, and innovation, enabling more effective mobilization of resources and services during times of disruption.

IMPACT ON RESILIENCE
A higher potential market size enhances resilience by providing a stronger economic foundation to absorb shocks, maintain employment, and invest in adaptive strategies. It supports a region's ability to maintain essential functions and recover quickly from disruptions.

RECOMMENDATIONS
Direct - Foster economic growth by investing in productive sectors and infrastructure. - Encourage innovation and entrepreneurship to raise regional GDP levels. Indirect - Support regional development through skills development, institutional capacity-building, and cross-border cooperation.

CALCULATION
Potential market size index percentage = (potential market size of region (GDP index by the population, taken from datasets below) / total EU market size) x 100 – EU27 = 100

REGION-SPECIFIC DATASETS	GENERAL DATASETS
•	• EUROSTAT: economic datasets
•	• EUROSTAT: population datasets

Name	Source	Link	Spatial resolution	Temporal resolution	Last updated	Data format	Variable	Reasons added	Used for computation (Y/N)
EUROSTAT: economic datasets	EUROSTAT	https://ec.europa.eu/eurostat/databrowser/view/tgs00006/default/table?lang=en&category=t_reg.t_reg_eco	NUTS 2	Annual	2023	CSV	GDP by NUTS 2 region. Expressed as a percentage of the EU-27 average (based on purchasing power standard (PPS) per inhabitant data)		Y
EUROSTAT: population datasets	EUROSTAT	https://ec.europa.eu/eurostat/databrowser/explore/all/popul?lang=en&subtheme=demo&display=list&sort=category	NUTS2	Annual	2024	CSV	Population on 1 January by age group, sex and NUTS 2 region		Y

Percentage of potential market size on total EU market size at NUTS2 level EUROSTAT 2023

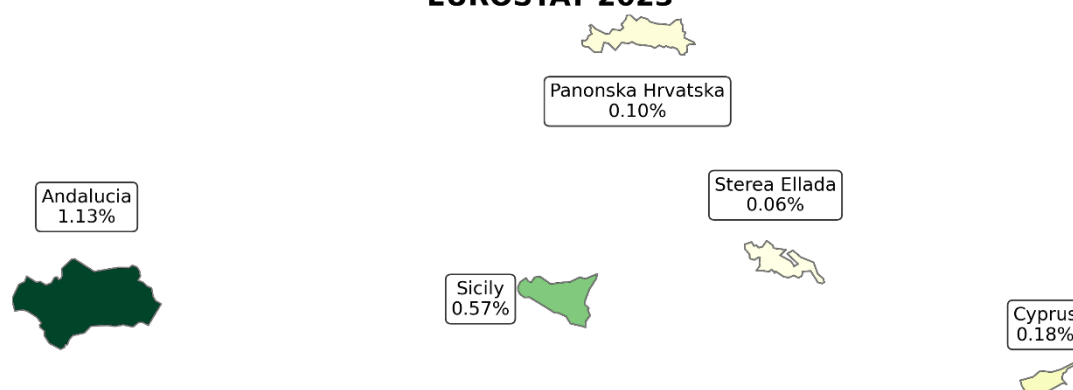


Figure 14: Percentage of potential market size on total EU market size based on EUROSTAT

NAME OF THE INDICATOR		DESCRIPTION
NUMBER OF LAND TRANSPORT ROUTES TO ENTER / EXIT THE COMMUNITY		This indicator measures the number of exit routes available in case of emergency (flooding, forest fires, etc.).
CORRESPONDING DIMENSION		
INFRASTRUCTURE		
CHARACTERISTICS		
REDUNDANCY: Areas with multiple entry and exit points offer better accessibility during emergencies. If some routes are blocked or destroyed, having various access pathways ensures the area remains reachable.		
IMPACT ON RESILIENCE		
A higher number of land transport routes enhances community resilience by ensuring continued access during emergencies, even if some routes are blocked. This redundancy supports faster emergency response, evacuation, and recovery efforts.		
RECOMMENDATIONS		
Direct: - Expand the number of entry and exit roads, particularly in communities currently served by a single access route. Indirect: SO7 Ensure infrastructure is designed or updated considering hazard risks, e.g., wildfire buffers or landslide protection measures. - Promote multi-modal transport options (waterways, airways, railways) as backup routes to complement road access.		
CALCULATION		
REGION-SPECIFIC DATASETS		GENERAL DATASETS
•		• OSM: streets

Name	Source	Link	Spatial resolution	Temporal resolution	Last updated	Data format
OSM: streets	OpenStreetMap (OSM)	https://wiki.openstreetmap.org/wiki/Downloading_data	Street-level (global)	Continuous / real-time	Live	XML (.osm), PBF, GeoJSON

NAME OF THE INDICATOR	DESCRIPTION
EXISTENCE OF EMERGENCY RESPONSE ORGANISATION	This indicator captures whether a formal, operational emergency response organization exists within a region. It includes fire services, civil protection units, disaster management agencies, or integrated emergency coordination centers responsible for crisis response and public safety.

CORRESPONDING DIMENSION
GOVERNANCE/STRATEGY/PLANNING

CHARACTERISTICS
ROBUSTNESS: The presence of a dedicated emergency response organization enhances systemic robustness by ensuring coordinated, timely, and professional action during crises, reducing the risk of systemic collapse or chaos. REDUNDANCY: A well-organized emergency response structure typically includes backup systems, personnel reserves, and multiple lines of communication and deployment—ensuring that if one element fails, others can compensate.

IMPACT ON RESILIENCE
An operational emergency response organization is fundamental to resilience. It enables rapid intervention, supports life-saving operations, and minimizes damage during emergencies.

CALCULATION
Percentage of firefighters on total employment, directly from the dataset

RECOMMENDATIONS
Direct - Prioritize the establishment and investment in formal emergency response organizations. Indirect - Strengthen coordination within and among existing emergency response organizations.

REGION-SPECIFIC DATASETS	GENERAL DATASETS
	- EUROSTAT: employment data - EUROSTAT: Government expenditure by function

Name	Source	Link	Spatial resolution	Temporal resolution	Last updated	Data format	Variable	Reasons added	Used for computation (Y/N)
Government expenditure by function (COFOG)	EUROSTAT	https://ec.europa.eu/eurostat/databrowser/view/gov_10a_exp\$defaultview/default/table?lang=en	National, some NUTS levels	Annual	2023	CSV	Government expenditure including the sector 'fire protection services'	Contains information on government expenditure regarding fire fighters	N
EUROSTAT: Employment data	EUROSTAT	https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230807-1	National	Quarterly, annual	2022	PDF	Percentage of firefighters on total employment	Numbers of employed firefighters per country	Y

Percentage of firefighters on total employment - EUROSTAT 2022

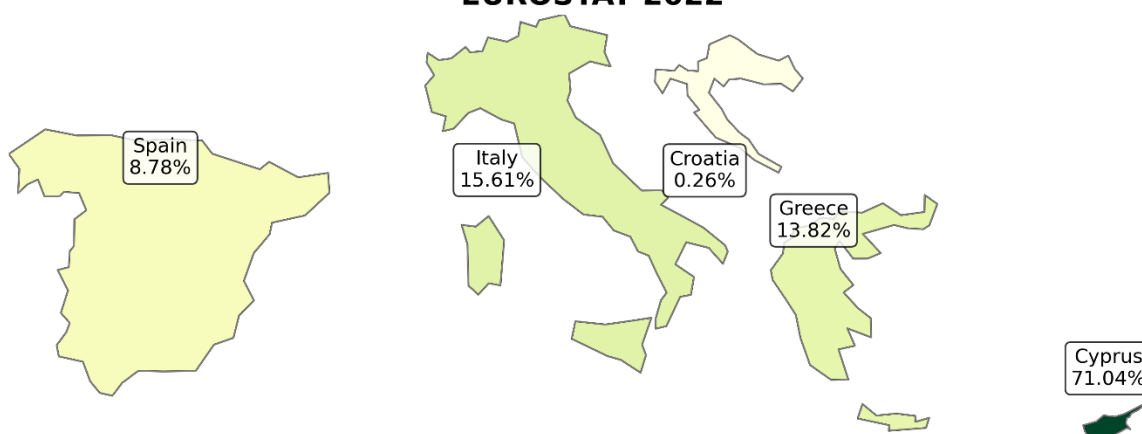


Figure 15: representation of indicator with respect to firefighters (based on EUROSTAT)

NAME OF THE INDICATOR	DESCRIPTION
PERCENTAGE OF NATURAL AREAS	This indicator captures the proportion of land within a region that remains natural or semi-natural, such as forests, wetlands, or grasslands, which provide essential ecosystem services.

CORRESPONDING DIMENSION
ENVIRONMENT / NATUR / SETTLEMENT AREAS

CHARACTERISTICS
Flexibility: Natural areas can absorb and buffer environmental stresses, offering multiple ecosystem functions under varying conditions. Resourcefulness: These areas provide resources such as clean water, air, and food alternatives during crises. Robustness: Diverse natural landscapes are better equipped to endure extreme events like storms, droughts, and fires without system collapse.

IMPACT ON RESILIENCE
A high percentage of natural areas boosts resilience by maintaining biodiversity, stabilizing local climates, and providing critical life-supporting services during and after crises.

RECOMMENDATIONS
Direct - Protect existing natural areas through regulations and enforcement. - Identify potential areas that could be transformed into natural or semi-natural areas. Indirect - Monitor the development of natural areas (increase, stability, or decrease) to guide planning and conservation efforts.

CALCULATION
CLC data retrieved on NUTS2/NUTS3 level and aggregation CLC classes (1, 2, 3 and 4-5). Percentage of total delivered results.

REGION-SPECIFIC DATASETS	GENERAL DATASETS
• PLINIVS LULC • ISPRA: Italy: land use • Greece: natural habitats • Italy: natural habitats	• LULC - COPERNICUS • Urban Atlas – LULC • Climate data store: ERA5-land • Global Forest Watch: Forest information • Global Forest Watch: Forest information (tree plantations) • Natura 2000 areas (OBZ not covered) • Climate data store: Imperviousness

Name	Source	Link	Spatial resolution	Temporal resolution	Last updated	Data format	Variable	Reasons added	Used for computation (Y/N)
Italy: land use	ISPRA	https://www.isprambiente.gov.it/en/databases/data-base-collection/soil-and-territory/use-of-soil	National / regional	Annual	2023	SHP, GeoTIFF, XLS	Land use		N
PLINIVS LULC	PLINIVS	Upon request	Local / urban scale	Project-specific	Not specified	SHP, GeoPackage (on request)	Land use		N
LULC - Copernicus	Copernicus	https://land.copernicus.eu/en/products/corine-land-cover	10 m / 100 m	Annual	2018	Netcdf, GeoTIFF	Corine land cover		Y
Climate Data Store: Imperviousness data	Copernicus	https://land.copernicus.eu/en/products/urban-atlas	20 m / 100 m grid	Annual	2018	GeoTIFF, Netcdf	Imperviousness in percent	Natural areas could be defined as all non-sealed areas	N
Italy: natural habitats	ISPRA	https://www.isprambiente.gov.it/it/servizi/sistema-carta-della-natura/cartografia/carta-della-natura-alla-scala-1-50.000	1:50,000 map scale	Static	2022	SHP, PDF	Natural habitats	The number / size of natural habitats could serve as a proxy for this indicator	N
Greece: natural habitats	Greek Ministry of Environment / Oikoskopio	http://www.oikoskopio.gr/map/index.php?lng=en-US seems to be down, is available only in Greek anymore: https://oikoskopio.geodiv.page/map#	Regional / national	Project-based (monitoring)	~2023 – land cover updated to 2007	Web GIS, SHP	Natural habitats	The number / size of natural habitats could serve as a proxy for this indicator	N

Name	Source	Link	Spatial resolution	Temporal resolution	Last updated	Data format	Variable	Reasons added	Used for computation (Y/N)
Urban Atlas – LULC	Copernicus	https://land.copernicus.eu/en/products/urban-atlas	10 m / 100 m grid	2006, 2012, 2018, 2021(?)	2018	GeoTIFF, SHP	Land use		N
Global Forest Watch: Forest information	GFW	https://www.globalforestwatch.org/dashboards/global/	Global (30 m Landsat-based)	Annual / real-time	2023	Web map, GeoTIFF	Forest coverage	The number of forests / size of forests could be used as a proxy for natural areas	N
Global Forest Watch: Forest information (plantations)	GFW	https://www.globalforestwatch.org/dashboards/global/	Global (plantation-specific)	Annual / recent	2023	Web map, GeoTIFF	Forest plantations	The number of forest plantations can give information on how old / resilient forest areas are	N
Natural habitats	European Environment Agency (EEA)	https://www.eea.europa.eu/en/datahub/datahubitem-view/6fc8ad2d-195d-40f4-bdec-576e7d1268e4	Europe-wide / national	6-year reporting cycles	2023	SHP, PDF, XLS, Web map	Natural habitats	The number / size of natural habitats could serve as a proxy for this indicator	N

Percentage of Corine Land Cover (CLC) type on NUTS 2 / NUTS 3 level COPERNICUS 2018

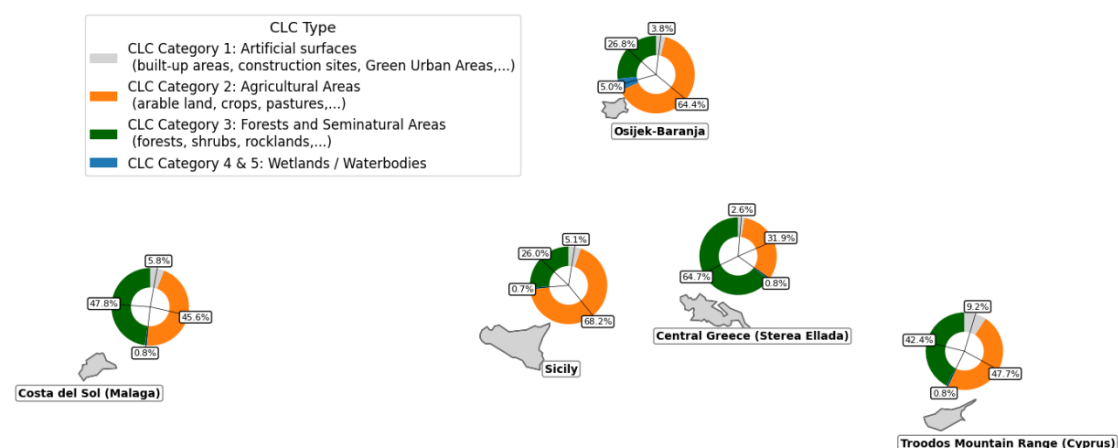


Figure 16: Percentage of Land Cover types according to CORINE data, different spatial resolutions possible

An overview of the indicators and the potential data sets and more importantly the missing ones is given below in Figure 17. The data gap recommendations follow in the next section.

Nature & Settlement Areas
"Settlement areas in danger zones": Proportion of residential buildings in a hazard zone X Percentage of groundwater bodies in poor condition due to overexploitation Percentage of natural areas Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves. Surface impermeability (and related indices) (Annual soil impermeability index) Water stress index
Governance
X % of population protected by structural disaster risk measures for hazards X % of population who actively participate in a local organisation that aims to prepare for disasters. Availability of hazard maps Existence of emergency response organisation X Percentage of municipalities with local flood risk management plans
Health & Wellbeing
X % of people with immediate access to first aid X Community water storage volume (cubic metres) Life expectancy Number of hospital beds per 100.000 inhabitants in the community Unmet needs for medical treatments
Infrastructure
X Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget X Average age of infrastructure e.g the water supply network, road network, electrical grid X Number of land transport routes to enter / exit the community X Percentage of critical facilities served by off-grid energy services X Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event
Population & Education
Age groups Employment rate - % of active population High education index X Percentage of city population covered by multi-hazard early warning Percentage of large families (>= 3 people per family unit) Percentage of population at high risk from natural hazards Percentage of population living within 1km of a grocery store X Percentage of schools teaching DRR
Economy & Labour Market
% of economic output attributed to different sectors. Crop Production & Yield (Total production, yield per hectare, seed variety performance) X Food import dependency X Percentage of properties with insurance coverage for high-risk hazards Percentage of SME businesses relative to total number of businesses Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values

Figure 17: Overview on the suggested resilience indicators, sorted by dimensions. The 16 indicators with current data gaps are highlighted with a grey X. Source: own presentation.

6 Recommendations for data collection

6.1 Identified data gaps

The 36 potential indicators listed in section 5 were checked against available data to determine, if they are computable on a sufficient spatial level. Available datasets, either explicitly stating the indicator or supporting the computation of it as well as being a good proxy, sufficient for its evaluation after some post-processing, were listed in the indicator factsheets in section 5.

As the indicators are highly specific, often an explicit dataset is not available, as is visualized in Figure 18. However, it is highly dependent on the complexity of the indicator itself: basic information about age groups or life expectancy are easy to quantify, while as an example 'Percentage of municipalities with local flood risk management plans' requires detailed regional knowledge and definitions of what is considered a flood risk management plan.

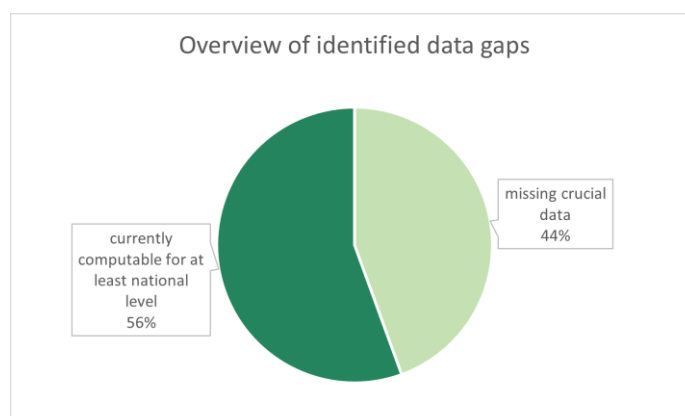


Figure 18: Percentage of indicators currently computable / not computable on at least national level. 16 out of 36 indicators show crucial data gaps. Source: own presentation.

In 4.1.1, the CoPs were asked to rank the indicators. All indicators with a total ranking above 2.5 (1 is low, 2 medium and 3 high importance) across regions are shown in Table 22 with an additional information from the CoP feedback, as well as currently available datasets for the computation. It reveals that the prioritized indicators are over proportionally having data gaps.

6.2 Recommended data to collect

Based on the gaps identified, it is suggested to collect data to support quantitative assessment of the missing indicators. If direct data collection is not possible, proxies or related data might still be available. As made clear with the feedback from the CoPs, data should be collected on the spatial granularity perceived as most useful by the stakeholders. For all listed indicators, at the target spatial resolution should be municipality/community level, as this would meet the requirements of all regions.

The two indicators ranked the most important can't be displayed due to missing data, therefore, we suggest that highest priority should be to collect data on the status (overexploitation) of water bodies and thus close these crucial gaps.

Regarding the water stress index, country-level data is already available with insufficient spatial resolution, therefore here the priority would be to collect highly resolved data. As indicators in the governance dimension often lack data and were on average also highly prioritized by the regions, a suggestion would be to focus on data collection.

The amount of emergency responders, their equipment, the coverage of early-warning systems as well the amount of people actively taken part in local organisations might be already available to municipalities or easily collected.

If possible, the collected data should be on the requested and most useful resolution (see Table 29), for Croatian and Italian stakeholders, this is always 'regional' and 'municipality/local', respectively), but especially for indicators missing crucial data on every spatial level, even national datasets are going to be a valuable addition.

Table 29: Overview table on all indicators with their ranking with focus on available data and identified gaps. The ‘average ranking’ is the mean perceived importance of all regions with 1 meaning low, 2 medium and 3 high importance. CoP feedback requested spatial granularity is not shown for OBZ and Sicily, as all indicators received the same answer: ‘regional’ and ‘municipality/local’, respectively. Source: own representation.

Indicator	Spatial/temporal preference	Average Ranking	Requested spatial granularity: COSTA DEL SOL	Requested spatial granularity: GREECE	Requested spatial granularity: TROODOS	Available datasets	Comment	Data gaps?
Percentage of groundwater bodies in poor condition due to overexploitation	MIXED	2.9	1-10 km GRID	REGIONAL UNIT	HYDROLOGICAL UNIT	Implicit/ related regional data and on country level	Explicit calculation is not possible as crucial data is missing on every spatial level; however, some proxies exist	yes
water stress index	MIXED	2.8	REGIONAL/ LOCAL	REGIONAL UNIT	HYDROLOGICAL UNIT, COMMUNITY	Explicit available on country level	Data is available on country level, not fulfilling the need for finer spatial resolution	yes
percentage of city population covered by multi-hazard early warning	SPATIAL	2.7	NUTS 2-3	MUNICIPALITY, LOCAL	COMMUNITY	None	Calculation is not possible on any spatial level, as this information is not available	yes
Surface impermeability (and related indices) (Annual soil impermeability index)	SPATIAL	2.7	REGIONAL/ LOCAL, 1-10 m GRID	MUNICIPALITY	10m GRID, COMMUNITY	10m resolved data Eu-wide available	On regional level, implicit information such as land use / land cover (LULC) information is available; EU-wide data exists for imperviousness	no
Number of hospital beds per 100.000 inhabitants in the community	SPATIAL	2.6	REGIONAL/ LOCAL, NUTS 2-3	REGIONAL UNIT, MUNICIPALITY	COMMUNITY, MUNICIPALITY	Explicit EU-wide data available, some on regional level	For Andalucia as well as Croatia, no regional datasets were available and the spatial granularity needs for Troodos area are not met.	no
Percentage of population at high risk from natural hazards	SPATIAL	2.6	REGIONAL/ LOCAL, HIGHER THAN NUTS3	REGIONAL UNIT, MUNICIPALITY	10-100m GRID, COMMUNITY	Will be provided by the project	The risk calculation is part of this project; Population numbers are available on regional levels	no
% of population who actively participate in a local organisation that aims to prepare for disasters.	SPATIAL	2.6	REGIONAL/ LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY	none	Calculation is not possible on any spatial level, as this information is not available	yes

Indicator	Spatial/temporal preference	Average Ranking	Requested spatial granularity: COSTA DEL SOL	Requested spatial granularity: GREECE	Requested spatial granularity: TROODOS	Available datasets	Comment	Data gaps?
Number of land transport routes to enter / exit the community	SPATIAL	2.5	REGIONAL/ LOCAL	LOCAL	COMMUNITY, MUNICIPALITY	Explicitly covered by OSM	There is no explicit dataset related to it, but services like OpenStreetMap can provide the necessary input;	no
% of people with immediate access to first aid	MIXED	2.5	NUTS 2-3	MUNICIPALITY	MUNICIPALITY	Only implicit datasets on national level	There are no regional datasets and on national level, only related datasets such as self-reported unmet needs, causes of death or number of physicians.	yes
Percentage of natural areas	SPATIAL	2.5	1-10 m GRID	MUNICIPALITY	ASSET-LEVEL, COMMUNITY	Only implicit and partial datasets at EU and regional level	There is no dataset directly related to it and there are missing informations relative to highly water intensitve economical activities	yes
Percentage of municipalities with local flood risk management plans	SPATIAL	2.5	REGIONAL/ LOCAL, NUTS 2-3	MUNICIPALITY	MUNICIPALITY, HYDROLOGICAL UNIT	none	Calculation is not possible on any spatial level, as this information is not available	yes
Existence of emergency response organisation	SPATIAL	2.4	REGIONAL/ LOCAL, NUTS 2-3	REGIONAL UNIT	COMMUNITY	Only explicit datasets at EU level regarding firefighters	No direct datasets for all emergency response oragnisations available, but fire fighters employment statistics on national level	yes
Percentage of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event	SPATIAL	2.4	REGIONAL/ LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY	none	Calculation is not possible on any spatial level, as this information is not available	Yes

Indicator	Spatial/temporal preference	Average Ranking	Requested spatial granularity: COSTA DEL SOL	Requested spatial granularity: GREECE	Requested spatial granularity: TROODOS	Available datasets	Comment	Data gaps?
'Settlement areas in danger zones': Proportion of residential buildings in a hazard zone	MIXED	2.3	1-10 km GRID	MUNICIPALITY	ASSET-LEVEL , COMMUNITY	Will be provided by the project	The risk calculation is part of this project	no
Percentage of properties with insurance coverage for high-risk hazards	MIXED	2.3	SCALE NOT RELEVANT	REGIONAL UNIT	COMMUNITY	Only implicit and partial datasets at EU level	No dataset directly related to it, the only one collected is too broad	yes
life expectancy	SPATIAL	2.2	REGIONAL/ LOCAL, NUTS 2-3	MUNICIPALITY	DISTRICT (NUTS 3), MUNICIPALITY	Explicit dataset at EU level	For all regions no regional datasets found	no
Community water storage volume (cubic metres)	MIXED	2.2	REGIONAL/ LOCAL, NUTS 2-3	LOCAL	COMMUNITY, ASSET LEVEL	Implicit datasets at EU level	No dataset directly related to it, the informations available are not sufficient to evaluate it	yes
Proportion of high hazard areas that are undeveloped public lands, such as parks, forests or preserves.	SPATIAL	2.2	1-10 km GRID, NUTS 2-3	REGIONAL, REGIONAL UNIT	COMMUNITY	Will be provided by the project	The risk calculation is part of this project	no
% of population protected by structural disaster risk measures for hazards	MIXED	2.1	REGIONAL/ LOCAL	MUNICIPALITY	ASSET-LEVEL , COMMUNITY	none	Calculation is not possible on any spatial level, as this information is not available	yes
Food import dependency	SPATIAL	2.1	REGIONAL/ LOCAL	MUNICIPALITY	NATIONAL	Datasets at EU level only for countries	Very coarse data available only at country level	Yes
high education index	MIXED	2.1	SCALE NOT RELEVANT	MUNICIPALITY	COMMUNITY	Explicit datasets at EU level	For all regions no regional datasets found	no

Indicator	Spatial/temporal preference	Average Ranking	Requested spatial granularity: COSTA DEL SOL	Requested spatial granularity: GREECE	Requested spatial granularity: TROODOS	Available datasets	Comment	Data gaps?
% of economic output attributed to different sectors	SPATIAL	2.0	REGIONAL/LOCAL	REGIONAL UNIT	DISTRICT (NUTS3)	Explicit datasets at EU level only for countries	No regional datasets found for all regions	yes
percentage of large families (>= 3 people per family unit)	SPATIAL	2.0	NUTS 2-3	MUNICIPALITY	COMMUNITY	Implicit/explicit datasets at regional level	No uniform information retrievable from regional datasets; for Spain information only at national level	yes
Crop Production & Yield (Total production, yield per hectare, seed variety performance)	MIXED	1.9	REGIONAL/LOCAL	MUNICIPALITY	COMMUNITY	Implicit datasets at regional level, explicit datasets at EU level	At EU level for all regions information about cereal, dry pulses and protein crop. At regional level no direct information available	Yes
Availability of hazard maps	SPATIAL	1.9	REGIONAL/LOCAL	LOCAL	MUNICIPALITY	Will be provided by the project	The risk calculation is part of this project	no
Annual expenditure on upgrades and maintenance of city service assets as a percentage of total city/regional budget	MIXED	1.9	REGIONAL/LOCAL, NUTS 2-3, SCALE NOT RELEVANT	MUNICIPALITY	COMMUNITY	Broad and generic dataset at EU level	Calculation is not possible on any spatial level, as this information is not available	yes
Average age of infrastructure e.g the water supply network, road network, electrical grid	MIXED	1.9	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY, ASSET LEVEL	Implicit datasets at EU level	No direct datasets related to it. The indirect datasets provide only some possible hints to a computation	yes
Percentage of critical facilities served by off-grid energy services	SPATIAL	1.9	REGIONAL/LOCAL, NUTS 2-3	MUNICIPALITY	COMMUNITY	none	Calculation is not possible on any spatial level, as this information is not available	yes

Indicator	Spatial/temporal preference	Average Ranking	Requested spatial granularity: COSTA DEL SOL	Requested spatial granularity: GREECE	Requested spatial granularity: TROODOS	Available datasets	Comment	Data gaps?
Employment rate - % of active population	SPATIAL	1.9	HIGHER THAN NUTS3	MUNICIPALITY	COMMUNITY	Explicit datasets at EU level and partially at regional level	Datasets at regional level are not available for Andalucia and Sicily	yes
unmet needs for medical treatments	SPATIAL	1.8	REGIONAL/ LOCAL	LOCAL	COMMUNITY, MUNICIPALITY	Explicit dataset at EU level, implicit datasets at regional level	From datasets at regional level is not possible to obtain informations to compute it	Yes
Potential market size expressed in GDP: index GDP (pps) EU28=100 - EU28 average computed as population weighted average of the NUTS2 values	SPATIAL	1.8	NUTS 2-3	REGIONAL UNIT	NATIONAL	Explicit dataset at EU level	No regional datasets found for all regions	yes
percentage of schools teaching DRR	SPATIAL	1.8	NUTS 2-3	MUNICIPALITY	COMMUNITY	none	Calculation is not possible on any spatial level, as this information is not available	yes
Age groups	SPATIAL	1.8	NUTS 2-3	REGIONAL, REGIONAL UNIT, MUNICIPALITY, LOCAL	COMMUNITY	Explicit datasets at EU level and partially at regional level	Datasets at regional level are not available for Central Greece and Cyprus	yes
Percentage of population living within 1km of a grocery store	MIXED	1.6	NUTS 2-3	MUNICIPALITY, LOCAL	ASSET-LEVEL, COMMUNITY	Explicitly covered by OSM and WorldPop	There is no explicit dataset related to it, but services like OpenStreetMap can provide the necessary input	no
Percentage of SME businesses relative to total number of businesses	SPATIAL	1.5	REGIONAL/LOCAL	MUNICIPALITY	COMMUNITY	Explicit datasets at EU level only for countries	Explicit datasets at EU and regional level for all regions not found	Yes

Some indicators are not directly quantifiable, such as “% of people with immediate access to first aid”, but can be substituted with data available, such as “unmet needs (EUROSTAT data)” or the combination of OSM based hospital locations interlinked with population density information. The latter is displayed below in Figure 19.

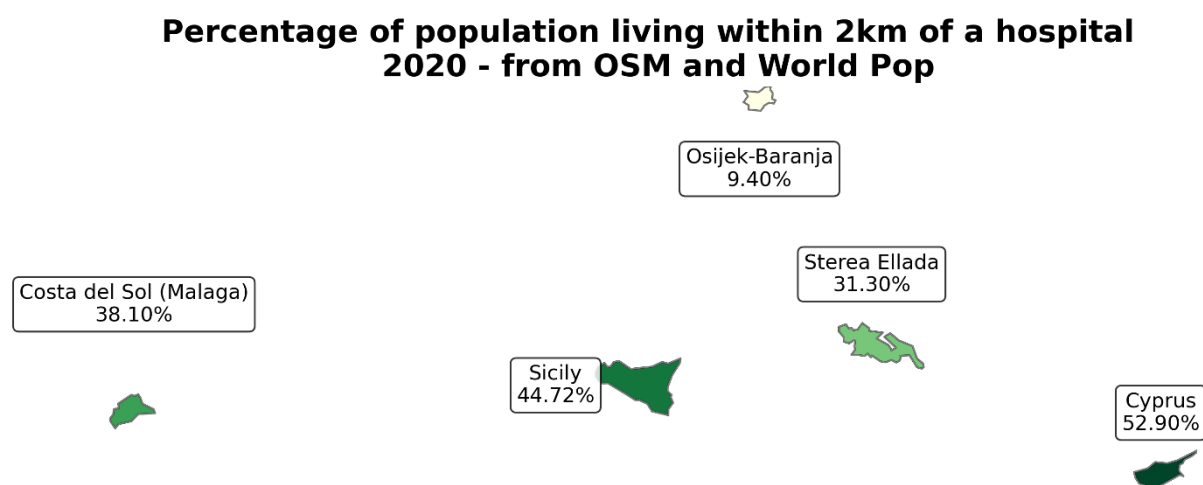


Figure 19: Percentage of population living within 2 km of a hospital from WorldPop 2020 data.

7 Link to other WPs

D2.4 strongly links to WP3 and WP4, since within WP3 user centric climate change resilience enhancing services are set up and within WP4 the corresponding learning materials, as well as local resilience recommendations are provided.

Specifically for WP3:

- Integration of risk assessment methodology to display local risk maps and related adaptation measures
- Incorporation of six resilience dimensions and related indicators
- Display of quantifiable indicators based on stated data sets, incorporating the information on characteristics and recommendations; in case of European data sets: display of rank within European regions/countries
- Qualitative story telling for non-quantifiable, highly-rated indicators
- Potential starting point for monitoring dashboard of specific resilience indicators

Specifically for WP4:

- Alignment of resilience recommendations (D4.3) and adaptation measures / recommendations provided per indicator
- Provision of learning materials on better understanding / communicating resilience; dimension; characteristics and chosen indicators within public bodies and civil society
- Uptake of additional important, currently non-quantifiable indicators within WP4 and the story telling approach
- Uptake of data collection recommendations

8 Conclusions

This deliverable concludes the work of WP2 „Addressing the Climate Change data and knowledge Gaps” and brings together the information collected so far within WP2 (data sets, climate services, data gaps, resilience frameworks and indicators), as well as the information and requirements from the CoPs (WP1 and consequently WP4).

As a first step, the risk assessment methodology clarifies the chosen approach regarding hazard, exposure and vulnerability. Due to the latest developments such as the CLIMAAX project, as well as sound expertise within the consortium, the risk assessment methodology for heat, wildfire, flooding and drought is provided. Thus, the suggested data sets, and if applicable, weights are displayed to enable the computation within WP3.

Based on the review of current resilience assessment approaches and the stakeholders’ needs and knowledge, a shortlist of resilience indicators was set-up and the regional stakeholders’ feedback collected. The results display that all 35 resilience indicators of the defined dimensions:

- Health & Wellbeing
- Population & Education
- Economy & Labour Market
- Infrastructure
- Governance / Strategy & Planning
- Environment/Nature & Settlement Areas

were rated as highly important, with spatial resolution overall being more important than temporal. However, the publicly available data sets mostly don’t cover the needs of the regions regarding spatial resolution, and for 14 out of the 35 indicators no public data sets are available. Thus, the data collection recommendations build upon the available data sets and requirements (regarding spatial/temporal resolution) stated and indicate which data sets are rated the most important by the regions and thus should be collected first.

Additionally, recommendations how to decrease specific risks, as well as increase the resilience displayed by the various indicators, are stated. By incorporating these within WP3 and WP4, regional stakeholders are given information on their current / future risk(s), as well as current performance in the above-mentioned resilience dimensions, together with specific action points on how to transform towards a resilient future. Thus, ensuring objective resilience assessment based on standardized data, linked to usable and applicable actions.

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