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D3.6 WP3 testing results

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D3.6 WP3 testing results

Summary

Deliverable 3.6 presents the results obtained from a total of six tests developed within the scope of WP3. The aim of such activities was to test and validate several developments done in previous tasks of this WP (specially Tasks 3.1, 3.2 and 3.4) by doing a preliminary implementation to one of the project case studies. The developments evaluated are related to the assessment of holistic resilience at a regional scale, resilience of critical assets , risk qualification and the first development of ICARIA decision support system for planning activities related to the improvement of asset resilience.

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List of Acronyms and Abbreviations

AMB	Barcelona Metropolitan Area
CBA	Cost-Benefit Analysis
CRPT	City Resilience Profiling Tool
CS	Case study
DSS	Decision support system
GDP	Gross domestic product
MCA	Multicriteria Analysis
RAF	Resilience Assessment Framework
RAT	Resilience Assessment Tool
SAGIS	Savannah Area Geographic Information System
SAR	South Aegean Region
SLZ	Salzburg Region
SSO	Strategic Subobjectives
WP	Work package

Executive summary

Work Package 3 of project ICARIA is focused on providing methodologies for tangible impact assessment of extreme weather events (including multi-hazard events) and for the holistic assessment of the climatic resilience of European regions. The objective of Task 3.5 is to test some innovative developments within this work package prior to their full implementation in the project case studies (CS). The tested developments have been selected to give the opportunity to the consortium to assess the performance of models and tools where the CS have little background, emerging methods, relevant updates in existing resources or new tools and methodologies.

A total of six tests have been carried out to evaluate the applicability of six new developments in one of the project case studies and identify potential limitations and improvements of the tested methods.

The list of tests carried out in this task is as follows:

A. New functionality of the holistic resilience assessment framework (RAF) for Natural Areas in the Metropolitan Area of Barcelona

B. Global assessment of heat wave impacts and resilience in the Metropolitan Area of Barcelona

C. Impacts of forest fires and related compound events in the South Aegean Region

D. Resilience assessment tool (RAT) on specific critical assets of islands in the South Aegean Region

E. Impacts of fluvial flooding on rural/peri-urban areas of the Salzburg Region

F. Performance application of the Decision Support System (DSS)

The results of the tests A and B indicate that the RAF is valid both for assessing resilience of specific natural areas and the regional resilience to heat waves. However, the complex scheme of institutions managing adaptation policies make it necessary to involve a large number of stakeholders to develop an accurate assessment. In Test C, the vulnerability of critical assets to forest fires in the SAR CS has been assessed based on historic fires, showing that a direct impact on a small share of the electricity distribution network can lead to impacts in large parts of the island. Test D has shown the viability to assess the overall resilience of CIs in Syros and Rhodes based on the knowledge of local stakeholders such as the civil protection department, electricity and water utility representatives or the regional government. In test E, A methodology based on the CLIMADA software has allowed assessing impacts of floods on rural areas of the SLZ region. Its results show consistency with the economic damage associated with historic floods in the municipality of Mittersill. Finally, test F summarizes the work conducted to conceptualize the ICARIA DSS and its main functionalities based on the methodology used for standard risk assessment of pluvial floods in the AMB.

All these experiences have allowed the consortium to dive into the implementation of methodologies and resources described in Deliverables 3.1 and 3.2 and identify measures to improve their usability in the different CS of the project. Following Task 3.5, all the hazard and impact assessment methods presented in WP1, 2 and 3 will be fully implemented in Tasks 4.2 and 4.3 of WP4, where the actual risk and resilience assessment of climate hazards in the ICARIA CS will be developed.

1 Introduction to project ICARIA

The number of climate-related disasters has been progressively increasing in the last two decades and this trend could be drastically exacerbated in the medium- and long-term horizons according to climate change projections. It is estimated that, between 2000 and 2019, 7,348 natural hazard-related disasters have occurred worldwide, causing 2.97 trillion US$ losses and affecting 4 billion people (UNDRR, 2020). These numbers represent a sharp increase of the number of recorded disaster events in comparison with the previous twenty years. Much of this increase is due to a significant rise in the number of climate-related disasters (heatwaves, droughts, flooding, etc.), including compound events, whose frequency is dramatically increasing because of the effects of climate change and the related global warming. In the future, by mid-century, the world stands to lose around 10% of total economic value from climate change if temperature increase stays on the current trajectory, and both the Paris Agreement and 2050 net-zero emissions targets are not met.

In this framework, **Project ICARIA** has the overall objective to promote the definition and the use of a comprehensive asset level modeling framework to achieve a better understanding about climate related impacts produced by complex, compound and cascading disasters and the possible risk reduction provided by suitable, sustainable and cost-effective adaptation solutions.

This project will be especially devoted to critical assets and infrastructures that are susceptible to climate change, in a sense that its local effects can result in significant increases in cost of potential losses for unplanned outages and failures, as well as maintenance – unless an effort is undertaken in making these assets more resilient. ICARIA aims to understand how future climate might affect life-cycle costs of these assets in the coming decades and to ensure that, where possible, investments in terms of adaptation measures are made up front to face these changes.

To achieve this aim, ICARIA has identified 7 Strategic Subobjectives (SSO), each one related to one or several work packages. They have been classified according to different categories: scientific, corresponding to research activities for advances beyond the state of the art (SSO1, SSO2, SSO3, SSO4, SO5); technological, suggesting and/or developing novel solutions, integrating state-of-the art and digital advances (SSO6); societal, contributing to improved dialogue, awareness, cooperation and community engagement as highlighted by the European Climate Pact (SSO7); and related to dissemination and exploitation, aimed at sharing ICARIA results to a broader audience and number of regions and communities to maximize project impact (SSO7).

- SSO1.- Achievement of a comprehensive methodology to assess climate related risk produced by complex, cascading and compound disasters
- SSO2.- Obtaining tailored scenarios for the case studies regions
- SSO3.- Quantify uncertainty and manage data gaps through model input requirements and innovative methods

- SSO4.- Increase the knowledge on climate related disasters (including interactions between compound events and cascading effects) by developing and implementing advanced modeling for multi-hazard assessment
- SSO5.- Better assessment of holistic resilience and climate-related impacts for current and future scenarios
- SSO6.- Better decision taking for cost-efficient adaptation solutions by developing a Decision Support System (DSS) to compare adaptation solutions
- SSO7.- Ensure the use and impact of the ICARIA outputs

2 Objectives and context of the deliverable

Work Package 3 (WP3) of project ICARIA is centered on providing risk assessment methods as well as an holistic resilience evaluation framework to be implemented in the project CS. This implies working in several directions such as the development of impact quantification methods, defining standardized resilience assessment methods and developing a decision support system (DSS) for planning the improvement of regional climate resilience.

Figure 1 represents all the hazards and risk receptors in the three CS. Importantly, the implementation of risk assessment methods is divided in two steps. Firstly, the Trial phase involves a full development of risk assessment methods so that results can be used “as is” for operative decision making (e.g. developing adaptation plans for infrastructure). Secondly, in the Mini trial phase, assessments focused on different hazards are conducted following the methods and tools implemented in other CS during the Trial phase. This procedure aims at ensuring the method’s replicability and to evaluate the possibility to achieve similar results in contexts with data and resources limitations.

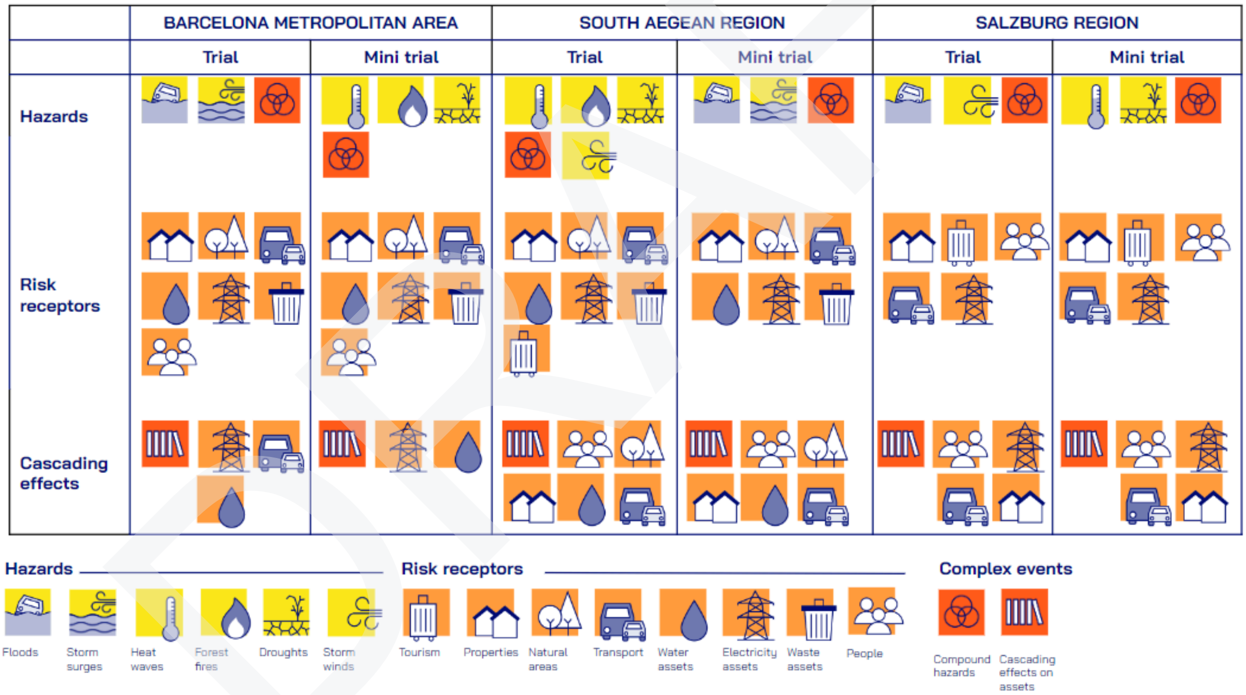


Figure 1. Summary of hazards and risk receptors considered in the different CS of ICARIA.

The wide range of climatic hazards and risk receptors considered stood as a challenge for WP3. On one hand, an extensive number of impact assessment methods has been collected in Deliverable 3.1 (Guerrero et al., 2024), including novel methodologies together with already tested methods from recent and ongoing EU projects. They ultimately aim at quantifying the impact associated with extreme weather events, either in monetary terms or risk score. On the other hand, the former Resilience Assessment Framework (RAF) from project RESCCUE has been redesigned to develop a tool able to assess the climate resilience of a region from an holistic point of view. As described in Deliverable 3.2 (Brito et al, 2024), it considers the main climatic hazards and key critical assets affecting each case study region. In parallel, the Resilience Assessment Tool (RAT) from project EU-Circle (Katopodis et al., 2018) has also been included in the ICARIA resilience assessment framework (Brito et al, 2024). Additionally, an innovative DSS tool is under development. It will enable local stakeholders to compare resilience and adaptation measures to protect critical assets against specific hazards based on cost benefit and a multicriteria analysis.

All the above mentioned work involves an important amount of innovations that have not been previously applied to any regional study for risk or climatic resilience assessment . For this reason, prior to the full implementation of the three ICARIA CS, this lab task has been conducted to allow a preliminary evaluation of the tools and methods that will be used in WP4 in combination with results from WP1 and WP2 (where similar lab tests have been carried out).

In Task 3.5, a total of six tests have been conducted to assess the capacity to implement several developments in the project CSs as well as to detect errors, barriers and limitations, and define possible improvements.

Table 1 summarizes these tests indicating the case study where they have been implemented and the members of the consortium who have been involved in the process.

Table 1. Test organization in Task 3.5.

Test	Issue	Case study	Partners involved
A	New functionality of the holistic resilience assessment tool for Natural Areas	AMB	AQUA, AMB, LNEC
B	Global assessment of Heat Wave Impacts and Resilience	AMB	AQUA, AMB, LNEC
C	Impacts of forest fires and related compound events	SAR	DMKTs, SAR
D	Resilience assessment tools on specific critical assets of islands (e.g. ports, airports…)	SAR	DMKTs, SAR
E	Impacts of fluvial flooding on rural/peri-urban areas	SLZ	AIT, VER
F	Performance application of the DSS	AMB	DRAX, AQUA

3 Methodology followed

The methodology employed for each of the six tests conducted in Task 3.5 follows a systematic and structured approach. It begins with a clear delineation of the test's objectives and boundaries, followed by the implementation of the designated model or tool within the specified case study region. Subsequently, the obtained results adequacy and alignment with the project needs is assessed. Any discrepancies or errors encountered during the process are meticulously identified and considered to propose enhancements or modifications to improve the applicability of the tested developments. Figure 2 depicts this process.

Figure 2. Scheme of the test development in Task 3.5.

Activities done in each step of the test are as follows:

1. **Scope definition**

   Definition of the objectives and scope of each test. Specifying the impact model or tool being implemented, the case study region involved and the desired outcomes.

2. **Model/tool implementation**

   Actual implementation of the chosen model or tool within the designated case study region. This involves setting up the necessary parameters, running simulations and/or performing assessments, and generating relevant data.

3. **Results adequacy assessment**

   Evaluation of the adequacy of the results obtained from the implementation phase. Assess whether the outcomes align with the predefined objectives and if they provide meaningful insights into the resilience and risk factors considered.

4. **Gaps and errors identification**

   Identify any shortcomings, gaps, or errors encountered during the implementation or assessment stages. This may include discrepancies between expected and actual results, limitations in data availability or quality, or technical issues with the models or tools used.

5. **Possible improvements definition**

   Propose potential enhancements or modifications to be applied to the tested methods or tools to address the identified gaps and errors. This could involve refining parameters, updating algorithms, incorporating additional data sources, or improving the usability of the tools for stakeholders.

Section 4 presents the implementation of this testing methodology to the cases presented in Table 1.

4 Tests developed

4.1 Test A: New functionality of the holistic resilience assessment tool for Natural Areas

4.1.1 Summary and objectives of Test A

Within the ICARIA framework, a holistic Resilience Assessment Tool has been updated following the guidelines of the RESCCUE project (Cardoso et al., 2019), while incorporating new features such as the inclusion of natural areas as a service and expanding the application to a regional scale.

This framework aims to enhance the understanding of climate-related impacts caused by complex, compound, and cascading disasters, and to identify potential risk reduction strategies through appropriate, sustainable, and cost-effective adaptation solutions (Russo et al., 2023).

The ICARIA RAF comprises a set of metrics covering a wide range of aspects and perspectives in relation to climate resilience. These metrics are presented in the form of questions that can be assigned answers and values, and provide, as a result, improvement opportunities and an assessment of the maturity of a region in terms of climate resilience. Importantly, such metrics are classified based on two different criteria:

- Dimensions of resilience: reflects which aspect of climate resilience development they assess.
    - Organizational dimension
    - Spatial dimension
    - Functional dimension
    - Physical dimension
- Relevance: reflects if the metric should be answered or not depending on the level of maturity of the assessment.
    - Essential
    - Complementary
    - Comprehensive

In summary, the RAF serves as a diagnostic tool for identifying critical assets and urban sector vulnerabilities in the region, as well as data gaps and areas for improvement (Brito et al, 2024).

As many metrics have been newly incorporated or modified based on multiple sources, a revision and validation of all the metrics through a case study is essential.

Therefore, the specific objectives of this test are the following:

- Test the RAF in a regional domain

- Assess the specific applicability of the metrics to the Barcelona Metropolitan Area, with a focus on natural areas
- Evaluate the availability of data to answer these metrics and the challenges in obtaining it
- Contrast the relevance of the questions when applied to natural areas
- Refine metrics to ensure their usefulness and coherence within a resilience assessment
- Identify the adequate stakeholders who can provide essential information for some aspects of the resilience assessment

Table 2. Test A summary.

Test A summary			
Tested tool	ICARIA RAF (Holistic Resilience Assessment Framework)	**Test responsible**	AQUA, AMB, LNEC
Developer of the tool	LNEC	**CS of the test**	AMB

4.1.2 Activities of Test A

The metropolitan area of Barcelona is composed of a dense network of natural spaces, including nature parks, river areas, beaches and agricultural zones, as well as over 300 hectares of urban parks distributed across the municipalities.

In total, natural spaces constitute 52% of the Metropolitan Area, providing significant environmental and social value, and offering valuable benefits to all citizens.

The two main open spaces in the area are Collserola and the Llobregat Delta. Collserola, a forest park system designated as a nature reserve, covers approximately 8,000 hectares and serves as a vital source of biodiversity and recreational activities. Conversely, the Llobregat River acts as a natural link: connecting the northeast to the Collserola Natural Park, the west to the Ordal range, and the south to the natural areas of the Delta. The agrarian park in the region, spanning 3,350 hectares, boasts high agricultural productivity.

Additionally, the Metropolitan Area features highly touristic coastlines that withstand the pressure of over 8 million visitors annually. The Besòs River area, characterized by its extensive forests, functions as the main metropolitan park and provides a space for industrial growth. In Figure 3, all these green areas of the region are shown (AMB, 2014).

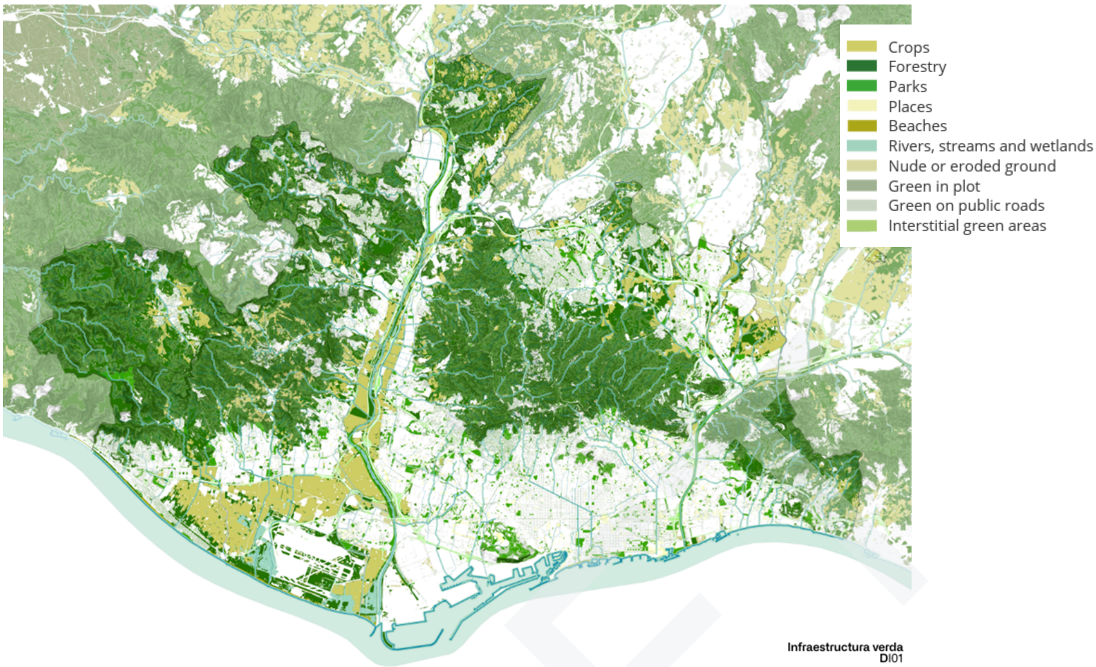


Figure 3. Metropolitan green infrastructure (AMB, 2024)

In Test A, metrics from the Functional and Physical dimensions, as well as a few metrics from the Spatial dimension, have been applied to natural areas. These metrics assess natural areas as strategic services within the region (functional dimension) and the infrastructure supporting these services (physical dimension), in addition to evaluating urban space and environment (spatial dimension). Figure 4 reflects the classification of metrics from the assessed dimensions. To revise the RAF, the questions were classified based on three criteria: a) Relevance, categorized into essential, complementary and comprehensive levels; b) Data availability, considering the difficulty of obtaining data for each question and assessing the feasibility within the project's development; and c) Applicability within the context of the area.

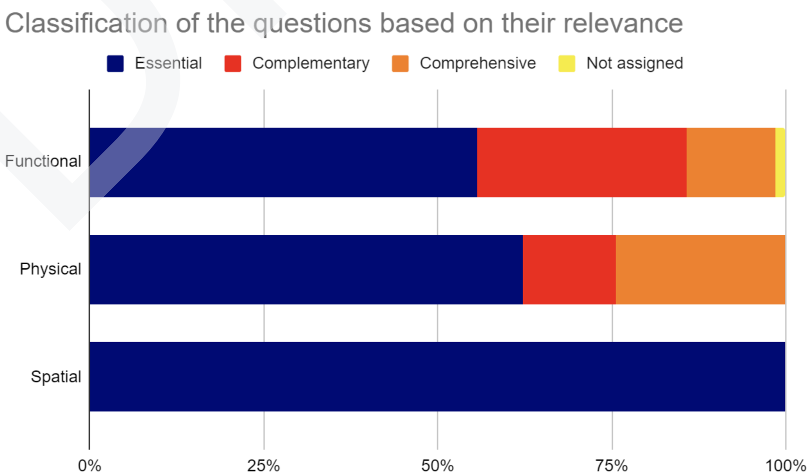


Figure 4. Classification of RAF metrics relevance for the resilience assessment of natural areas.

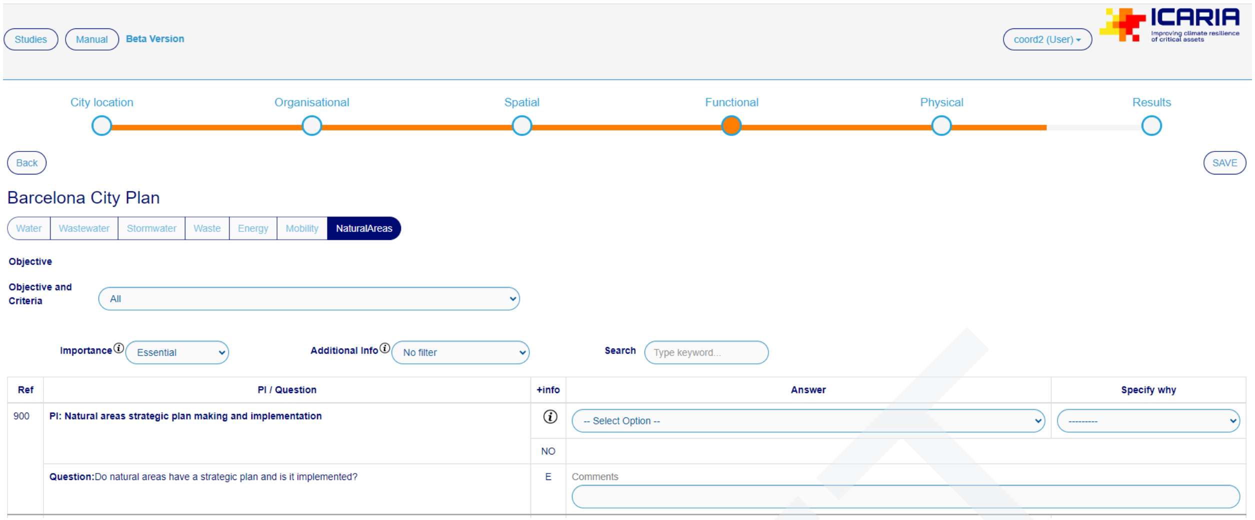


Figure 5. Screenshot of Functional dimension metrics of the ICARIA RAF tool.

Relevance of the questions:

- Initially, each question was classified by the app development team based on its relevance as Essential, Complementary or Comprehensive according to the criteria of the RAF developers.
- During Test A, AMB and AQUATEC re-evaluated the relevance of each question based on their expert criteria and knowledge of the CS. This exercise served to reduce the number of essential metrics, thus making the resilience assessment procedure more concise and accurate by giving more weight to the questions that are actually essential.

Data Availability:

Different levels of data availability have been pre-defined for the region to answer:

- Data Available: The data is accessible or will certainly be available during the project's lifespan.
- Data May Be Available (Not Sure): The data is likely available, but consultation with other departments or stakeholders is necessary to confirm this.
- Data May Not Be Available (Not Sure): The data is probably sensitive or unlikely to be available, but other organizations or stakeholders in the region could be consulted.
- Data Available but Difficult to Obtain: The data, plans, or information exists but will be very difficult to access during the project's lifetime, likely due to sensitivity, the need for coordination with multiple departments, or restrictions.
- No Accessible Data: The data exists but is not reachable and cannot be used for the project's purposes.
- No Data: The data does not exist and the relevant study has not been conducted in the region.

- No Idea: The availability of the data is unknown at this point and requires further investigation to determine if it exists and can be accessed.

Applicability:

The answers regarding the applicability of the questions in the AMB region were classified into four levels (Highly, Moderately, Slightly and Not Applicable) based on the region's unique characteristics. These include factors such as the complexity of authorities involved, coordination between entities, availability of natural services and size, among others.

The analysis was carried out by AQUATEC and AMB, with the identification of several additional offices within the region and external stakeholders to assist with the assessment. This collaboration is necessary because the region relies on various departments and municipalities for the management of the diverse natural areas. The offices that were contacted include:

- Climate change and environmental awareness department of the AMB
- Green infrastructure department of the AMB
- Parc Natural de Collserola (public institution managing a protected mountain area on 83 km^2)
- Consorci Parc agrari del Baix Llobregat (entity managing a 90 km^2 area of agricultural land)

Identifying these departments and other relevant stakeholders within the region is crucial to ensure the data validation process and to provide their expertise and experience in these topics. Moreover, it is essential to adopt a collaborative approach and increase regional coordination.

4.1.3 Results of Test A

The assessment encountered difficulties due to the large nature of the domain, which comprises several natural areas, including the Collserola natural park, municipal parks across the 36 municipalities, beaches, the agricultural park of Llobregat River and additional green infrastructure like green roofs. Each of these natural areas falls under the jurisdiction of different authorities at various scales, ranging from provincial to metropolitan or even municipal levels. This fragmentation in management presents challenges in coordination and data access. Most doubts and issues encountered in the validation process were related to this reality, as it is difficult to coordinate with the different areas that manage each natural service. In addition, some of the large green spaces are managed by consortiums involving different entities.

Importantly, the intrinsic differences between the spaces considered as natural areas make it complex to assess all of them at once. For instance, in this test the Natural Park of Collserola and the beaches in the AMB shoreline have been considered. However, these two spaces face very different climate risks, as wildfires and drought can have clerical impacts on forests while sea level rise and storm surges affect the integrity of coasts and sandy beaches. As a consequence, resilience assessments and adaptation plans for these two areas need to be case-specific.

To address such complexities, it is recommended to follow two considerations in future assessments.

1. Focussing the resilience study in a subset of natural areas with common characteristics that face similar threats.

2. Prior to initiating the assessment, all the main stakeholders involved in the natural area of interest should be identified and involved in the resilience assessment process as they will have the best knowledge on the specific cases.

This approach offers some benefits, including simplifying the assessment process by reducing complexity and allowing engagement with stakeholders linked with these specific natural areas under study.

The activity in Test A has allowed assessing the availability of information to answer the different metrics focused on natural hazards, specifically, the ones belonging to the Spatial, Physical and Functional metrics. Figure 6 shows that, out of the 114 metrics evaluated, 71 (57%) are classified as Available or May be available meaning that information is already editing and public or that it will be generated within the project. However, an important part of the Functional metrics (23 out of 70) are either difficult to obtain or it is uncertain whether they could be answered adequately, limiting the conclusions that could be reached with a full implementation of the RAF to these risk receptors.

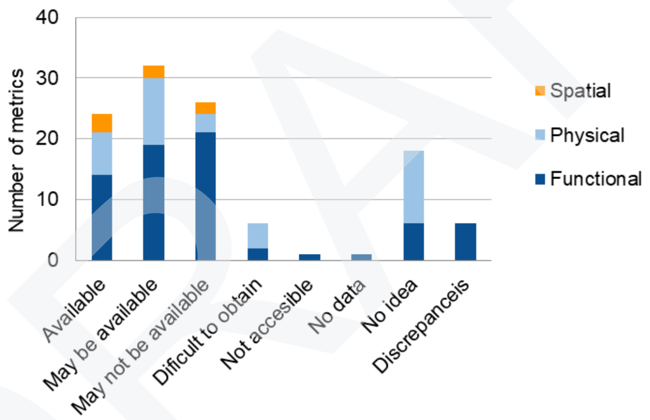
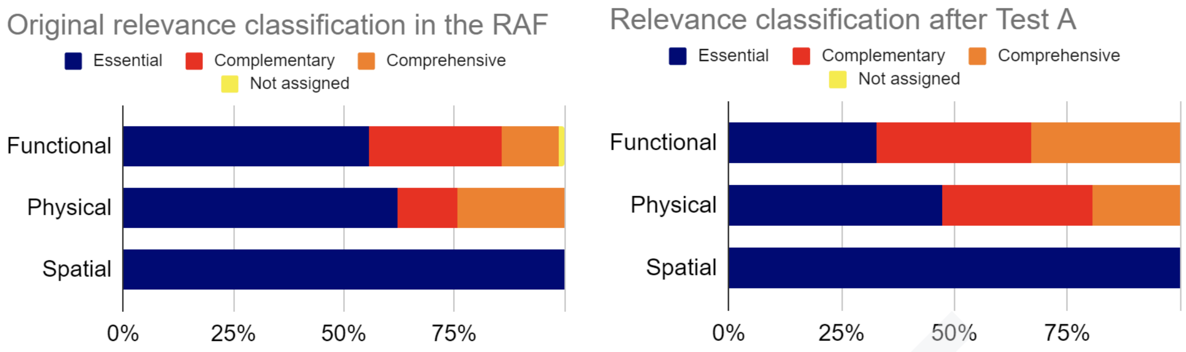


Figure 6. Classification of natural areas resilience assessment metrics based on expected data. availability.

As for the relevance of the proposed metrics, the assessment done in this test shows that a large number has not been considered as essential (in the Functional and Physical dimensions) in contrast to the original classification. Importantly, these changes have been essentially based on an individual assessment of the information that can be extracted from each metric. The difficulty to obtain the information required to answer metrics has not been considered at all as a carrier for this reclassification, as hard-to-answer questions can provide key insight in assessing regional resilience.



(a) (b)

Figure 7. Classification of the relevance of metric for assessing the resilience of natural areas as it is defined (a) in the original RAF and (b) after Test A.

4.2 Test B: Global assessment of Heat Wave Impacts and Resilience

4.2.1 Summary and objectives of Test B

The Metropolitan Area of Barcelona is coping with the increasing frequency and intensity of urban heat waves, exacerbated by the urban heat island effect. These heat waves have significant impacts on health, energy consumption and water usage.

In Barcelona, a heat wave is defined as a period where maximum temperatures exceed 33.1ºC for three or more consecutive days. In 2023, one of the most intense and prolonged heat waves in Catalonia's history (and specifically in the AMB) was recorded, with the highest daily minimum temperatures ever measured (29.5ºC) and the second highest maximum (38.5ºC) ever in the AMB (Generalitat de Catalunya, 2023). These extreme heat events are expected to become more frequent in the future (Lorenzo et al., 2021). Furthermore, the percentage of the vulnerable population is projected to increase in the coming years due to aging, increased migration, and the rise of single-person households (Ajuntament de Barcelona, 2018).

To address these challenges, it is crucial to prepare the region to cope with high temperatures by enhancing services, facilities and response times during extreme heat events, with a special focus on the most vulnerable inhabitants.

Therefore, the objective of the test is to revise the ICARIA RAF metrics to assess the regional resilience to heatwaves in order to validate the applicability in AMB and be able to identify strengths and weaknesses in the domain's response. Additionally, it can serve as an exercise to evaluate the availability of the data to eventually carry out a regional resilience assessment. Importantly, this tool has been conceived to allow a structured resilience assessment with a regional scope.

Although several resilience assessment studies have been carried out in the last years in the AMB,, there are notable differences among the various municipalities. For example, the city of Barcelona has developed numerous publicly available plans that could be utilized for implementing the Resilience Assessment Framework (RAF) (Gonzalez et al., 2020). In contrast, other municipalities may lack such comprehensive strategies. One of the objectives of the test will be assessing the feasibility of applying the RAF to regional domains with such internal differences.

Finally, as in test A, test B it will evaluate the relevance of the questions and the stakeholders or departments that can be helpful in evaluating the region's resilience.

Table 3. Test B summary.

Test B summary			
Tested tool	ICARIA RAF	**Test responsible**	AQUA, AMB, LNEC
Developer of the tool	LNEC	**CS of the test**	AMB

4.2.2 Activities of Test B

As mentioned in the previous section, the ICARIA RAF structures its metrics based on the dimension of resilience that they assess. In total there are four categories: organizational, considering governance relationships; spatial, covering urban space and environment; functional, focused on strategic services in the city (water, wastewater, stormwater, waste, energy and mobility); and physical, centered on infrastructure of these services.

In Test B, the organizational and spatial dimensions were selected to evaluate the region's resilience to heat waves. The spatial dimension focuses on urban space and the environment, whereas the organizational dimension focuses on city governance, testing in these dimensions both strategic and tactical metrics.

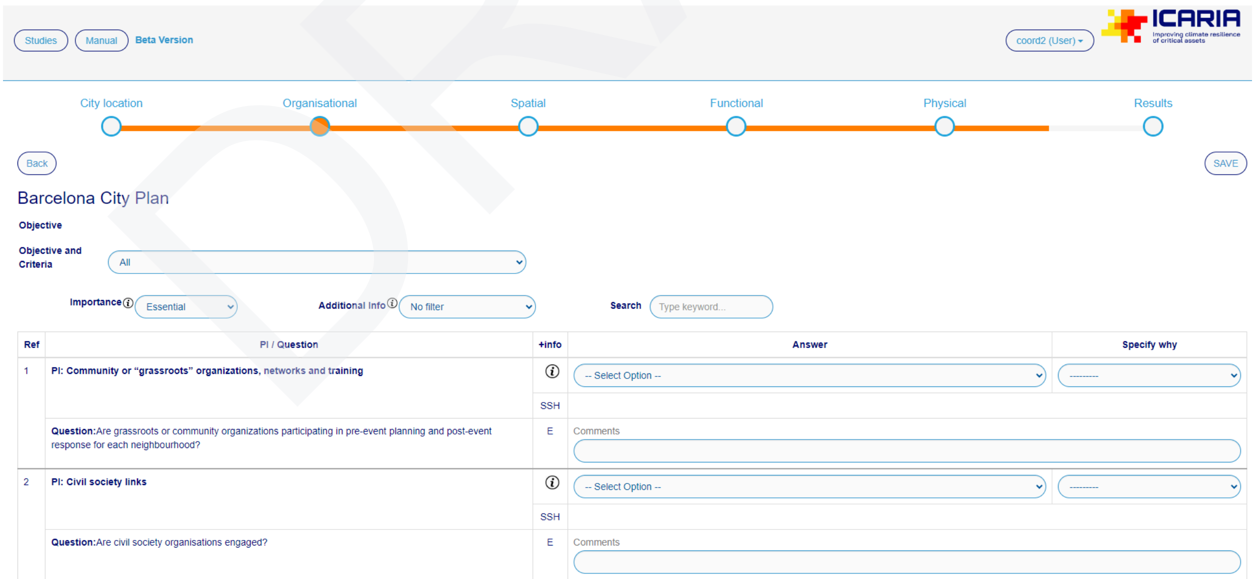


Figure 8. Screenshot of Organizational dimension metrics of the ICARIA RAF tool.

From the 113 metrics reviewed, 77 correspond to the functional dimension and 36 to the physical dimension. Such metrics are further classified into “strategic” and “tactical” sub groups as follows:

- Functional dimension: 41 strategic and 36 tactical metrics.
- Physical dimension: 12 strategic and 24 tactical metrics.

AMB and AQUA participated in the review of all questions to ensure they are meaningful, feasible and to identify potential stakeholders who could provide answers.

Three aspects of the questions were evaluated:

Question Relevance

Initially classified by LNEC during the development of the app, AQUA and AMB redefined the importance of the questions, tailoring them to the context of the Barcelona Metropolitan Area and a heatwave assessment.

Data availability

The classification of questions according to data availability has been maintained as in Test A. The dimensions are as follows:

- Data Available
- Data May Be Available (Not Sure)
- Data May Not Be Available (Not Sure)
- Data Available but Difficult to Obtain
- No Accessible Data
- No Data
- No Idea

The first two dimensions (Data Available and Data May Be Available) indicate that the data requested by the app to complete the Resilience Assessment may be accessible during the project's lifespan, though there is some uncertainty with the latter. The next four dimensions suggest that the data is likely not available. Finally, the last dimension indicates the need to reach out to third parties and other participants within AMB related to the area of research.

Applicability

The questions were classified according to four levels of applicability ("Highly Applicable," "Moderately Applicable," "Slightly Applicable," "Not Applicable"; see Test A) concerning the assessment of heatwaves in the metropolitan area.

4.2.3 Results of Test B

After an initial assessment of data availability, the results are presented in Figure 9. Most tactical metrics within the functional category indicate that data will or may be available. Similarly, within the physical category, tactical metrics also show a higher percentage of availability compared to strategic metrics. Conversely, there are significant uncertainties regarding data availability for strategic within functional dimension.

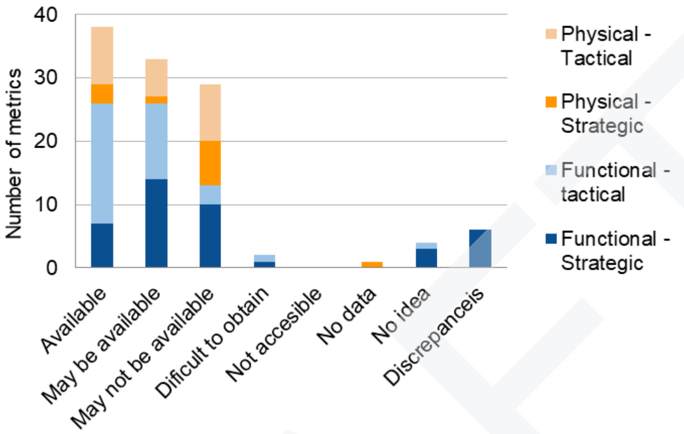
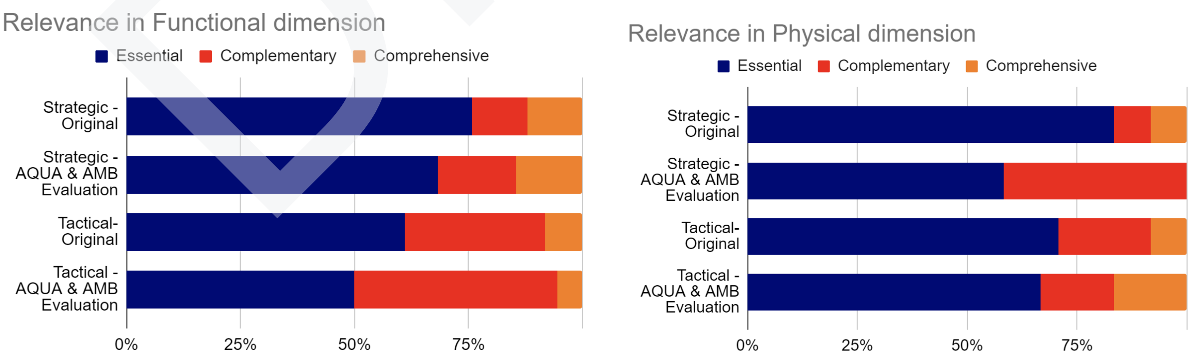


Figure 9. Classification of heat wave resilience assessment metrics based on expected data availability.

Six questions were answered quite differently by AQUA and AMB regarding data availability. These were marked as 'discrepancies' (see Figure 9). Some of them concern the coordination on resilience topics with other organizational and administrative offices within AMB, as well as the mechanisms that govern this coordination. These discrepancies in the answers may be due to the nature of the case study, which involves a group of municipalities, each one having its own independent governing offices and departments. Therefore, to answer these questions and determine if data will be available, stakeholders belonging to these groups should be contacted.



(a) (b)

Figure 10. Classification of heat wave resilience assessment methods based on relevance of (a) Functional and (b) Physical dimensions.

The Figure 10 illustrates the re-evaluation of the question's relevance, showing changes in their categorization by relevance: Essential, Comprehensive and Complementary.

The number of essential questions has decreased, with several being reclassified as complementary. The complementary category has expanded, absorbing questions from both the essential and comprehensive categories. Finally, the comprehensive category has lost some questions to the complementary group in some dimensions, but it has also gained others from the same category.

Finally, most of the questions of test B have been classified as "Applicable" or "Moderately applicable" for the region.

In general terms, the metrics prospered in the RAF are adequate to assess regional resilience to heat waves. However, Test A has served to highlight the reality that a large number of governing entities and stakeholders are involved in policy making and implementation of adaptation measures. Consequently, there is an important heterogeneity in terms of availability and dispersion of relevant data. Hence, it is recommended to users of this tool to consider the need for a multidisciplinary working group, involving stakeholders representing policy-making, asset operators, social entities, urban planners etc., to develop a thorough implementation of the ICARIA RAF in a region.

4.3 Test C: Impacts of forest fires and related compound events

4.3.1 Summary and objectives of Test C

Rhodes island has been historically affected by forest fires, with the most destructive ones presented in Table 5. These events are associated with extensive damages on the critical assets of the island, as well as to the local population, livestock, wildlife and natural areas.

The high coverage of the island with forests and the climatic conditions favor the evolution and progression of forest fires. As shown in the historical data, major forest fires lasted longer than 4 days, with the burned area exceeding 7.000 acres. The extent of burned areas shows that a great percentage of critical assets in the area are affected and damaged by these events. In the vulnerability assessment framework, developed for forest fire hazards, we focus on the critical assets located in the most affected areas.

Table 4. Test C summary.

Test C summary			
Tested tool	Critical assets vulnerability analysis methodology	**Test responsible**	DMKTS, SAR
Developer of the tool	DMKTS	**CS of the test**	SAR

Table 5. Forest fire historical events.

Historical forest fire events	
09/08/1987	1. Duration: 4 days 2. Total burned area: 12.865 acres 3. Damages: a. 47 agricultural facilities b. 935 animals c. 33 agricultural equipment
24/09/1992	1. Duration: 9 days 2. Total burned area: 7.200 acres 3. Human casualties: 1 4. Damages: a. 1 House b. 5 agricultural facilities c. 400 animals d. 4 agricultural equipment
17/07/2023	1. Duration: 10 days 2. Total burned area: 17.630 acres 3. Damages: a. 45 houses b. 2.500 animals

4.3.2 Activities of Test C

The objectives of Test C are the implementation of a vulnerability analysis framework of critical assets affected by forest fires and compound events. This methodology is based on the spatial analysis of critical assets (road network, power grip, buildings, natural reserves, etc.) with respect to historical fire distribution data.

The assessment framework, shown in Figure 12, follows a multilayer analysis approach of geospatial data:

1. **Layer 1** - Geospatial data of CI:
    a. Road network
    b. Power grid
    c. Natural areas
    d. Buildings
    e. Water distribution network
    f. Healthcare infrastructure
2. **Layer 2** - Burned areas due to forest fire, based on historical fire events (3 in total).
3. **Layer 3** - Analysis of data layers 1 and 2:
    a. Critical assets overlapping spatially with the burned area are considered: **Vulnerable**

   b. Critical assets not overlapping spatially with the burned area considered: **Not vulnerable**
   c. The vulnerability score is calculated, based on the times each infrastructure asset was affected (0: not affected, 1: affected once, 2: affected two times, 3: affected 3 times).
4. **Layer 4** - Geospatial analyzed data of vulnerable CI:
   a. Vulnerable road network
   b. Vulnerable power grid
   c. Vulnerable natural areas
   d. Vulnerable buildings
   e. Vulnerable water distribution network
   f. Vulnerable healthcare infrastructure

The results of this framework show the percentage of each critical asset that is vulnerable to forest fires. This approach can be further expanded with the combination of reparations costs for each CI, in order to estimate the economic impact caused on CI. In the current state of the project and with the existing data gaps in such datasets, this additional step cannot be performed accurately. To overcome this barrier, economical data that is indirectly related to the reparation costs of the CI will be used to calculate the economic impact of forest fires on the CI.

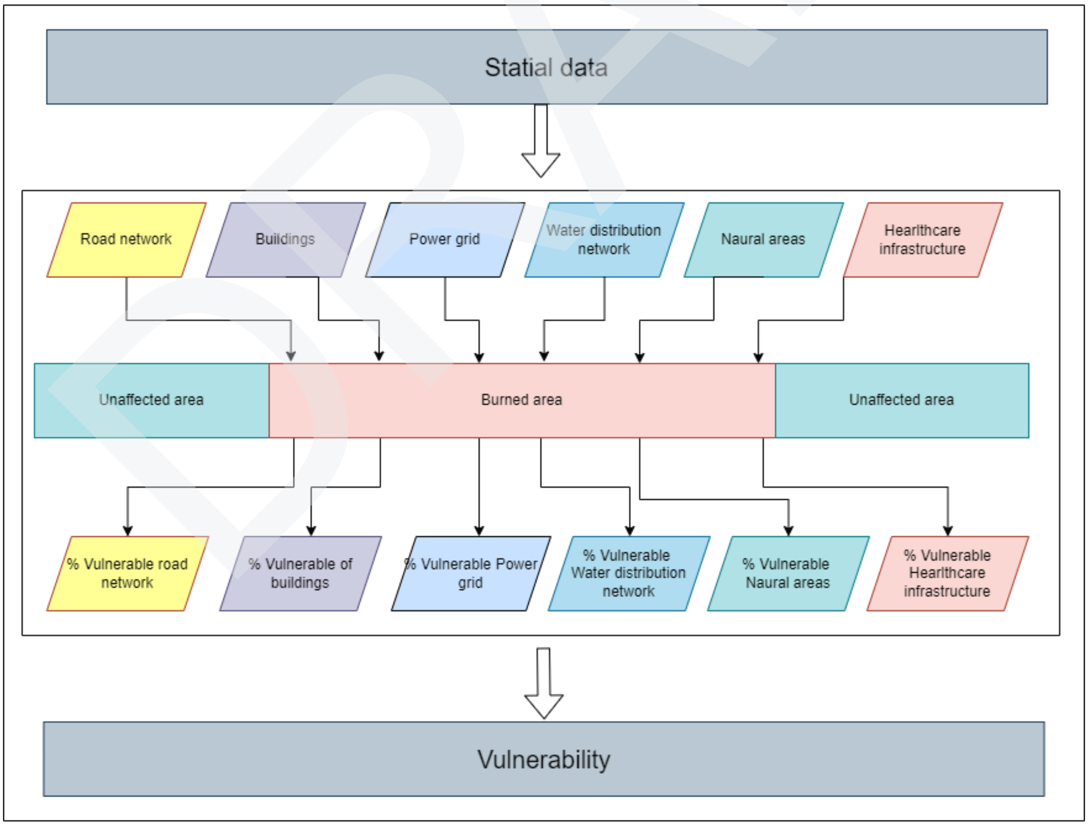


Figure 11. Vulnerability analysis methodology.

4.3.3 Results of Test C

Following the vulnerability assessment framework, presented above, the initial results are presented in Figure 12 and Figure 13. According to the results from the geospatial analysis of the critical assets' data, the most vulnerable assets are the Green areas, mostly the forested areas of the island. These areas are located in the most sparsely populated areas of the island (southern Rhodes), which is unaffected by urbanization. Thus, the most vulnerable asset in this region are the green areas, with a small number of buildings to be vulnerable to forest fires in the region. Regarding the road network and power grid, they were significantly affected in the past and thus are also vulnerable to forest fires. Although a small percentage of critical assets are vulnerable to forest fires, as Figure 13 shows, the unique characteristic of the island is the network of high voltage power lines connecting the two main power plants of the islands and distributing laterally all the villages with electricity. Although only a small percent of the network was exposed to forest fire in the event of 2023, based on the proposed analytical framework, only a small part of it was actually damaged (1.2 km of cables, 110 pillars, and 3 substations). However, even with these limited damages the island of Rhodes suffered from power shortages, with nearly 50% of the island to be out of electricity for the first 24 hours, as it was reported in the case of the 2023 fire event. It is also important to note that the burned area is located upstream of the major torrents of the island of Rhodes and the coastal areas that are characterized as high flood risk areas. These areas were not affected by any flood events, due to mild winter precipitation, which given the extent of the burned areas and geomorphology could have had catastrophic effects on critical assets in the area, following the 2023 event.

The proposed vulnerability assessment framework proved to be a valuable tool for the vulnerability assessment of the CI of the island. The effectiveness of this framework is directly linked to the geospatial data availability, both for the burned areas and CI. This framework proved to be easy to use, but it can be improved with a more detailed classification of the CI. This observation is notable in the case of electricity network vulnerability assessment, where although a small network was damaged, the actual area affected by power shortages was greater than the burned and surrounding areas.

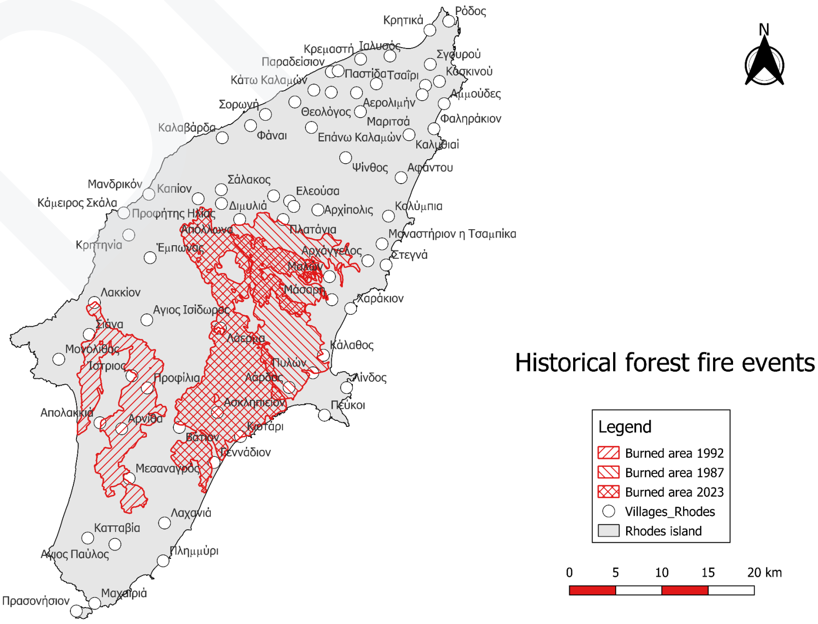


Figure 12. Summary of historical forest fire events spatial distribution.

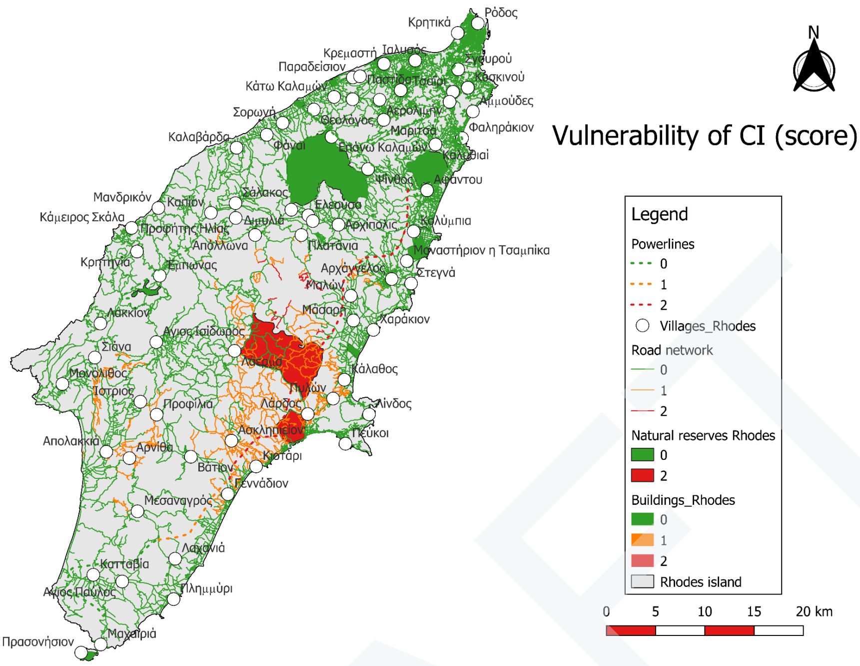


Figure 13. Summary of critical assets vulnerability assessment results.

4.4 Test D: First application of ICARIA resilience assessment tool (RAT) on specific critical assets of islands

4.4.1 Summary and objectives of Test D

The Resilience Assessment Tool (RAT) assesses critical assets resilience to climate change, at asset level, network level and network of networks level. In summary, the resilience framework has multidimensional components, incorporating risks and capacities with the focus on critical assets and climate hazards.

RAT is a resilience capacity driven diagnosis. It is supported on the compliance of the following resilience capacities: anticipation, absorption, coping, restoration, and adaptation. For each resilience capacity, a set of points of view are identified, which unfold into specific ones. The answers are a pre-set list. Within Resilience Assessment Tool, the following *infrastructure capacities* are considered:

- **Anticipatory capacity**: is the ability of a system to anticipate and reduce the impact of climate variability and extremes through preparedness and planning.
- **Absorptive capacity**: is the ability of a system to buffer, bear and endure the impacts of climate extremes in the short term and avoid collapse.
- **Coping capacity**: is the ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters.

- **Restorative capacity**: is the ability of a system to be repaired easily and efficiently.
- **Adaptive capacity**: is the combination of assets, skills, technologies, and confidence to make changes and adapt effectively to the challenges posed by long term trends, such as future climate change.

It is clear from the bibliography review that diverse existing frameworks have been developed with different purposes, focusing on different themes, with distinct structures and formulations. The UN-Habitat guide to the City Resilience Profiling Tool (CRPT) was used as the basis for the RESCCUE RAF, and the European Directive on Critical Infrastructure Protection (2008/114/EC) was used as the basis for EU-CIRCLE RAT. The selection of these tools as a basis for ICARIA purposes was assumed in the project proposal and has the advantage of being widely available to regional, city and services managers. Given the gaps identified in the above frameworks, the efforts to develop the ICARIA resilience methods focused on the inclusion of natural areas and forest fires. Each method required specific development, e.g. for the RESCCUE RAF to include forest fires or the EU-Circle RAT to include compound hazards. Overall, each existing metric was re-examined with a view to broadening its application where deemed relevant. The set of metrics was also reviewed as a group to provide a comprehensive assessment of the global fit with ICARIA's objectives. For example, the social sciences and humanities metrics were fully scrutinized.

In the scope of the D3.6, trial D refers to "First application of ICARIA Resilience assessment tools (RAT) on specific critical assets of islands". The methodology to implement the trials has been defined through selected stakeholders of the South Aegean Region. Two participants of the stakeholder's group from each island (Syros and Rhodes) were requested to test the web-application RAT (DEMOKRITOS, 2024) to their best knowledge. This test has been conducted on a voluntary basis, and each stakeholder represents a specific critical asset in the SAR.

Table 6. Test D summary

Test D summary			
Tested tool	Resilience Assessment tool	**Test responsible**	DMKTS and SAR
Developer of the tool	DMKTS	**CS of the test**	SAR

4.4.2 Activities of Test D

Only a very brief presentation of the web-application RAT has been sent to the participants. They tried to respond to the questions that are presented in section 4.2.4 of Deliverable 3.2 and the final results have been obtained (Brito et al., 2024). The participants conducted the Resilience Assessment using their best knowledge at the time, and of course this process could be replicated using thoroughly collected data and information.

4.4.3 Results of Test D

The main focus of the performed test was to check the functionality of the web-version of the RAT tool and perform an initial assessment of the obtained results. Table 7 introduces the sector and the SAR island of the stakeholders that filled the RAT.

Table 7. Participants in Test D.

Participant ID	Sector	Island
1	Regional Development	**Rhodes**
2	Power Utility	**Syros**
3	Water utility	
4	Civil Protection	

Initial results based on the input from the various participants indicated are presented in the figures below. Participant 1 (Figure 14) filled in RAT focusing on the resilience of Regional Development of Rhodes island. The results show an overall Resilience Index (RI) of 7.0/10, with the lowest score to be Absorption capacity with a score of 4.29/10, followed by an Adaptation capacity of 6.85/10.

The rest of the inputs, until now, were focused on Syros island and more specifically on Power utility, Civil protection and Water utility. The overall resilience index of the electrical network of Syros island is 6.14/10 (Figure 15), with again the Absorption capacity to be the limiting factor. The electrical network scored high in the rest of the categories. The water distribution network of the island shows a relatively high Resilience index 6.68/10 (Figure 17), with again Adoption and Adaptation capacity to be the limiting factor for this CI. Finally, the department of Climate crisis and Civil protection used RAT to calculate the Resilience index of Syros island with respect to flooding (Figure 16). The calculated Resilience Index is 5.7/10.

Overall, the up-to-date results indicate an above average Resilience Index in the South Aegean region. The limiting factor in all sectors tested is the low capacity of adequate physical protection of their assets. On the other hand, all sectors show a high Coping capacity, with the ability to resist and mitigate the consequences of extreme weather events. Moreover, they also show increased capacity to recover from any extreme weather events and natural disasters.

The Resilience Assessment Tool (RAT) proved to be a valuable tool towards the resilience assessment by members of the CoP, at the voluntary testing stage. This tool was reported by the users to be easy to use and with an adequate number of questions to obtain an accurate result, without tiring the users. The only drawback reported was the English terminology, with the test users to propose a Greek translation, to increase participation and awareness, via the RAT usage.

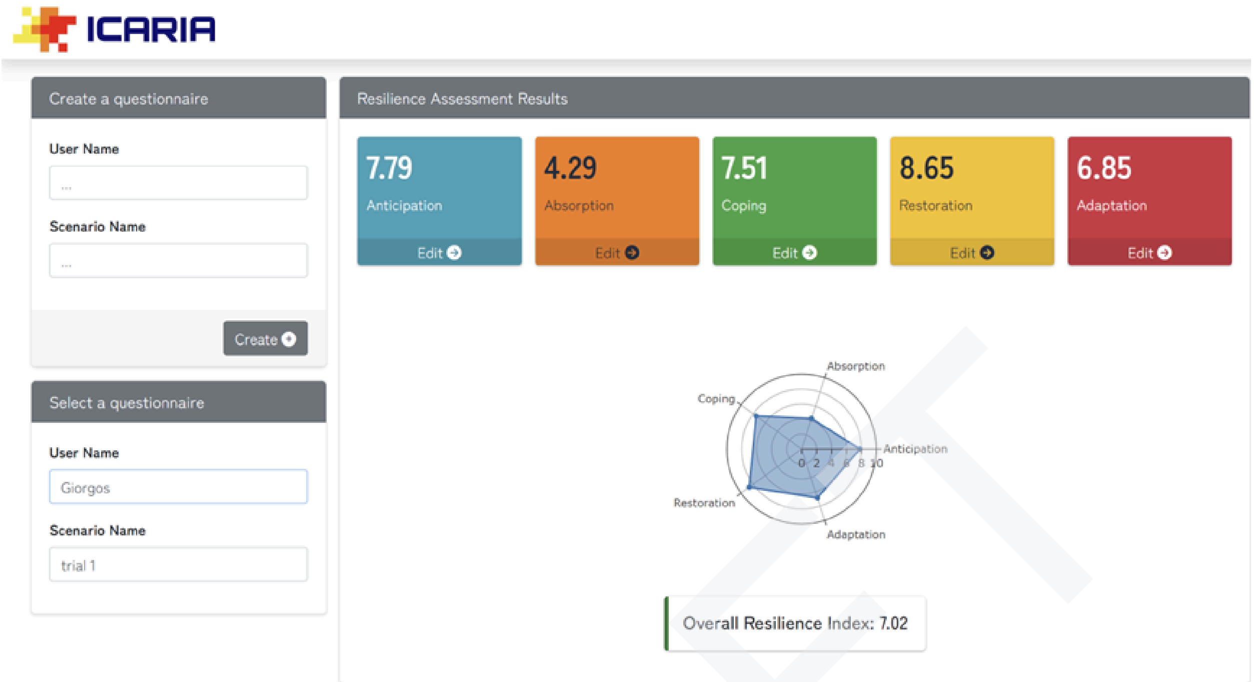


Figure 14. Results of Participant 1 in Test D.

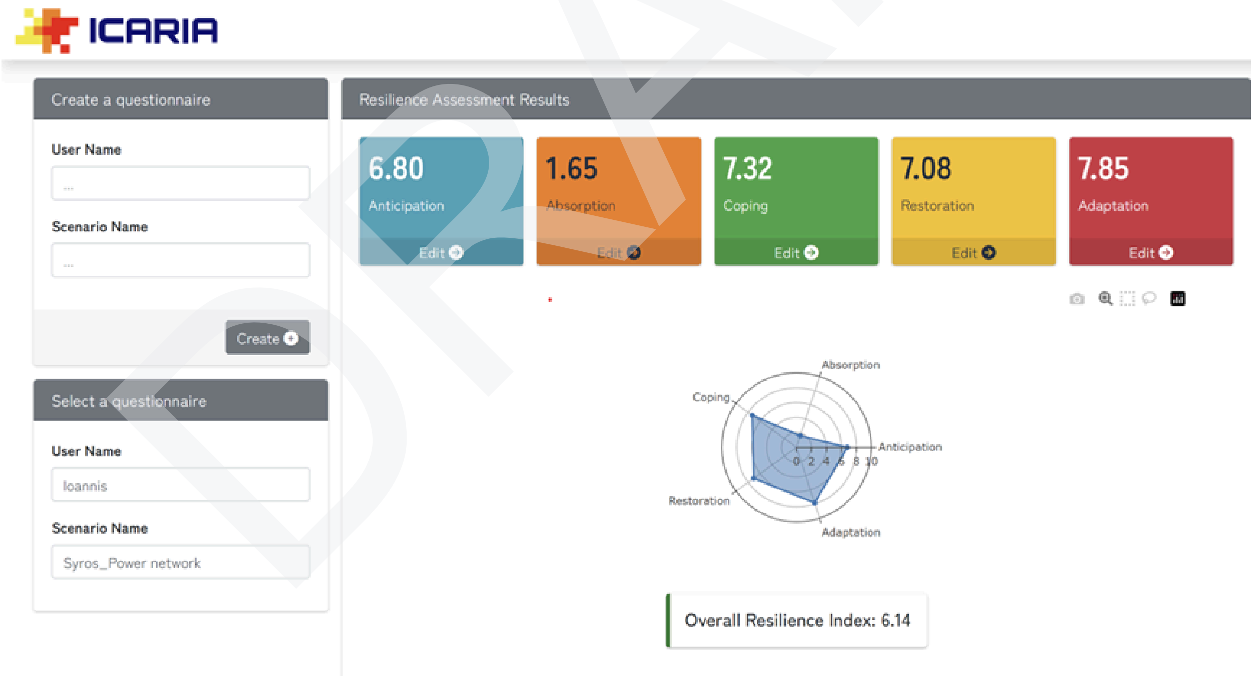


Figure 15. Results of Participant 2 in Test D.

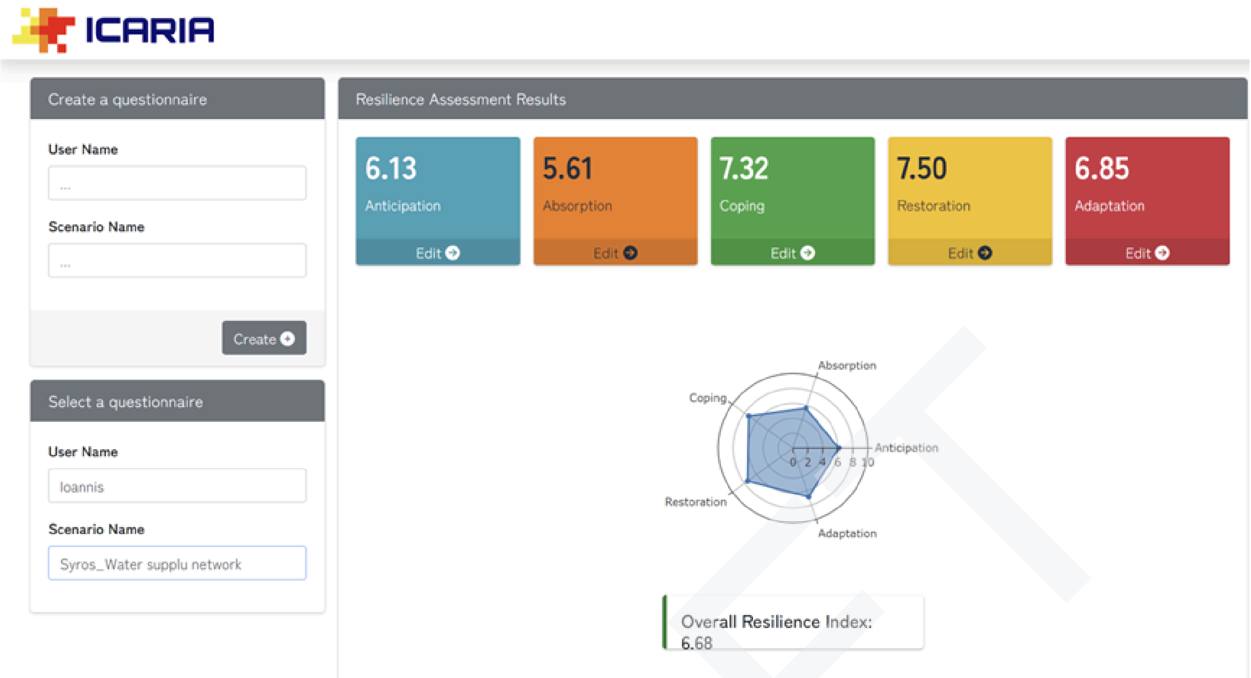


Figure 16. Results of Participant 3 in Test D.

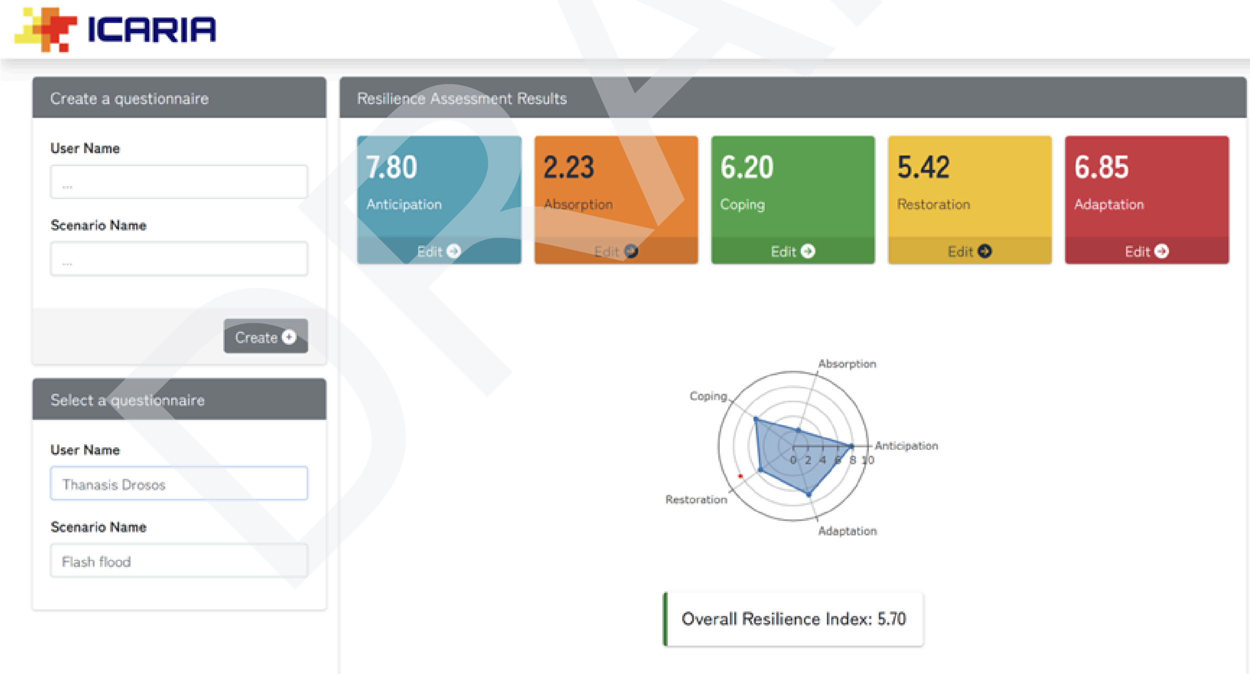


Figure 17. Results of Participant 4 in Test D.

4.5 Test E: Impacts of fluvial flooding on rural/peri-urban areas

4.5.1 Summary and objectives of Test E

This test focused on assessing the impact of flooding within the rural regions of Salzburg. Due to the size of the Salzburg region, one specific area was targeted, which has been heavily affected by flooding over the past 20 years: **Mittersill**.

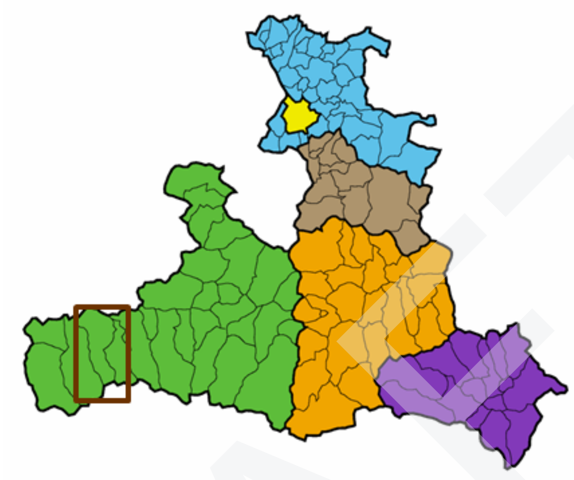


Figure 18. Salzburg region with Mittersill being indicated by a brown rectangle.

With focus on this region, the flooding model HydroMT-SFINCS and the impact assessment model CLIMADA were tested.

Therefore, the HydroMT-SFINCS has been chosen. It is a physics-reduced hydrological model, runned by integrating the HydroMT framework with the Structure Functions In Catchments and Soils (SFINCS) approach, supplying a powerful tool to understand and assess river flood hazards. It has been tested for different use cases and also with respect to compound events (Eilander et al., 2023). The model employs physics-based principles to simulate key hydrological processes such as river discharge, precipitation and spatially-varying infiltration and bed roughness. By reducing computational complexity without sacrificing essential physical principles, HydroMT-SFINCS efficiently captures the interactions between land, water and atmosphere that influence river flooding.

Using state-of-the-art probabilistic modeling, CLIMADA allows to estimate the expected economic damage as a measure of risk today, the incremental increase from economic growth and the further incremental increase due to climate change. Further, an adaptation methodology is implemented to assess the impact of weather and climate with respect to economic damage, including cost/benefit perspectives on specific risk reduction measures. The model is well suited to provide an open and independent view on physical risk, in line with e.g. the TCFD (Task Force for Climate-related Financial Disclosure[1]), and underpins the Economics of Climate Adaptation (ECA) approach.

Table 8. Test E summary.

[1] https://www.fsb-tcfd.org

Test E summary			
Tested tool	SFINCS[2] (Leijnse et al., 2021) CLIMADA[3] (Aznar-Siguan et al., 2019)	**Test responsible**	AIT
Developer of the tool	Deltares ETH Zürich	**CS of the test**	SLZ

4.5.2 Activities of Test E

To evaluate the capability of the planned hazard (SFINCS) and impact model (CLIMADA), SFINCS was applied to Mittersill based on a past event. Therefore, the flooding of 2002, which affected different European countries (e.g. Czech Republic, Germany) and also Austria, was chosen. In 2002, the so-called Vb meteorological conditions (low over northern Italy, causing a steady influx of humid and warm air over Austria) caused unprecedented flooding within Austria. Also Mittersill was affected with the Salzach experiencing a flooding of a 10 year return period.

Therefore, the geographical conditions and river bed geometry was provided. Furthermore, precipitation observations were used as input to SFINCS for computing the flooding map. The observation data was taken from the SPARTACUS data set, an Austrian gridded data set which includes the spatial distribution of observed air temperature (minimum temperature and maximum temperature), precipitation and absolute sunshine duration from day to day since 1961 in kilometer resolution over Austria. The dataset is provided by the Geosphere Austria and can be retrieved from its data hub[4]. The observation data was used instead of climate model output to be able to calibrate the model and to be sure that the correct precipitation rate is applied. Thereby, an overestimation of flood depth relates to calibration issues within SFINCS and not an overestimation of precipitation amount within the input data. However, due to the very steep terrain at a very high resolution (1m), SFINCS displays unrealistically high flood levels. This issue has been reported before and we are currently assessing the impact of coarser resolution to improve the flood depths.

Within CLIMADA, hazard data (e.g. flooding maps) are combined with exposure data (e.g. buildings and their economic value) as well as impact functions to assess the economic damage. Since damage data is not as easily available for Austria, but needed to assess the impact of flooding, open source data was used. Within CLIMADA, flooding is already implemented in a sense that there exist impact curves, as well as references to possible hazard and damage data. The suggested exposure data set is based on Gross domestic product (GDP) data, since monetary damage to regions due to flooding was pre calculated based on means of national Gross domestic product (GDP) converted to total national wealth as a proxy for asset distribution, downscaled by means of data from spatially explicit GDP distribution. Data for past (1971-2010) and future (2005-2100) periods can be accessed at ISIMIP[5].

[2] https://sfincs.readthedocs.io/en/latest/overview.html
[3] https://climada-python.readthedocs.io/en/stable/
[4] https://data.hub.geosphere.at/dataset/spartacus-v2-1d-1km
[5] https://www.isimip.org/

To improve the CLIMADA damage assessment, high resolution GDP data was retrieved and used instead of the default data (see figure below).

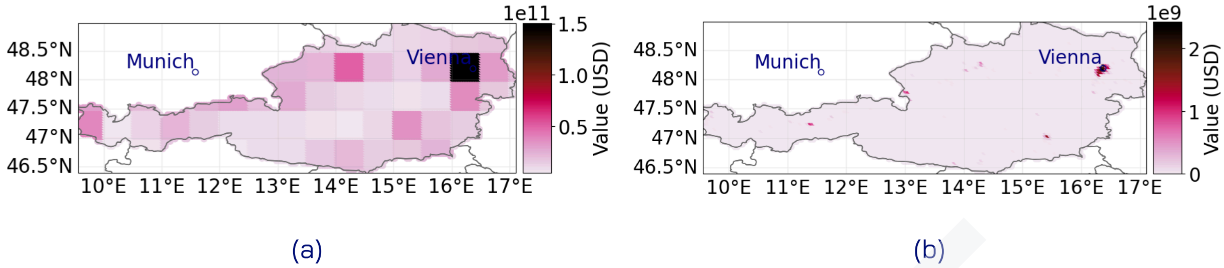
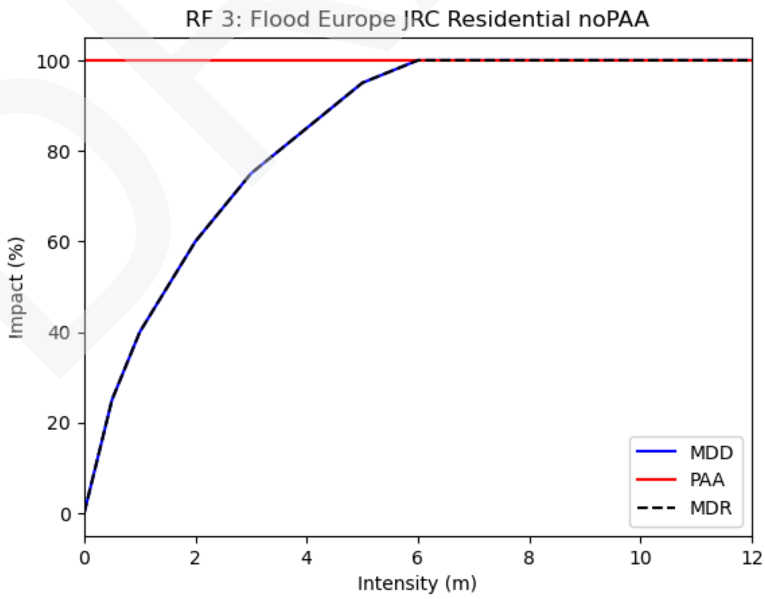


Figure 19. GDP distribution in Austria[6].

Regarding the hazard data, Initially, the flood map provided by SFINCS was expected to be used as input to CLIMADA, however, the flood depths computed within the first test were too high (as explained above), therefore, the ISIMIP flooding data (climate model simulation: clm45_gfdl-esm2m as input to the cama-flood model[7]) was used for the past period (1980-2005). This option remains also for future events, however, if this approach is taken, then the newly derived climate data based on CMIP6 projections and computed during ICARIA (see deliverable D1.2) will not be used. Therefore, using SFINCS and providing updated flooding maps is foreseen, yet, if SFINCS is not feasible to be applied within the steep terrain, ISIMIP data will be used.

4.5.3 Results of Test E

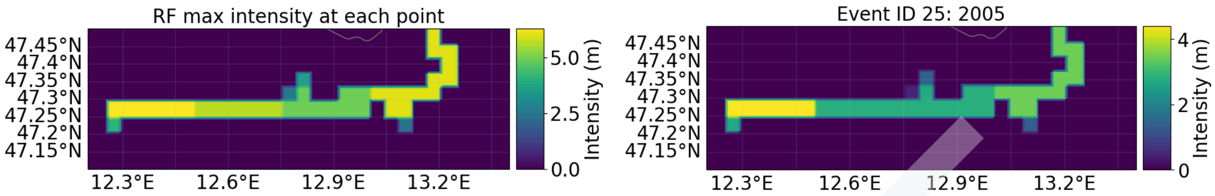
Using the default impact function of CLIMADA which relates flood depths to impact on residential buildings, the flood maps of ISIMIP and GDP data as displayed above, the river flooding max intensities for the period of 1980 - 2005 were derived for Austria.



[6] https://zenodo.org/records/7898409
[7] https://hydro.iis.u-tokyo.ac.jp/~yamadai/cama-flood/

Figure 20. Damage curves for residential buildings in Austria relating depth flood and % of impact; MDD = mean damage, PAA=percentage of affected assets, MDR = mean damage ratio

Regarding the event of 2005, it can be seen that it represented the maximum river flooding intensity for the whole period in the region of Mittersill (12.48E).



(a) (b)

Figure 21. Results of maximum water depth simulated for the time 1980 - 2005 on the left side and the extreme event in June 2005 (right) for the Salzach river which flows through Pinzgau all the way up to Salzburg and caused enormous flooding in Mittersill in 2005. The figure is cut off below the city of Salzburg as the focus is on rural areas and especially Mittersill within the lab test.

Based on the GDP data applied, the expected annual damage for the period 1980-2005 is up to 1 Mio. USD within Pinzgau, and about 0.3-0.5MUSD in Mittersill, with respect to residential buildings.

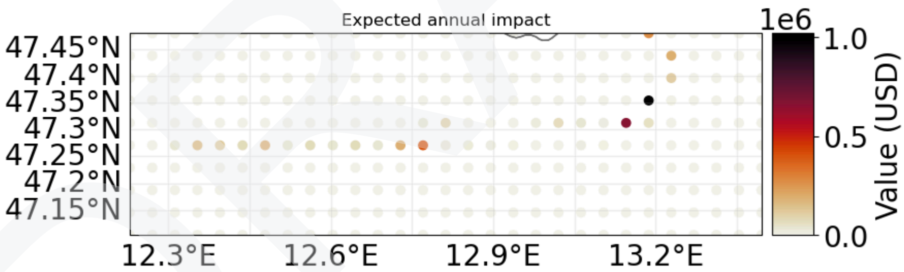


Figure 22. Expected annual damage for the period 1980-2005 in the region of Mittersill.

4.6 Test F: Performance application of the DSS

4.6.1 Summary and objectives of Test F

The ICARIA Decision Support System (DSS) is one of the main technological outcomes of the project. It has been conceptualized as a toolbox of detailed and holistic approaches provided through a user-friendly web-based platform and interface to allow decision-makers to visualize impacts from single and compound hazards and the most cost-effective adaptation scenarios. The platform will enable stakeholders to compare different resilience and risk assessment scenarios in their region and evaluate the adequacy of different adaptation solutions. In parallel, the general public will be allowed to access a simplified view of data and results.

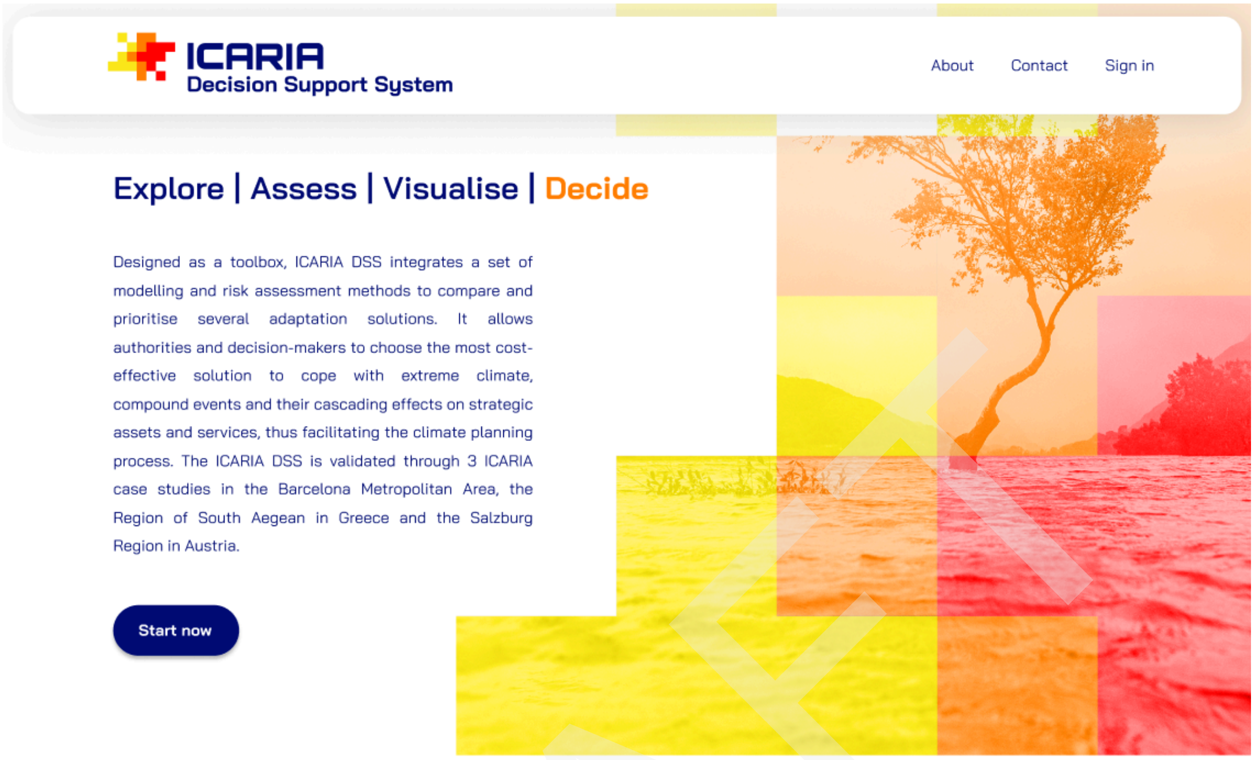


Figure 23. Provisional landing page mockup

The high-level topology of the DSS can be seen in the diagram of Figure 24 where the primary inputs and outputs are depicted. Importantly, the DSS will integrate the rest of the tools from WP3, namely the portfolio of adaptation solutions, the RAT and RAF applications. At the same time it will consider the modeling methodologies resulting from WP2 as well as the climate data from Task 1.2, such as climate projections and weather observations. The risk/impact assessment methods will play a crucial role in the DSS, by allowing the users to quantify tangible or intangible impacts on risk receptors of interest. Additionally, through the DSS users will have access to ICARIA results (mainly spatial data representations) through map viewer, as well as key indicators from the RAF and RAT applications, and Multicriteria (MCA) and Cost Benefit Analysis (CBA) functionalities to compare and prioritize adaptation solutions.

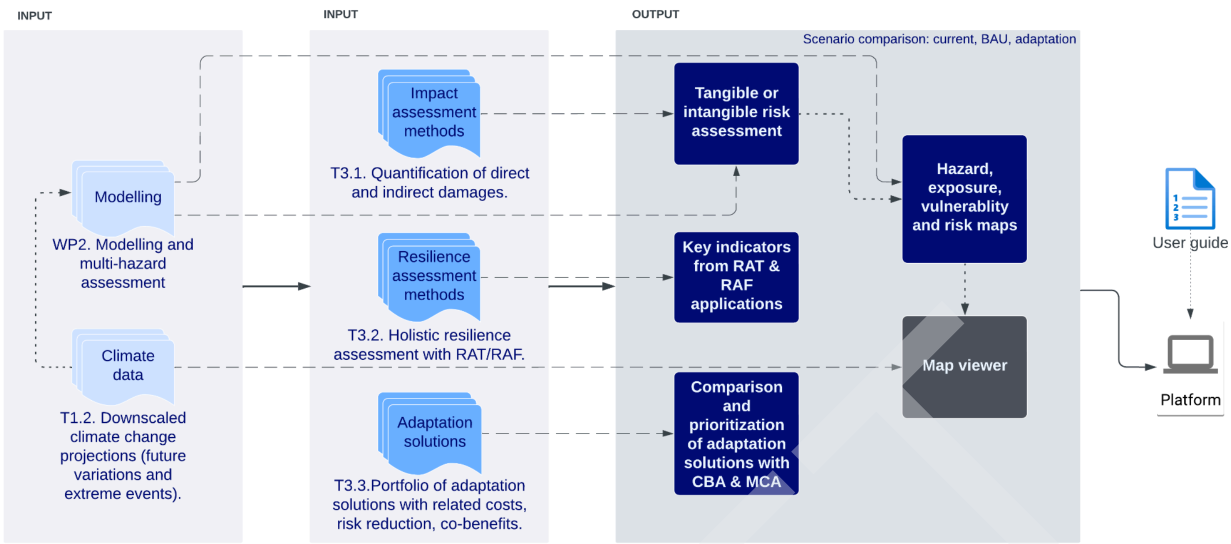


Figure 24. DSS high-level topology.

Table 9. Test F summary

Test F summary			
Tested tool	DSS workflow and concept	**Test responsible**	AQUA, DRAXIS
Developer of the tool	DRAXIS	**CS of the test**	AMB

4.6.2 Activities of Test F

The DSS is due in M30 as a first version and M33 as a final version. In the first 18 months of the project, the work on the DSS included requirements' elicitation and conceptualization, as well as validation of its main components with all three ICARIA case studies. In terms of requirements, high-level user requirements were collected in the form of user stories ("As a *user role*, I want to *do something* so that *I receive some benefit*"). It provided an opportunity for partners to express their expectations or wishes regarding the functionalities of the DSS, together with external stakeholders involved in ICARIA through the Communities of Practice who also participated in this conceptualization process by expressing their needs and interest in relation to the DSS.

The conceptualisation step elucidated the requirements, both those set by the Grant Agreement as well as the one derived from the user stories. The process consisted of a series of meetings, firstly with AMB as a first representative of the ICARIA case studies, where the entire concept of the DSS was clarified using AQUATEC's flooding hazard and impact models as examples. Following that, the resulting workflow was validated against the modeling practices of SAR and SLZ to ensure interoperability across the ICARIA regions and the hazards examined in the project.

4.6.3 Results of Test F

The conceptualization process has resulted in the definition of a workflow that serves as a structure to develop the DSS Tool. As it can be seen in Figure 25, the tool will guide the user through a 5 step process. In each one, a particular aspect of a risk assessment process will be addressed either providing information generated outside the DSS (steps 1 and 2) or defining the desired metrics to assess risk and resilience of the assets of interest (septs 2 and 4). Furthermore, this resource will incorporate the outcomes of the other main tangible results of ICARIA to enrich the DSS capabilities as a support for decision-makers: the portfolio of adaparion solutions (step 3) and the RAF and RAT tools (step 4). Finally, step 5 will allow users to compare adaptation scenarios based on a Cost-Benefit Analysis (CBA) and a Multicriteria Analysis (MCA) whose parameters and criteria of prioritization are defined by the own user. This design enables users to navigate through this 5-step process but also to focus only on individual steps.

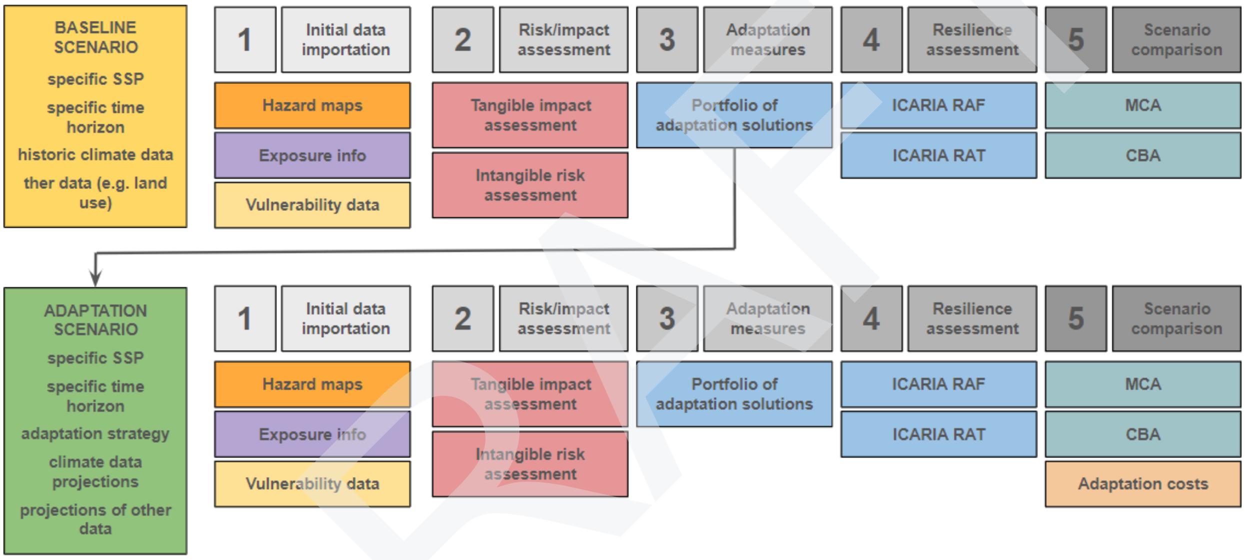


Figure 25. Conceptual design of the ICARIA DSS risk assessment process.

Following the documentation and validation of the DSS workflow with the ICARIA case studies, the DSS can be described by its main components as seen below. It should be noted that since development is due to start in the following months, some aspects might change.

- Landing page
    - User authentication and authorisation
    - Introduction to the DSS
- General pages, such as:
    - About page
    - Account management
    - User feedback and guide
- Project manager
    - Data upload

        - Hazard maps, exposure and vulnerability data
    - Creation and management of projects
    - Building of scenarios with or without adaptation measures
        - The user starts by specifying a hazard and/or a region to get the appropriate requirements for input files
- Map viewer
    - Preloaded (static) project data, such as:
        - Hazard maps, climate projections, weather observations, other spatial representations
    - User data uploaded via the project manager
        - Hazard maps (with or without adaptation)
        - Vulnerability information
        - Exposure information (e.g. location of risk receptors)
    - Essential GIS functionality, such as:
        - Delivery of single or multiple data layers and side-by-side comparison
        - Data legends and other descriptive information
        - Download options for data or other results
        - Temporal range of data presented
- Risk/impact assessment
    - Quantification of risk score, quantification of damage (expected annual damage) or service disruption
        - Resulting from the hazard, exposure and vulnerability data, Figure 25 shows the impact assessment process for the AMB flooding model
- Adaptation measures
    - Integration of measures from ICARIA's portfolio
    - CBA and MCA can be carried out by the user to match them with the most appropriate solution in each case:
        - In CBA, cost is understood as the cost of implementing an adaptation solution while the benefit can indicate the reduced economic loss
        - In MCA, weights are assigned to a list of co-benefits (economic, social and environmental) derived from the ICARIA portfolio of adaptation solutions
- Holistic resilience assessment
    - Integration of RAT and RAF applications to allow the user to receive metrics on the resilience of their region or critical assets..

Currently, the user roles foreseen for the DSS include:

- Administrator: full access and control of the platform and data
- Registered technician user: provision and access to all data including project manager/ upload function
- Registered stakeholder user: access to all data generated by the technician role
- Unregistered visitor: viewing the map viewer, limited data access to project-generated data without registration/login

Unregistered users will only have access to what is deemed appropriate by the project. Access to user-uploaded data from registered users will be managed through user authentication and authorisation.

Upon progress in development, the DSS is slated to be trialed in the ICARIA case studies to allow for feedback, validation and refinement.

5 Conclusions

The work developed in Task 3.5 has aimed at testing the applicability of several developments of WP3, focused on impact and resilience assessment methods, in one of the ICARIA Case Studies. These tests have been centered on innovations implemented in the Holistic RAF (Tests A and B), impact assessment of forest fires on critical assets (Test C), the applicability of the RAT for critical assets (Test D), impact quantification of fluvial flooding in rural and peri-urban areas (Test E), and the performance application of the ICARIA DSS (Test F).

Tests A and B have been focused on evaluating the applicability of certain groups of metrics of the RAF to a resilience assessment of the AMB at a regional level. The first has focussed on resilience assessment of natural areas while the latter on the overall regional resilience to heat waves.

In both cases it has been concluded that the metrics proposed are adequate for the respective assessments. Some modifications have been suggested in terms of relevance, where some essential metrics have been redefined as complementary or comprehensive, indicating that they are less meaningful than originally considered. The assessment of data availability has shown that answering all the metrics to assess resilience of natural areas would require involving a large number of stakeholders. In the context of AMB, very different spaces are grouped under this category of risk receptors (e.g. private forests, a publicly managed natural park, coastal areas and beaches, agricultural areas, urban parks and small scale areas such as green roofs). Therefore, there is a large number of stakeholders involved in the management and climate adaptation of natural areas. A similar situation has been observed in Test B, where big discrepancies in the availability of climate adaptation plans exist among municipalities.

Tests C has demonstrated the application of an impact assessment method for forest fires on the island of Rhodes for historic events. The methodology is based on crossing the mapping of the burned area with the location of the assets of interest allowing to quantify the % of vulnerable CI. Despite affecting a reduced % of roads and the electricity distribution network, the interconnected nature of small islands amplifies its repercussions on the population and dependent services.

The application of the RAT tool to assess resilience of assets has been tested for several CIs in the islands of Rhodes and Syros based on the expert opinion of esper stakeholders. In summary, they conclude that the resilience of critical assets in Rhodes is above average. However, there is a common consensus on the lack of improving the physical dimension of resilience measures to reduce the impacts of forest fires and the resulting cascading effects.

Test E has shown the application of the CLIMADA impact quantification model to assess the economic impact of a major fluvial flood that affected the municipality of Mittersill in 2005 in case of poor detail of damage data distribution. Importantly, this method allows us to estimate economic damage of extreme weather events when no data from insurance companies is available. Hence, it allows impact quantification under data scarcity conditions.

The conceptualization of the DSS is an ongoing process of the project. At a testing level, the initial design of the tool has been adapted to the pluvial flood risk assessment methodology applied by AQUATEC to the AMB CS. Based on this example, a five-step workflow and the main features to be included in the DSS have been defined. The main conclusion of this process is that, despite having a general workflow, the hazard assessment of each extreme weather event presents its own particularities. This reality is even more complex on the risk and impact assessment step, where each hazard-risk receptor relationship requires a specific quantification approach. Therefore, an adapted DSS workflow will have to be developed for each specific case.

Deliverable 3.6 is linked to Milestone 2 of the project and demonstrates its fulfillment in M18 (June 2024). Hence it demonstrated the development of new (respect to consortium background) impact quantification models, holistic resilience assessment methods and tools are ready to be used in the implementation phase of the project (trials) reaching the new required scope (regional scale)

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Annex A: Data Management Statement

Table A.1. Data used in preparation of ICARIA Deliverable 3.6.

Dataset name	Format	Size	Owner and re-use conditions	Potential utility within and outside ICARIA	Unique ID
na	na	na	na	na	na

Table A.2. Data produced in preparation of ICARIA Deliverable 3.6.

Dataset name	Format	Size	Owner and re-use conditions	Potential utility within and outside ICARIA	Unique ID
na	na	na	na	na	na

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