ICARIA
Improving climate resilience of critical assets

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D4.4 Exploitation & Sustainability Plan

Design and initial expectations

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D4.4: Exploitation and Sustainability Plan

Summary

This document is the initial version of the Exploitation and Sustainability Plan. The report outlines the division and organisation of the project tasks, while also assessing the future exploitation of its results and their potential for replication across three different regions.

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List of Acronyms and Abbreviations

€	Euros
AMB	Area Metropolitana de Barcelona
CBA	Cost Benefit Analysis
CoP	Community of Practice
CS	Case Study
CSF	Case Study Facilitators
D	Deliverable
DRR	Disaster Risk Reduction
DSO	Distribution System Operators
DSS	Decision Support System
E&S	Exploitation and Sustainability
ESM	Earth System Model
EU	European Union
GA	Grant Agreement
GDP	Gross Domestic Product
GIS	Geographic Information System
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
KER	Key Exploitable Result
M	Millions
MCA	Multi-Criteria Analysis
NATECH	Natural hazard-triggered technological
N/A	Not Applicable
NDA	Non-Disclosure Agreement
NGO	Non-Governmental Organisation
OER	Other Exploitable Result
PPP	Public Private Partnership
R&I	Research and Innovation
RAF	Resilience Assessment Framework
RAT	Resilience Assessment Tool
RCM	Regional Climate Model
SAR	South Aegean Region
SCADA	Supervisory Control and Data Acquisition
SLZ	Salzburg Region
SSP	Shared Socioeconomic Pathways
TBD	To Be Determined
USP	Unique Selling Point
UVP	Unique Value Point
WMO	World Meteorological Organisation
WP	Work Package

Executive Summary

This deliverable is part of the initial efforts conducted in Task 4.4 of ICARIA of "Improving climate resilience of critical assets" Horizon Europe project (GA No. 101093806), which encompasses the development of the Exploitation & Sustainability plan. The present document (D4.4) articulates strategies and initial exploitation intentions for each project result and establishes clear targets and approaches to maximise impacts and ensure the long-term sustainability and effective utilisation of the project's results beyond its end.

The report outlines the focus on maximising the impact of the project's key exploitable results (KERs), which were initially identified during the Grant Agreement (GA) preparation phase. Based on the input received from the partners, it is indicated that of the final 9 KERs, 3 are commercial—1 is specifically intended for commercial exploitation, while 3 have potential commercial applications. The remaining KERs are focused on non-commercial uses or are intended for scientific purposes. While many of the results are set to be exploited individually by consortium partners, others will benefit from collaborative efforts between up to three partners, fostering targeted cooperation where it adds the most value.

Additionally, three results were excluded from the initial list of Key Exploitable Results (KERs), due to being deemed non-exploitable. Some results have been further divided into sub-results, and 2 new KERs have emerged as significant outcomes with considerable potential for exploitation. Despite the extensive mapping of KERs and sub-KERs, the ultimate goal is to integrate all of them into the final three KERs on the list of KERs namely, the Resilience Assessment Framework (RAF) & Resilience Assessment (RAT) tools, the Portfolio of adaptation solutions, and the Decision Support System (DSS). This strategy aims to ensure that all components will work together to support and enhance these three primary KERs, providing a cohesive approach to maximising the project's long-term impact and utility.

The report further presents the results of the ICARIA project, including both KERs and Other Exploitable Results (OERs), which represent the sub-results. Each KER is detailed with the problem it addresses, current alternative solutions, the proposed solution, the target audience, and its unique value proposition. Additionally, the type of exploitation for each result is specified. It also includes details on Intellectual Property (IP) intentions, such as Background IP, Foreground IP, and considerations for IP beyond the project.

Subsequently, the report details ICARIA's exploitation strategies, outlining the overall approach and categorising the plan into three primary types: commercial (such as developing, creating, manufacturing and marketing a product, tool, method, or process, creating and providing a service), non-commercial (such as recommendations for policymaking, policy advice, educational purposes, improving public knowledge etc.), and scientific (such as further research, scientific publications etc.). In alignment with these, it maps the identified exploitable results into these categories, providing a comprehensive overview of the exploitation pathways and specifying the required actions and intentions of consortium partners. Based on input from the partners, certain KERs will be directed towards commercial exploitation, while the rest will be dedicated towards non-commercial or scientific exploitation. Ultimately, all results will be integrated into the DSS, which will serve as the platform for the commercial exploitation of the project's results.

Additionally, the ICARIA Case Study Facilitators (CSF) have outlined their plans for implementing the project's results in three distinct areas, each facing significant climate challenges: the Region of

South Aegean, the Salzburg Region, and the Barcelona Metropolitan Area. Each of the three Case Studies outlines its objectives, the benefits of its results, potential challenges, required resources, and the potential for replicability.

Overall, this deliverable establishes the foundation for the long-term impact and sustainability of the ICARIA project's results, by systematically outlining the exploitation strategy, categorising key results, and addressing the challenges and opportunities in the post-project landscape. The collaborative efforts among consortium partners, supported by well-defined IP considerations and market analysis, will play a critical role in achieving the intended outcomes. As the project moves forward, this deliverable will serve as a crucial reference point, guiding the consortium in effectively translating ICARIA's innovative solutions into tangible benefits for disaster resilience and climate adaptation across Europe.

1. Introduction

Climate emergency represents the most severe economic, social, and environmental threat to our planet and humanity. Over the past two decades, climate-related disasters have nearly doubled, exacerbating inequalities both within and between countries. Those who contribute the least to global emissions frequently suffer the most severe consequences of this crisis. Climate change is intensifying the frequency and severity of hazards, amplifying the exposure and vulnerability of communities and individuals. At current rates, the world may face a temperature rise of 3 degrees or more, and current mitigation efforts are inadequate to address this urgent challenge (UNDRR, 2022).

The frequency of extreme weather, climate, and water events is rising and is expected to become even more common in the future, leading to more heatwaves, droughts, and wildfires, as recently seen in Europe and North America (WMO, 2021). As exposure to these events grows, so do economic losses. However, there is a message of hope within these stark figures: improved multi-hazard early warning systems have significantly reduced mortality rates (WMO, 2021). Still, much work remains to be done. Greater international cooperation is crucial to addressing the ongoing issue of millions of people being displaced annually by floods, storms, and droughts (WMO, 2021).

While climate change is already affecting people, its impact will persist even with effective global emissions reductions. Floods, droughts, heatwaves, and other climate-related hazards are becoming more severe, prolonged, and frequent, with significant health and economic consequences. While some communities and regions are more vulnerable than others, Europe as a whole is not adequately prepared for the rapidly increasing climate risks. Adapting to climate change is essential to building resilience and minimising disaster risks across the EU (EEA, 2024).

Project ICARIA aims to develop a comprehensive asset-level modelling framework to improve the understanding of complex, compound, and cascading climate impacts, and to formulate effective, sustainable adaptation strategies (Russo et al., 2023). The project focuses on critical assets and infrastructures, such as housing, natural, and land areas, while considering the potential effects of climate change that could lead to unexpected outages and failures (Russo et al., 2023). By implementing state-of-the-art methods, including asset-level coupled models and multi-risk assessment approaches, ICARIA will replicate its framework in three regions across the EU. This will help predict how future climate scenarios could impact the life-cycle costs of these investments over the coming decades and assist risk owners in managing both public and private infrastructures by evaluating the costs and benefits of various adaptation solutions. Two of these regions are located in the South Aegean, where there is a rising occurrence of extreme weather events such as storm surges, pluvial floods, and heatwaves (Russo et al., 2023). The third region is in Austria, where climate-related changes are affecting crucial energy production assets and other significant sectors (Russo et al., 2023).

1.1 Document Scope

This deliverable outlines the exploitation plan, strategy, and activities related to the KERs of the ICARIA project. Its primary objective is to enhance the utilisation of these results beyond the project's conclusion. The strategy encompasses the presentation of the exploitable results, the identification of various exploitation pathways, and the development of routes for commercial, non-commercial, and scientific applications. Ultimately, the plan aims to maximise both the economic and social impact of the project's outcomes, ensuring that all KERs are effectively disseminated and leveraged to their

fullest potential, thus driving innovation and contributing to societal and environmental advancements.

1.2 Document Structure

The rest of the document is organised as follows:
Section 1. Provides an overview of the ICARIA project and defines the structure and scope of this deliverable.
Section 2. Offers an in-depth explanation of the strategies and methodologies related to the explanation of the ICARIA project's results, the management of Intellectual Property Rights (IPR), and the processes used for data collection.
Section 3. Furnishes a thorough examination of the market landscape, including an analysis of the barriers and drivers influencing the project's potential impact and a comprehensive PESTEL analysis. This section aims to assess the external and internal factors that could affect the exploitation of the ICARIA project results, helping to identify opportunities and challenges in the market and guiding strategic decision-making for effective implementation and dissemination of the project's outcomes.
Section 4. Outlines a comprehensive overview of all the results generated by the ICARIA project. This section is structured to distinguish between the main KERs, which represent the most significant results of the project, and their sub-KERs, which represent other exploitable results that offer further value to them. The purpose of this section is to clearly identify and describe each result, its unique value proposition, the problem it addresses as well as its exploitation potential.
Section 5. Provides a comprehensive overview of the strategies and plan for maintaining and continuing the ICARIA project results after its formal conclusion. It covers several key components essential for ensuring the long-term impact and application of the project's results. By detailing how the project results will be sustained, this section highlights the ongoing relevance and adaptability of the ICARIA project across diverse locations.
Section 6. Presents the initial ideas for the strategies that should lead to sustainability of the project's results.
Section 7. Distils the insights derived from the exploitation planning process and sets forth a strategic roadmap for advancing the ICARIA project. It synthesises the key findings and lessons learned, providing a clear path for future actions to ensure the continued relevance and impact of the project's outcomes.
ANNEX. Presents useful terms on exploitation and IPR (**ANNEX A**), as well as the questions from the questionnaire which was distributed to the partners (**ANNEX B**).

1.3 Theoretical background

Exploitation and Sustainability are key factors of a project, as they significantly contribute to achieving the desired impacts over time, especially beyond the project's duration. The pathway to impact starts with generating project results, followed by their dissemination and exploitation. This process helps achieve the expected outcomes of the project's framework and, ultimately, leads to broader scientific, economic, and societal impacts.

Figure 1 - Steps towards the achievement of the expected impacts

Source: European Commission, Webinar: Dissemination & Exploitation

At this stage, it is important to clarify the key terms discussed in this report, including, among others, project results, exploitation, and sustainability.

The term **Result** refers to any tangible or intangible effect of the action, such as data or information, whatever its form or nature, whether or not it can be protected, as well as any IPRs attached to it (European Commission, 2023). It is of the utmost importance that, since the primary focus is on the exploitation of these results, the document's concentration is on those with the highest potential for exploitation, thus creating the biggest impact, the so-called key results.

Regarding the **Exploitation**, it refers to the use of results in further research and innovation activities other than those covered by the project's action that generated results. Its objective is to effectively use project results through scientific, economic, political or societal exploitation routes aiming to turn Research and Innovation (R&I) actions into value and impact for society, whilst it focuses on making concrete use of research results (European Commission, 2023).

Concerning **Sustainability**, considering that there is no official definition of sustainability provided by the European IPR Helpdesk, for the purpose of this deliverable, sustainability actions refer to the following:

- The implementation and/or continuation of a project result at the project's case studies e.g. application of strategies, plans, roadmaps etc.
- The continuation/maintenance of project results after the project's end.

Finally, **Replicability** refers to the possibility of transferring or "copying" results from one case study to another with potentially different boundary conditions. In other words, if a case study was proven to work it could be distributed to other regions/markets but considering different conditions is crucial as they can be significantly different. Replication also includes the management process that was used in the case study scheme or the cooperation structure between critical stakeholders. (Thermoss project, 2020)

2. Methodology

This section outlines the overall methodology used to develop ICARIA's E&S Plan. After providing certain definitions in 1.3 to ensure a shared understanding of the terms used throughout the document, this section begins by presenting the exploitation approach, and then, it details the approach taken to draft the deliverable, including the tools and processes employed for data collection.

2.1 Exploitation Approach

The exploitation approach for the ICARIA project focuses on maximising the utility and impact of its results across various domains. This strategy is designed to ensure that the project's results are effectively harnessed for commercial, non-commercial, and scientific purposes.

The list of KERs was curated as per the guidelines specified in the GA and refined in collaboration with all project partners. Based on the updated information, an IPR Matrix was developed and shared with all partners to incorporate any new KERs or sub-KERs. Specifically, some results were divided into multiple sub-KERs for greater precision. Additionally, three results were removed from the list due to their classification as non-exploitable: (1) Multi-risk and resilience assessment for the three EU cases, (2) Replication, sustainability, and exploitation of ICARIA, and (3) Methods for addressing data gaps and uncertainties. Furthermore, two new KERs have been added, while KER#4 was further divided into multiple sub-results to enhance clarity. Ultimately, the final list comprises nine (9) results, including additional sub-results. All identified KERs will contribute to and support the final three KERs on the list of results: Climate Resilience Assessment Tools (RAF & RAT tools), Portfolio of Adaptation Solutions, and the Decision Support System (DSS).

Subsequently, questionnaires were designed to address all results and sub-results in terms of exploitation and sustainability, which were distributed to result owners and case study facilitators respectively. Questionnaires included questions regarding the main features of each result, the problems it addresses, its unique value proposition (UVP), the exploitation type (commercial, non-commercial, scientific), IP intentions, and relevant market information.

2.2 Data Collection

To develop the ICARIA exploitation plan, which covers commercial, non-commercial, and scientific applications, extensive data collection was necessary. This process involved primarily using primary research methods, with supplementary secondary research as needed to obtain thorough insights.

The primary research approach involved creating and distributing a comprehensive questionnaire and holding meetings with consortium partners to validate and refine the information on exploitable results. For secondary research, a variety of relevant resources, including publications on exploitation and IP rights management, were reviewed and utilised to enhance and support the exploitation plan.

Input from partners was gathered during July and August of 2024. To ensure all relevant information was captured, dedicated formats (questionnaires) and telecommunications were utilised to gather and assess exploitation opportunities and IP considerations. The questionnaires were designed to obtain detailed insights into each organisation's exploitation goals and IP claims, which were essential for identifying and mapping the project's exploitable results and associated IP assets. This information is integrated into this deliverable, providing crucial insights into the project's

commercialisation potential, the allocation of intellectual property rights, and the strategic alignment of results with future market opportunities and needs.

Project partners were requested to thoroughly address several key aspects when completing the questionnaires. These included: the exploitation of KERs as outlined in the GA and their associated IP considerations; the exploitation of additional results or sub-results developed during the project and their relevant IP rights; and details concerning the exploitation of project outcomes and sustainability activities. Images of the questionnaire distributed to the partners can be found in ANNEX B: Questionnaire (Exploitation & Sustainability plan).

3. Market Analysis

3.1 Market Size, barriers and drivers

3.1.1 Background and Motivation

According to a comprehensive report from the World Meteorological Organisation (WMO), disasters related to weather, climate, or water hazards have occurred daily over the past 50 years, resulting in an average of 115 fatalities and $202 million in losses each day. The frequency of these disasters has increased fivefold during this period, driven by climate change, more extreme weather patterns, and improved reporting. Fortunately, advancements in early warning systems and disaster management strategies have decreased the number of deaths nearly threefold (WMO, 2021). The leading causes of human losses from 1970 to 2019 were droughts, storms, floods, and extreme temperatures, while storms ($521 billion) and floods ($115 billion) accounted for significant economic losses (WMO, 2021).

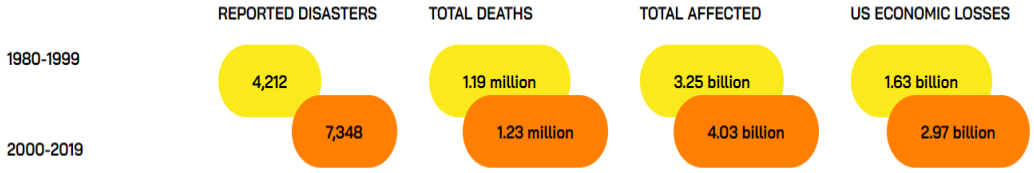

Figure 2 - Disaster Impact Overview

Source: https://www.icaria-project.eu/about-icaria/

As climate change continues to reshape the environment, it is expected to significantly affect the frequency, intensity, and timing of precipitation-related natural hazards, particularly flooding. Currently, flooding is the leading cause of damage across Europe, and this trend is likely to continue (Bezak et al.). Europe, warming faster than any other continent, faces significant vulnerabilities due to escalating climate-related risks. Over recent decades, climate-related disasters have caused substantial and growing losses across Europe. In 2023, the hottest year on record, disasters cost the continent over €77 billion (World Bank, 2021). If no action is taken, the projected costs under a high warming scenario could reach 7 percent of the EU's GDP (World Bank, 2021).

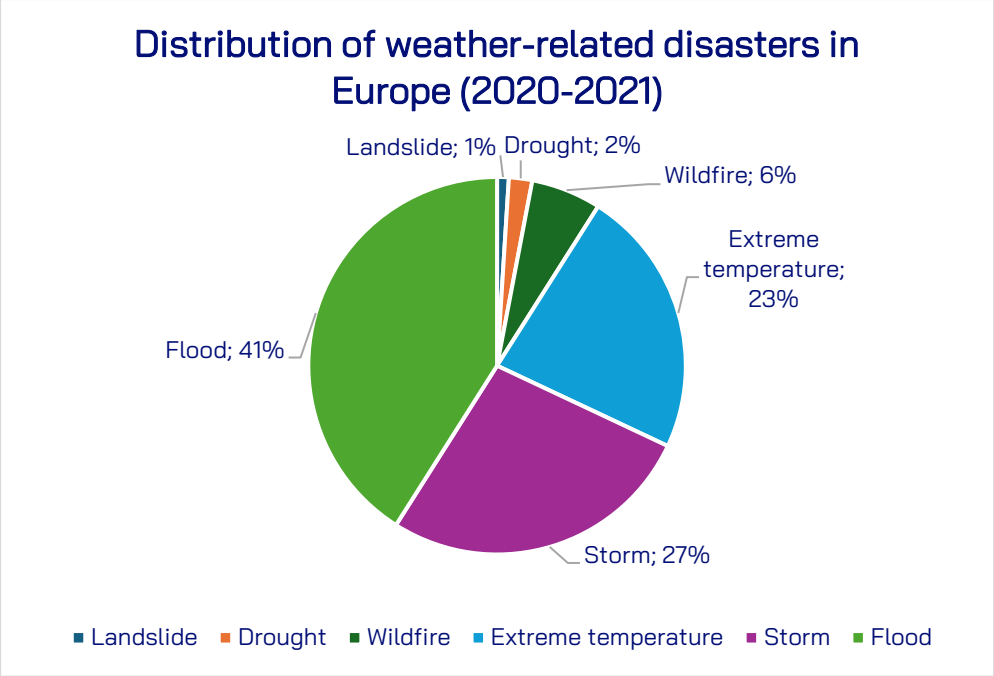

Figure 3 - Distribution of weather-related disasters in Europe (2020-2021)

Source: Statista, https://www.statista.com/statistics/1269886/most-common-natural-disasters-in-europe/

Figure 3 illustrates the distribution of different weather-related disasters across Europe. Floods are the most frequent disaster type, representing 41% of the total incidents, followed by storms at 27%. This distribution highlights that while floods and storms are the predominant disaster types, there is a relatively lower occurrence of droughts and landslides. Understanding this distribution can help in targeting resources and efforts more effectively towards the most frequents and impactful disaster types.

In addition to floods and storms, extreme temperatures also present a significant threat. Currently they lead to approximately 407,000 deaths annually, with heat-related fatalities six times more common in southern Europe than in the north. By 2100, these deaths are projected to increase by 9.3 times in the south (Joint Research Center, 2024). Without additional adaptation measures, an extra 55,000 deaths could occur each year by the century's end, underscoring the significant cost of delaying climate action (Joint Research Center, 2024). The increase in extreme rainfall has also resulted in devastating events, including widespread flooding in Italy, Greece, Slovenia, Norway, and Sweden in 2023 (Copernicus, 2024), as well as catastrophic flash floods in Poland, Czechia, and Austria during the preparation of this report in September 2024. Simultaneously, southern Europe has endured severe droughts and wildfires.

These escalating climate threats pose significant risks to both global and national economies, particularly in countries like Greece, where key sectors such as tourism, agriculture, infrastructure, and trade are expected to be directly impacted (Karakatsani, 2023). Rising temperatures may deter tourists from visiting during the hot summer months, while prolonged heat waves and floods can devastate crops, leading to higher production costs and increased prices (Karakatsani, 2023). Additionally, reduced labour productivity due to extreme heat could hinder the country's economic growth. Overall, it is anticipated that extreme weather will affect every aspect of human activity, with far-reaching consequences for economies in both the near and long term. Governments, including Greece's, must urgently develop effective strategies to mitigate the environmental impact and address the economic challenges posed by climate change (Karakatsani, 2023).

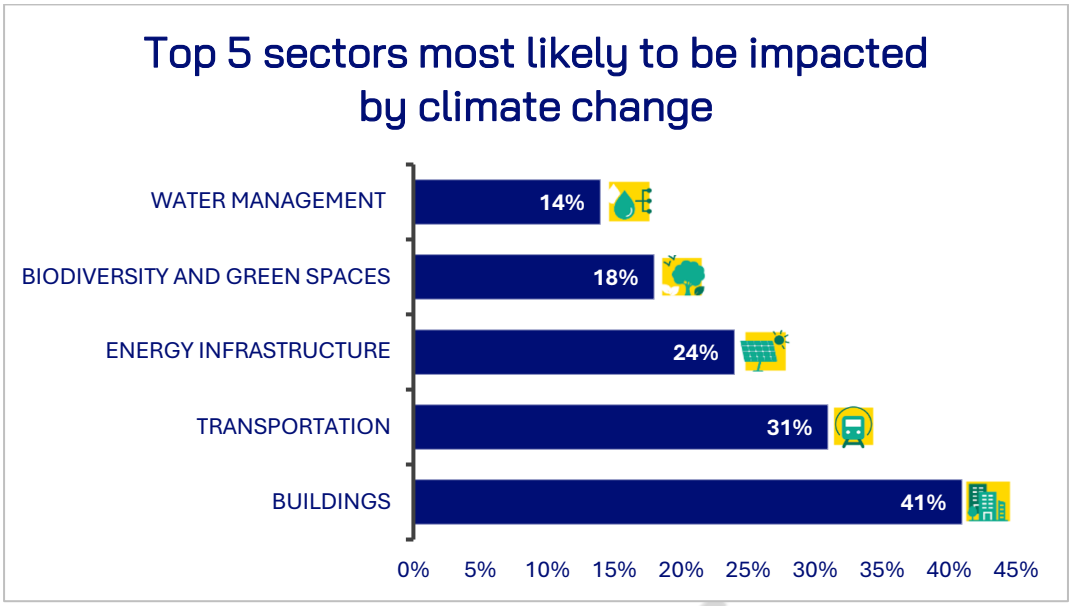

Figure 4 - Top sectors most likely to be impacted by climate change.

Source: EuroCities Monitor 2024, https://monitor.eurocities.eu/climate-adaptation/

Cities across Europe have been strengthening their defenses against climate threats through various measures, often utilising nature-based solutions that benefit local communities. Flooding, extreme heat, and other climate hazards pose risks to many municipal sectors. As shown in Figure 4, the ones considered most vulnerable include buildings (41%), transportation (31%), and energy infrastructure (24%), with additional concerns related to biodiversity and green spaces (17.5%), water management (14%), and health (14%).

Climate-related hazards, such as extreme temperatures, heavy rainfall, and droughts, pose serious threats to human health and the environment and can lead to substantial economic losses. Between 1980 and 2022, weather and climate-related extremes resulted in estimated economic losses of EUR 650 billion across EU Member States, including EUR 59.4 billion in 2021 and EUR 52.3 billion in 2022 alone (European Environment Agency, 2023). With the expected increase in the intensity of severe weather and climate-related events, it is unlikely that these economic losses will decrease by 2030 (European Environment Agency, 2023). The future financial impact of these hazards will depend on the frequency and intensity of such events and factors like the value of exposed assets and the effectiveness of planned climate adaptation measures. The economic effects of climate-related extremes vary widely across countries; for instance, Germany experienced the highest economic losses in the EU between 1980 and 2022, followed by France and Italy (European Environment Agency, 2023).

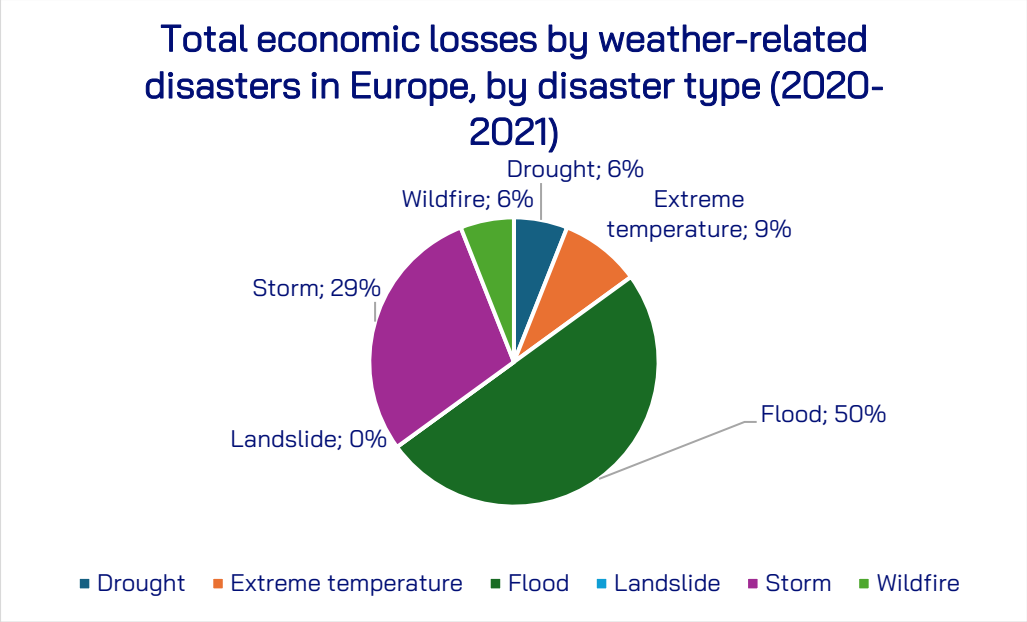

Figure 5 - Total economic losses by weather-related disasters in Europe, by disaster type (2020-2021).

Source: UCLouvain, https://www.preventionweb.net/media/74027/download?startDownload=20240909

Figure 5 illustrates the distribution of economic losses across different weather-related disasters in Europe during 2020-2021. Floods are the most meaningful contributor, accounting for 50% of the total economic losses. This underscores the grievous touch that flooding events had in this period. Storms also represented a physical portion, with 29% of the losings attributed to them. Overall, the chart emphasises the predominant economic impact of flooding and storms, which should be a focal point for future disaster management and prevention strategies in Europe.

3.1.2 Implications

Impact of Natural Disaster on Infrastructure, Human Lives and Habitat

Natural disasters like floods, wildfires, landslides, and heatwaves are increasingly threatening Europe, causing significant damage to infrastructure, human lives, and natural habitats. Recent data indicates that from 1980 to 2020, such disasters caused average annual economic losses of around €12 billion (World Bank, 2021). The rising frequency and intensity of these events, driven by climate change, highlight the urgent need for Europe to strengthen its resilience. These disasters result in substantial economic losses, disrupt essential services, and pose severe risks to life and well-being, including mental health challenges. Additionally, they cause long-term environmental degradation, threatening ecosystems and the sustainability of communities reliant on them.

Impact on Capital Stock and Infrastructure

Natural disasters significantly impact a nation's capital stock, including essential assets like buildings, machinery, and infrastructure, which are crucial for economic production. These events cause widespread destruction, reducing available capital and hindering economic activity, leading to lower output, income, and increased poverty (Hallegatte et al.). The recovery process, which can take years or even decades, depends on the speed of resource mobilisation, the effectiveness of reconstruction policies, and the resilience of the affected economy. Countries with strong financial

systems and effective governance recover more efficiently, while those with weaker institutions face prolonged economic challenges. (Hallegatte et al.).

Macroeconomic Consequences

The macroeconomic consequences of natural disasters extend beyond the immediate destruction of physical assets. Disasters can disrupt supply chains, reduce labour productivity, and create uncertainty that affects investment decisions. Additionally, natural disasters can have reputational consequences that might affect future investments. For instance, sectors like tourism can suffer significantly if a region is perceived as high-risk or if its recovery is slow and poorly managed. Moreover, the recovery process is often uneven, with some sectors and regions recovering more quickly than others. For example, sectors that are closely linked to infrastructure and construction may experience a surge in demand as rebuilding efforts get underway, while other sectors, such as agriculture or tourism, may continue to suffer from the long-term effects of the disaster. This uneven recovery can create challenges for policymakers, who must balance the need to support growth in specific sectors with the broader goal of ensuring a sustainable and inclusive recovery (Hallegatte et al., 2022).

Long-term Economic Implications

The long-term economic effects of natural disasters are influenced by the effectiveness of recovery efforts and the broader economic context. Disasters can prompt investments in resilient infrastructure and better risk management, leading to positive change. However, if recovery is poorly managed or vulnerabilities are not addressed, they can result in long-term economic stagnation (Coronese et al., 2019). With climate change increasing the frequency and intensity of natural disasters, it is crucial for policymakers to enhance resilience and reduce future vulnerabilities through investments in disaster preparedness, early warning systems, and climate adaptation measures.

The impacts and implications of natural disasters is vast, encompassing a wide range of economic activities and sectors. From the immediate impact on capital stock and infrastructure to the long-term consequences for economic growth and stability, natural disasters pose significant challenges for policymakers, businesses, and communities. However, these challenges also create opportunities for innovation, investment, and market development, particularly in areas related to disaster risk management and resilience. As the frequency and intensity of natural disasters continue to rise, understanding the economic implications and developing effective strategies for recovery and resilience will be essential for ensuring sustainable and inclusive growth in the years ahead.

3.1.3 Total addressable market

The global disaster preparedness systems market, valued at USD 162 billion in 2022, and is projected to grow at a CAGR of 8.4%, reaching approximately USD 361.23 billion by 2032. (Precedence Research, 2023). This expansion is fuelled by the rising demand for disaster prevention, preparedness and adaptation, particularly in Europe where climate-related and natural disasters are becoming more frequent. Recognising the need for enhanced disaster resilience, the European Union has committed to significant investments, as highlighted by financial commitments from the World Bank and the European Commission. With adaptation costs in Europe projected to range from €34 to €110 per person annually, and the total costs potentially reaching between €15 billion and €64 billion by the 2030s, the market presents increasing opportunities for industries specialising in risk assessment,

infrastructure resilience, data analytics, and disaster management (European Commission, 2019). The growing recognitions of the need to strengthen infrastructure and systems to withstand natural disasters is a key driver of this market's expansion (European Commission, 2019).

Investing in resilient infrastructure and effective disaster management is essential not just for mitigating immediate damage, but also for preserving economic stability and supporting long-term growth. As Europe confronts escalating climate-related risks, these investments are crucial for protecting both the continent's physical assets and its economic future. The impact of natural disasters extends beyond the direct damage to infrastructure and loss of life; it also affects economic stability, productivity, and future growth prospects. Thus, addressing these challenges is key to maintaining both current resilience and future economic prosperity.

Overall, it is evident that the impacts of natural disasters are multifaceted, affecting various sectors and communities in diverse ways. This complexity necessitates coordinated efforts among different stakeholders—including governments, businesses, and local communities—to effectively mitigate risks and seize emerging opportunities. In this context, ICARIA aims to provide essential tools for enhancing disaster resilience. By delivering innovative solutions for risk mitigation and recovery, the project's results will play a crucial role in addressing these interconnected challenges, ultimately fostering more sustainable and resilient communities for all.

3.2 Collaborating with authorities involved in climate disaster management

Authorities involved in climate policy, disaster management, and resilience play a pivotal role in shaping the response to and preparedness for natural disasters and climate-related risks. These agencies are responsible for developing and implementing strategies that address the growing challenges posed by climate change, such as extreme weather events, floods, heatwaves, and other hazards. As such, they are key stakeholders in initiatives like the ICARIA project, which aims to enhance disaster resilience through advanced modelling and adaptation tools.

By engaging with these authorities, the ICARIA project can help align its tools with national and regional priorities, increasing the likelihood of successful implementation, as they are suited to meet their real needs. For instance, ministries of the environment or ecological transition typically oversee climate action plans, making them essential partners for integrating ICARIA's tools into broader climate adaptation frameworks, and sounder assessments. Meanwhile, civil protection agencies are on the frontline of disaster response and can benefit directly from the project's ability to model complex, compound, and cascading climate impacts, improving their capacity to anticipate and manage emergencies.

Collaboration with these authorities can also open doors to funding opportunities, as governments often allocate resources to projects that align with their strategic objectives in climate resilience and disaster management. Additionally, these partnerships can facilitate the sharing of data, expertise, and best practices, which are crucial for the continuous improvement and local adaptation of ICARIA's tools. By establishing strong relationships with these key governmental bodies, the ICARIA project can not only enhance its impact but also contribute to the overall resilience and preparedness of the regions it serves.

Table 1 - Potential Collaborators

Countries	Government authorities/agencies	Role
Greece	Ministry of Environment and Energy - YPEN	Oversees environmental protection, climate change policies, and energy.
Greece	Civil Protection	Manages disaster response, resilience, and risk reduction.
Greece	Ministry of Health	Addresses public health aspects to environmental hazards and climate change impacts.
Greece	Ministry of Infrastructure and Transportation	Deals with infrastructure resilience, which is crucial for disaster preparedness and climate adaptation.
Spain	Ministry for the Ecological Transition and the Demographic Challenge (MITECO)	Responsible for climate change, environmental protection, and sustainable development.
Spain	Spanish Agency for International Development Cooperation (AECID)	Supports disaster management and climate adaptation projects.
Spain	National Meteorological Agency (AEMET)	Provides meteorological data and forecasts essential for disaster preparedness and climate resilience.
Spain	Spanish Civil Protection	Coordinates emergency response and disaster management, including preparedness and recovery efforts.
Austria	Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology (BMK)	Manages climate action policies, environmental protection, and technological innovation.
Austria	Austrian Red Cross	Coordinates disaster response and resilience activities.
Austria	Austrian Federal Agency for Water Management (BWG)	Manages water resources and flood protection, which are critical components of disaster preparedness and climate adaptation.
Austria	Austrian Institute of Technology (AIT)	Conducts research and development in areas related to technology and infrastructure resilience, contributing to disaster preparedness and climate resilience.
Austria	Austrian Environment Agency	Focuses on environmental protection, climate change research, and sustainability initiatives.
Italy	Ministry of Environment and Energy Security (Ministero dell'Ambiente e della Sicurezza Energetica)	Responsible for environmental protection, climate policies, and energy security.
Italy	Department of Civil Protection (Dipartimento della Protezione Civile)	Manages disaster response, risk reduction, and resilience strategies.
France	Ministry for the Ecological Transition (Ministere de la Transition Ecologique)	Oversees environmental policies, climate action, and sustainable development.

Countries	Government authorities/agencies	Role
France	Civil Protection Directorate (Direction Generale de la Securite Civile et de la Gestion des Crises)	Manages disaster response, emergency planning, and crisis management.
Portugal	National Civil Protection Authority (ANPC)	Its aim is to "draft the protection measures, limit risks and minimise loss for the national civil population caused by natural disasters or emergencies due to the war, or anything that represents a threat or destruction of public or private goods and natural resources
Netherlands	Ministry of Infrastructure and Water Management	It is committed to improving quality of life, access and mobility in a clean, safe and sustainable environment. The Ministry strives to create an efficient network of roads, railways, waterways and airways, effective water management to protect against flooding, and improved air and water quality.
Sweden	Ministry of Environment	It focuses on building a sustainable society resilient to climate change. Given the global nature of many environmental challenges, much of this work involves international collaboration.
Germany	Federal Office for Civil Protection and Disaster Assistance (BBK)	Coordinates disaster preparedness, response, and recovery efforts, including managing resources and crisis management strategies.

3.3 Barriers & Drivers

Despite the growing awareness of the importance of disaster resilience, several drivers and barriers still influence the effectiveness of efforts to mitigate natural disaster risks in Europe. While there are motivations pushing for more robust strategies, significant obstacles continue to hinder comprehensive and effective action.

Barriers:

Inadequate funding

Inadequate funding is a critical barrier to the success of the climate resilience tools offered through the ICARIA project since these tools often require significant financial investment for implementation, maintenance and scaling. The insufficient capitalisation of disaster response funds, such as the Solidarity and Emergency Aid Reserve, directly impacts the EU's ability to invest and deploy these tools across various regions. Without adequate funding, the ability to purchase, integrate, and sustain these tools is compromised, especially in regions with higher exposure and vulnerability climate hazards (Hochrainer-Stigler et al., 2024).

Insufficient Data Interoperability

Insufficient data interoperability can also be a major barrier for the project's results since they depend on effective data sharing among non-profit organisations, government agencies, and emergency units for successful disaster risk reduction (DRR). The lack of interoperable data systems impedes the timely and accurate exchange of information, which is essential for effective emergency responses and preparedness. This disruption can lead to delays and inefficiencies in addressing both natural hazards, such as floods and earthquakes, and NATECH disasters, like dam failures. Consequently, the ability to integrate data from various sources can result in greater damage to communities and assets, diminishing the tools' effectiveness and hindering their adoption.

Public awareness and preparedness

Public awareness and preparedness can also present a significant challenge to the project's tools adaptation since these tools are most effective when communities are informed and ready to act on disaster risks. Despite efforts to implement educational programs and initiatives aimed at increasing community preparedness, many populations remain unprepared for the realities of natural disaster risks. This lack of preparedness undermines the effectiveness of early warning systems, emergency response efforts, and overall community resilience. The gap in public awareness and preparedness also highlights the importance of ongoing education and communication efforts to ensure that communities are better equipped to respond to and recover from natural disasters (European Environment Agency, 2024).

Drivers:

Adoption of a risk-based approach

The adoption of a risk-based approach to disaster management is a key driver of market growth in the field of disaster resilience and climate adaptation. By continuously assessing and updating risk

profiles for various regions, the EU enhances its ability to allocate resources more effectively and improve overall disaster resilience. This strategic approach ensures that resources are directed towards areas with the highest risk, thereby optimising preparedness and response efforts (Laurien et al., 2022).

This focus on risk assessment drives demand for advanced tools and technologies, such as sophisticated risk assessment software, climate data analytics platforms, and specialised consulting services. These innovations provide the critical insights needed for informed decision-making, allowing for more precise and effective disaster management strategies. As organisations and governments adopt this approach, they stimulate growth in related markets, including technology solutions and consultancy services that support risk analysis and management. This shift towards a risk-based framework not only enhances disaster resilience but also creates substantial market opportunities for companies offering advanced risk assessment and management solutions.

Promotion of PPPs

The promotion of public-private partnerships (PPPs) is a crucial driver of market growth in disaster risk management and resilience. By facilitating collaboration between government entities and the private sector, PPPs foster innovation, resource sharing, and financial investment in disaster preparedness and response. These partnerships are instrumental in developing resilient infrastructure, enhancing emergency response capabilities, and advancing research and technology.

The Private Sector Alliance for Disaster Resilient Societies (ARISE), as established by the United Nations Office for Disaster Risk Reduction (UNDRR), encourages public private collaboration to improve disaster resilience. (UNDRR, 2022). Public-Private Partnerships (PPPs) are pivotal in this effort, as they pool resources and expertise, resulting in more effective and efficient disaster risk management solutions. By facilitating the development of cutting-edge technologies and infrastructure upgrades, PPPs enhance resilience against natural disasters.

Furthermore, PPPs alleviate the financial burden of disaster management, enabling large-scale projects that might otherwise be prohibitively expensive. This emphasis on collaborative efforts not only strengthens disaster resilience but also stimulates market growth by creating opportunities for companies involved in infrastructure development, emergency management technologies, and consulting services. Through this collaborative approach, PPPs drive economic activity and foster innovation within the sector.

Vulnerability of Europe's critical infrastructure

The vulnerability of Europe's critical infrastructure further exacerbates the challenges posed by natural disasters. Many essential infrastructures, including transportation networks, energy systems, and emergency services, remain susceptible to damage from natural disasters (Union Civil Protection Knowledge Network, 2023). This vulnerability underscores the urgent need for significant investments in upgrading and maintaining critical infrastructure to enhance resilience against future disasters.

Investment in infrastructure resilience

Investment in infrastructure resilience is a key driver of market growth in the context of disaster risk management and climate adaptation. As essential services such as electricity grids, water systems, and transport networks become increasingly strained, especially in vulnerable regions, the need for resilient infrastructure grows. Natural hazards amplify the challenges faced by these systems,

highlighting the urgent need for upgrades and innovations that enhance their ability to function during and after disasters.

The Lifelines report provides a comprehensive framework for understanding infrastructure resilience and underscores its economic significance. By investing in resilient infrastructure, governments, businesses, and stakeholders can mitigate the impacts of natural disasters, reduce potential economic losses, save lives and support sustainable development. This investment not only strengthens the reliability of critical services but also fosters growth in related industries, including construction, engineering, and technology solutions. (Stephane Hallegatte et al., 2019)

The push towards building more resilient infrastructure drives market growth by creating demand for advanced technologies and construction practices. It also helps in overcoming key obstacles identified in resilience frameworks, thus enabling societies to better withstand and recover from natural shocks. As a result, the focus on infrastructure resilience is crucial for promoting long-term prosperity and stability, making it a significant driver in the market.

Research and innovation

Research and innovation are playing a vital role in driving market growth. Investments in research are fuelling the development of new technologies and methodologies for managing multi-hazard scenarios. This includes advancements in climate modelling, early warning systems, disaster response technologies, and sustainable practices that can help mitigate the impacts of natural disasters. By supporting research and innovation, the EU is not only enhancing its disaster resilience but also creating new market opportunities for companies specialising in these areas.
Institutional innovations in risk management, particularly those observed in Austria, play a key role in leveraging these advancements. In Austria, multi-functional protection schemes—integrating various functions like risk management strategies, sustainable land-use development, and individual preparedness—demonstrate how innovative approaches can optimise resources, save costs, and improve overall resilience. These schemes highlight the potential for research-driven solutions to transform traditional risk management practices (Thaler et al., 2022).

Economic Considerations

The absence of resilience-enhancing tools significantly magnifies the financial burden of recovering from climate-related disasters. Without prior resilience measures, recovery efforts necessitate extensive emergency response activities, which include the immediate deployment of resources and personnel to address the crisis. These initial costs can be substantial, covering emergency services, temporary shelters, and urgent medical care (World Bank, 2021).
Moreover, the financial strain is compounded by reconstruction expenses. Rebuilding damaged infrastructure—such as roads, bridges, and public buildings—requires significant investment. The scale of destruction can lead to delays and increased costs, further straining public finances and impacting economic recovery. Additionally, there are substantial economic losses from long-term business disruptions while reconstruction takes place. Businesses forced to halt operations during recovery face reduced productivity, layoffs and loss of income.
Research underscores the economic advantage of investing in disaster preparedness and prevention. Studies conducted across Europe, consistent with global findings, show that investments in disaster and climate resilience are not only economically sound but also offer numerous co-benefits to society. By prioritising resilience and preparedness, regions can mitigate the severe financial impacts of disasters, reduce the burden of emergency response and reconstruction, and enhance overall economic stability and recovery (World Bank, 2021).

Overall, by addressing the barriers to disaster resilience and leveraging the drivers for market growth, Europe can build a more resilient framework for responding to and recovering from natural disasters. This will not only protect human lives, infrastructure, and ecosystems but also create significant market opportunities in disaster risk management and climate adaptation sectors.

3.4 Market Environment (PESTEL)

Natural disasters, increasingly intensified by climate change, have emerged as a pressing concern in Europe. Events such as floods, heatwaves, and landslides are not only causing immediate damage to life and property but are also creating profound and long-term social challenges. These disasters lead to the displacement of communities, widen social inequalities, trigger mental health crises, and disrupt essential services like healthcare and education. As Europe contends with the growing frequency and severity of these natural events, understanding their broader implications is essential to developing comprehensive strategies for resilience and adaptation. This PESTEL analysis will explore the political, economic, social, technological, environmental, and legal factors that influence ICARIA's efforts to enhance disaster resilience and adaptation across Europe.

PESTEL Analysis
Political
• The success of the ICARIA project is influenced by government policies on climate change, disaster risk management, and infrastructure resilience. Supportive policies and funding from the EU and national governments, including resources from the Disaster Risk Management Knowledge Centre and the Union Civil Protection Knowledge Network, can significantly enhance the implementation and expansion of ICARIA. These networks facilitate the collection and sharing of disaster-related data, research, and best practices, strengthening the links between disaster management and civil protection (European Commission, 2019). Countries with strong political commitment to climate action often provide robust support for climate adaptation initiatives. Conversely, political instability or a lack of commitment may result in inconsistent policy enforcement and funding shortages, potentially impacting the availability of resources for ICARIA's tools and initiatives. • The effectiveness of ICARIA relies significantly on the backing of regional governments in Europe, particularly in Spain, Austria, and Greece. Political stability and a strong commitment to climate action in these areas are essential for the effective implementation of the project and the engagement of stakeholders.
Economic
• The future costs associated with climate-related hazards are influenced not only by the frequency and intensity of these events but also by various other factors, including the value of exposed assets and the implementation of climate adaptation strategies. Research indicates that adaptation measures, including nature-based solutions, can effectively reduce the impacts of weather and climate extremes in Europe (European Environment Agency, 2023). The ICARIA project is designed to evaluate and mitigate economic losses stemming from climate-related disasters. By providing tools for enhancing resilience, ICARIA has the potential to diminish future economic damages and provide long-term economic benefits to the regions involved. • The ICARIA project emphasises the importance of managing multiple hazard scenarios, which is crucial for comprehensive economic planning. Multi-functional protection schemes that address various hazards simultaneously can optimise resource allocation

and reduce overall costs. By evaluating and implementing such schemes, ICARIA can contribute to more cost-effective disaster management and economic resilience.

Social

- One of the most immediate social impacts of natural disasters is the displacement of populations. In Europe, floods, wildfires, and heatwaves have led to the displacement of thousands of people. For instance, the Mediterranean region has been particularly hard-hit by floods, with Medicane Daniel in 2023 causing extensive damage and forcing many to abandon their homes. Such displacements often lead to long-term social challenges, including homelessness, loss of livelihoods, and the breakdown of community networks. Globally, it is estimated that in 2022 alone, extreme weather events displaced over 12 million children, particularly in regions already grappling with poverty and low literacy rates (UNDRR, 2023). The ICARIA project is designed to address these pressing issues by enhancing disaster resilience and adaptation across Europe.

- The health impacts of natural disasters are multifaceted, ranging from direct injuries and fatalities to long-term mental health issues. Heatwaves, in particular, are becoming more frequent and severe, leading to an increase in heat-related illnesses and deaths. In 2023, Europe witnessed some of its hottest temperatures on record, resulting in widespread health crises, particularly among the elderly and those with pre-existing health conditions (WMO, 2023) Additionally, the trauma of experiencing a natural disaster can lead to significant mental health challenges, including anxiety, depression, and post-traumatic stress disorder (PTSD) (Walinski et al., 2023). By developing and implementing innovative solutions, project ICARIA aims to reduce the frequency and severity of these impacts associate with extreme weather events.

- Natural disasters also disrupt essential services, further compounding the social impacts on affected communities. In many cases, infrastructure such as roads, bridges, and power lines are damaged or destroyed, making it difficult for emergency services to reach those in need. This was seen during the 2021 floods in Western Europe, where the destruction of critical infrastructure hindered rescue efforts and delayed the provision of aid to affected communities (Copernicus, 2021). The project's focus on advanced risk assessment and management tools is intended to minimise disruptions to essential services, thereby facilitating quicker and more efficient responses to disasters and supporting affected communities in their recovery efforts.

- The disruption of healthcare services is particularly concerning, as it can lead to a range of public health issues. During natural disasters, hospitals and clinics may be damaged, and access to medical supplies and personnel may be limited. This can result in the worsening of chronic health conditions, increased rates of infectious diseases, and higher mortality rates. (Salam et al., 2023). The 2023 heatwave in Europe, for example, not only strained healthcare systems but also led to a spike in heat-related illnesses and deaths (United Nations, 2024). The disruption of healthcare services during natural disasters underscores the need for resilient infrastructure and well-prepared emergency response systems (Salam et al., 2023).

Technological

- The ICARIA project can benefit from cutting-edge advancements in climate modelling and forecasting. Technologies that allow for detailed and accurate assessments of climate impacts, including multi-hazard scenarios and compound events, enhance the project's ability to predict and manage climate risks effectively.

- Technological advancements, such as data analytics, machine learning, and artificial intelligence, can significantly enhance the accuracy of ICARIA's tools. Data analytics enables more precise and insightful analysis of complex datasets, which improves decision-making and outcomes. Machine learning enhances predictive capabilities, leading to more accurate forecasting and risk assessment, along with damage evaluation with multiple purposes. Meanwhile, artificial intelligence can automate and

optimise various processes, refining tools for data collection, interpretation, and application with greater precision (OCHA, 2023).

Environmental

- Extreme weather events, a central focus of the ICARIA project, pose significant threats to the water-energy-carbon nexus through cascading effects. Events such as droughts, floods, heatwaves, hurricanes, and wildfires disrupt the interconnected systems of water supply, energy production, and carbon emissions. For example, California's drought notably reduced hydroelectric power generation, increasing reliance on natural gas and consequently raising carbon emissions. Additionally, droughts often require higher energy consumption to obtain water from more remote or energy-intensive sources, further straining the nexus. Similarly, floods and heatwaves in Europe have strained energy infrastructure, leading to increased carbon output (Zhao et al., 2024). These examples underscore the urgent need for integrated resilience strategies to address these interconnected environmental challenges. Developing and implementing strategies that consider the interplay between water, energy, and carbon systems is crucial for managing the impacts of climate change-driven extreme weather events. A global perspective, incorporating insights and data from various countries, is essential for effectively tackling these environmental issues and enhancing overall resilience.

- Drought-affected regions are expected to become more widespread, while the frequency of intense precipitation events is likely to increase, raising the risk of flooding (ISDR, 2008). In this evolving climate scenario, the implementation of ICARIA tools becomes essential to effectively manage and mitigate these growing risks.

Legal

- Effective management of IP and data protection is critical for the ICARIA project. Legal issues related to the ownership and protection of the innovative tools, models, and methodologies developed must be addressed to ensure that IP rights are secured and respected. This includes securing patents, copyrights, or trademarks as appropriate. Additionally, compliance with data protection regulations, such as the EU's General Data Protection Regulation (GDPR), is essential to safeguard sensitive and personal data collected during the project. Proper IP and data management facilitate innovation, support collaboration among stakeholders, and ensure legal compliance, thereby contributing to the project's overall success and effectiveness.

- Water Framework Directive and Floods Directive require member states to protect and improve water quality and manage flood risks effectively (European Commission, 2023). Since ICARIA focuses on regions vulnerable to extreme weather events like floods, the project must align its strategies with these directives to avoid exacerbating water quality issues or flood risks. Compliance might involve integrating natural water retention measures or enhancing flood defences while ensuring minimal disruption to natural waterways.

Overall, the success of the **ICARIA project** depends on several factors. Politically, it requires support and stability from governments. Economically, it seeks to minimise the costs associated with climate-related events. Socially, it aims to address issues like displacement and health impacts from disasters. Technologically, it relies on advanced tools and data analysis. Environmentally, it focuses on managing impacts on natural systems. Legally, it must comply with regulations related to intellectual property and data protection.

4. ICARIA Exploitable Results

The purpose of this section is primarily to present all the ICARIA results. After a thorough review, (3) three out of (10) ten results from the original list (according to the GA), were excluded, as they were ultimately deemed non-exploitable. With the consensus of all partners, a total of 7 results were concluded (as shown in Table 2), along with 2 new KERs proposed (shown in Table 3). Additionally, KER#4 has been divided into multiple sub-results, each assigned to specific result owners. The mapping process was conducted to determine whether each identified result holds potential for individual exploitation. In the end, all identified KERs will contribute to the final (3) three primary KERs on the list of results, which are:

- **Climate resilience assessment tools (RAF & RAT)**
- **Portfolio of adaptation solutions**
- **Decision support system (DSS)**

Table 2 - List of results

Results	IPR holder	Commercial – Potentially Commercial	Non-Commercial-Scientific
1. Project framework	UNINA		X
2. Climate scenarios methods and results			
2.1 AMB corrected and extended weather observations, 2.2 SAR corrected weather observations, 2.3 SLZ corrected weather observations, 2.4 FICLIMA climate change projections at local scale, 2.5 FICLIMA climate change spatial projections	FIC		X
2.6 Spatially downscaled climate projections (2 RCMs) *	AIT		
3. Multi-Hazard modelling tools			
3.1 Pluvial Flooding and Storm Surge	AQUATEC		X
3.2 Flooding and Extreme Wind	AIT / NCSR		X
3.3 Extreme Wind and Forest Fire, 3.4 Drought and Heatwave, 3.5 Drought and Forest Fire, 3.6 Heatwave and Forest Fire, 3.7 Heatwave, Drought and Forest Fire	NCSR		X
3.8 Scenario Selection and Join Probability of Compound Events	UNEXE		X
4. Climate-related multi-risk tangible impact assessment method			
4.1 Coastal flood	AB		X
4.2 Drought (Agriculture, Economic sectors, Natural area) *	CETAQUA		
4.3 Drought (Electricity)	IREC		X
4.4 Drought (Water sector) *	AQUATEC		

4.5 Drought (Water sector, Wastewater), 4.6 Floods (Water Sector – Wastewater)	AB		X
4.7 Floods (Electricity)	IREC		X
4.8 Floods (Natural area: agriculture, water sector)	CETAQUA		X
4.9 Floods (People), 4.10 Floods (Properties: Infrastructure)	AQUATEC		X
4.11 Floods (Transport)	UNEXE/ AQUATEC		X
4.12 Forest Fires (Electricity), 4.13 Forest Fires (Housing, Natural areas: Agriculture, Trasport, Water sector), 4.17 Wind (People + Transport), 4.18 Wind (Properties)	NCSR / IREC		X
4.14 Heat Wave (Electricity)	IREC		X
4.15 Heat Wave (People)	UNINA		X
4.16 Wind (Electricity + Trees) *	IREC / AIT		X
4.19 Gridwatch	IREC		
5. Climate resilience assessment tools			
5.1 Holistic Resilience Assessment Framework (RAF) and tool (RAF-app)	LNEC	X	
5.2 Resilience Assessment Tool (RAT) for critical infrastructure	NCSR	X	
6. Portfolio of adaptation solutions	CETAQUA	X	
7. ICARIA DSS	DRAXIS	X	

Table 3 - New Results

New Results	IPR holder	Commercial – Potentially Commercial	Non-Commercial-Scientific
8. Trial Guidance methodology	AIT		X
9. ICARIA cookbook: recipes for data gap filling	CERTH, UNINA, FIC		X

4.1 Key Exploitable Results

This section presents and briefly describes the results of the ICARIA project, including both KERs and OERs. Each KER is outlined with details on the problem it addresses, the existing alternative solutions, the proposed solution, the target audience, and the unique value proposition. Additionally, the type of exploitation for each result is indicated.

Table 4 - KER#1 Project framework

KER #1	Holistic modelling framework (Project framework) - UNINA
Main Features	The ICARIA holistic modelling framework aims to ensure consistency in risk/impact analysis across different climate- and weather-related hazard categories (i.e. heat waves, droughts, forest, fires, storm surges, storm wind, and floods). Applying the framework allows building multi-hazard scenarios in the target study area, ensuring harmonised data collection process, performing exposure and vulnerability assessments of critical assets (i.e. building and open spaces) and services (i.e. water, transport, energy, waste, natural areas, and tourism sectors), filling gaps and/or uncertainties, and thus estimating related tangible direct and indirect damage. The modelling framework ensures that the effect of adaptation strategies applied at the regional and local scales is quantified in terms of avoided physical and economic impacts, supporting the prioritisation of measures delivering socio-economic and environmental benefits for communities. The ICARIA framework is based on the approach applied by the IPCC in the context of the 6th Assessment Report and thus compliant with the approaches highlighted by the latest cross-sectoral technical guidance available at EU level (2021/C 373/01). The ICARIA modelling framework guides modelers in developing context-specific time histories of such complex events and implementing exposure and vulnerability analyses for targeted assets, to quantity impacts through ICARIA models (or other legacy model required by users). The framework is intended to help assessing the effect of alternative adaptation measures and performing scenario comparisons for alternative strategies.
Problem	Single hazard approaches commonly adopted to assess risks and impacts of extreme weather events are not suitable to address complex scenarios characterised by compound events and cascading effects.
Alternative Solution	A few multi-hazard/impact models have been implemented as simulation tools e.g. HAZUS (focusing on hurricanes, earthquakes and floods); RiskScape (ash fall, floods, tsunamis, landslides, storms and earthquakes); CAPRA (hurricanes, extreme rainfall, landslides, floods, earthquakes, tsunamis and volcanic eruptions). These models may underestimate the impact arising from multi-hazard conditions, as they do not consider the spatial and temporal overlap of hazards and their interactions.

KER #1	Holistic modelling framework (Project framework) - UNINA
Unique Value Proposition	The UPV of the ICARIA modelling framework lies in its potential of aggregating any background/legacy single-hazard/impact model by collecting in a harmonised way all datasets and functions needed to characterise Hazard, Exposure and Vulnerability information in a time-and space-dependent scenario customised on the study area, offering methods to address data gaps and uncertainties. The cumulative damage resulting from complex scenarios characterised by compound events and/or cascading effects is calculated by using economic impact as a common indicator across targeted sectors and services. The effect of adaptation measures is assessed according to each selected hazard and asset/service in terms of avoided physical damage and economic impacts.
Target Audience	ICARIA CFSs (trials and minitrials), ICARIA followers, hazard/impact modelling experts.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	No
IPR beyond the project	No protection, but intended free use/open access with free access rights to the consortium partners once the project is over for more than 5 years.

Table 5 - KER#6 Portfolio of adaptation solutions

KER #6	Portfolio of adaptation solutions - CETAQUA
Main Features	The platform for adaption strategies offers publicly a portfolio of adaptation solution, creation of adaptation strategies, composed by sets of measures that follow a common adaptation objective, and a guide to support the application of a prioritisation methods for measures.
Problem	The platform is designed to help prioritise and select adaptation measures in situations with limited investment budgets and limited capacity to assess various impacts. To aid decision-making, the measures are presented in terms of damage reduction and welfare improvement
Alternative Solution	The estimates made by the insurance sector
Unique Value Proposition	Science-based knowledge, adaptable to different areas.
Target Audience	Public policy decision makers, analysts, and other public audience with interest in developing an adaptation strategy for their territory.
Exploitation Type	Non-Commercial
IPR Considerations	
Background IPR	Yes. Methodology to prioritise adaptation measures. Included in the consortium agreement as “background included” addressed by the partners.
Foreground IPR	No
IPR beyond the project	No protection

Table 6- KER#7 Decision Support System (DSS)

KER #7	Decision Support System (DSS) - DRAXIS
Main Features	The DSS has the following features: -Project manager for data upload, creation and management of projects to build scenarios with or without adaptation measures. -Map viewer with static project data such as ICARIA's climate projections, user data uploaded via the project manager (e.g. hazard maps, vulnerability and exposure information), providing essential GIS functionality (e.g. delivery of single or multiple data layers). -Impact assessment with quantification of risk score, damage or service disruption resulting from calculations on the user-uploaded data. -Adaptation measures integrated from ICARIA's portfolio where users can carry out CBA and MCA. -Holistic resilience assessment with the integration of the ICARIA RAT and RAF applications, allowing the user to receive key metrics on the resilience of the region or critical assets.
Problem	Need for a comprehensive decision support system encompassing fundamental steps in a climate risk and resilience assessment process along with the prioritisation of adaptation solutions.
Alternative Solution	ArcGIS, QGIS and similar tools, other custom tools or code not available commercially.
Unique Value Proposition	Popular tools used for hazard modelling and visualisation of geospatial data are very complex and typically used only by experts. ICARIA DSS, taking advantage of the project's own modelling framework and resilience assessment tools, allows users to extract value from complex hazard and impact modelling processes, while also considering adaptation measures and holistic resilience approaches. The DSS is designed to be used by experts who provide data and generate impact assessment scenarios based on their region and hazards of interest; by stakeholders who can evaluate the impact assessment results and compare different resilience strategies or decide the best adaptation solutions at a higher level; by the public as the DSS gives access to ICARIA's climate data and other spatial results through a user-friendly interactive map viewer.
Target Audience	Regional authorities and other decision makers, Asset and service managers, Experts on climate risk/resilience assessment, Citizens and general audience.
Exploitation Type	Commercial
IPR Considerations	
Background IPR	No
Foreground IPR	Yes, Software.
IPR beyond the project	Yes, Copyright.

In addition to exploitable results directly related to the project's KERs, one more generic exploitable result was identified by AIT who is particularly interested in using in further research projects and possibly also commercially, in the form of support/consulting for organisations looking for methodologically sound ways to assess the value of available tools, methods and procedures.

Table 7 – KER#8 Trial Guidance methodology

KER #8	Trial Guidance methodology - AIT
Main Features	Actionable and tested methodology for designing, executing, and assessing the innovation potential of tools, methods and tools (solutions) through trials.
Problem	The need for various stakeholder organisations to assess the innovation potential of methods and tools (solutions) on offer against their specific needs and expectations. Also, the need of R&D project teams to validate the project's outputs in a way that makes the findings comparable against regions, organisations, projects, and initiatives.
Alternative Solution	Various ad-hoc validation methods, demonstrators, organisation-specific solutions.
Unique Value Proposition	Sound, and well-defined methodology that has been tested and proven valuable in multiple EU projects in the domain of crisis management and Climate change adaptation. Extended through introduction of mini-trials and demonstrators in ICARIA, to streamline the validation process and separate it from dissemination.
Target Audience	Solution designers/developers on the one side and potential users of solutions (e.g. policy makers, city planners, civil protection, disaster managers, first/second responders) on the other.
Exploitation Type	Scientific: helping different consortia to trial innovative solutions in different R&I projects; publishing the lessons learnt, good practices and experiences with applying and adjusting the methodology for specific domains and audiences. Potentially also training, support and consulting related to designing, organisation and assessing the trial results on a contract basis.
IPR Considerations	
Background IPR	DRIVER+ Trial guidance methodology – no IPR restrictions.
Foreground IPR	Extension of methodology and lessons learnt in the project – no IPR restrictions.
IPR beyond the project	No IPR restrictions.

Finally, the main methodologies used in ICARIA to address data gaps and uncertainties are being compiled in a new result, a dedicated "cookbook", structured as an open access Jupyter book illustrating peer-reviewed methodologies and tools that support data collection for Climate Change, Hazard, Exposure, Vulnerability, and impact data needed to perform risk/impact assessment based on the Holistic modelling framework.

Table 8 – KER#9 ICARIA cookbook: recipes for data gap filling

KER #9	ICARIA cookbook: recipes for data gap filling
Main Features	The ICARIA cookbook is a comprehensive catalogue of datasets and methodologies to address data gaps and certainties, structured as a Jupyter notebook. This notebook outlines suitable methods to address specific

KER #9	ICARIA cookbook: recipes for data gap filling
	information and data gaps in the modelling process, leading to more effective assessment results and communication of related assumptions and limitations. The Jupyter book is divided into subsections based on methodological approach applied (e.g. statistical methods, dynamical downscaling techniques, data-driven approaches, expert elicitation methods, etc.) and data category (climate projection, hazard, exposure, vulnerability, impact).
Problem	Quantifying the impacts of complex events, including compound hazards and cascading effects, on multiple, interconnected assets and services adds complexity to evaluating Hazard, Exposure, and Vulnerability variables over time, requiring the appropriate spatial resolution to provide quantitative impact assessments that support resilient planning and decision-making. As a result, addressing data gaps involves mapping them across specific applications, both to fill the gaps and manage related uncertainties, while also recognizing the assumptions and limitations of the data and their processing through modelling.
Alternative Solution	Generic web research
Unique Value Proposition	The ICARIA cookbook, while being designed to address data gaps and uncertainties in relation to the Holistic modelling framework approach, it provides support to any kind of quantitative hazard/impact modelling methodology. Being open source and updatable over time (this will be done within ICARIA lifetime following case study modelling implementation), the cookbook can gather information on additional methods from scientific community worldwide, thus becoming a potential standalone web resource as a one-stop-shop solution for modellers. The user-friendly nature of Jupiter notebook allows further improvement of the cookbook to be implemented in a simple way.
Target Audience	Scientists, modelling experts
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	No
IPR beyond the project	No

4.2 Other Exploitable Results

This section encompasses all the sub-results derived from the primary KERs. These sub-results represent the detailed outcomes that have emerged from the main KERs, offering a more granular view of their contributions and applications. It provides a comprehensive understanding of how each KER has been expanded and utilised to achieve specific objectives and outcomes within the project.

Table 9 - OER#2.1, 2.2, 2.3 Corrected and extended weather observations

OER #2.1, 2.2, 2.3	AMB/SAR/SLZ Corrected and extended weather observation – FIC
Main Features	Database of observed timeseries filtered with an exhaustive data quality control (physical consistence, inhomogeneities, outliers and gaps), whose data were previously collected from AMB/SAR/SLZ facilitators and meteorological entities.
Problem	Direct observations collected from climate databases usually present issues on the data quality such as physical inconsistencies, inhomogeneities, outliers and gaps. Moreover, modelers of climate change impacts need to train their models with actual data and the high-quality requirement is essential to reduce the uncertainty cascading.
Alternative Solution	In the case of insufficient high-quality observed data, an alternative to complement reference observations is the ECMWF ERA5-Land reanalysis. This is a numerical model that simulates surface observations in the past according to the ERA5 reanalysis, which assimilates actual observations from the main meteorological observations in the world.
Unique Value Proposition	Modelers should choose this kind of products to feed their model training since it is the most reliable way to set a baseline reference of past observations to be crossed with records of climate-related impacts and losses.
Target Audience	Scientific community (mainly hazard/impact modellers).
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	No
IPR beyond the project	No protection

Table 10 - OER#2.4 FICLIMA climate change projections at local scale

OER #2.4	FICLIMA climate change projections at local scale – FIC
Main Features	Ensemble of climate projections (time series) at a local scale produced by applying a two-step analogue-regression (FIClima approach to the outputs of ten CMIP6 Earth System Models, previously selected to cover the ICARIA case studies with adequate resolution. This ensemble consists of 10 past simulations and 40 future projections, corresponding to a Historical experiment (per each ESM) from 01/01/1950 to 31/12/2100.

OER #2.4	FICLIMA climate change projections at local scale – FIC
Problem	Modelers of climate-related hazards such as fluvial and coastal flooding require reliable data to feed the models. The ensemble of the climate projection is essential to quantify the uncertainty level due to the ESM sensitivity and the SSP scenarios selected.
Alternative Solution	When the personnel or computational resources are insufficient, an alternative to the statistical downscaling is to use simpler bias-correction of Earth System Model outputs, but they keep the same climate change signal as in the raw output (grid point) and therefore they are not able to detect local peculiarities such as the Foehn effect in very close places (sub-grid distances).
Unique Value Proposition	To produce high quality and high-resolution simulations of climate change impacts, Modelers should consider statistical downscaled products such as those provided by FIClima. Moreover, the uncertainty assessment and management are easier with a large enough set of climate projections than with just one or two simulations. For the case of limited resources, it is recommended to select three representatives.
Target Audience	Scientific community (mainly hazard/impact modelers) and general advanced end-users.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	Yes, Licensing agreement. Have used the FIClima statistical downscaling method to produce this result.
Foreground IPR	No
IPR beyond the project	No protection

Table 11 - OER#2.5 FICLIMA climate change spatial projections

OER #2.5	FICLIMA climate change spatial projections - FIC
Main Features	Spatialisation (GeoTIFF maps) of the climate projections (timeseries) described in the product #2.4. A sophisticated method based on geostatistical approaches are applied to obtain realistic spatial distribution of the climate variables according to the regional topographic variability. A selected set of maps are produced to represent different climate periods to compare the SSP-based future projections with the Historical experiment used as a reference baseline.
Problem	In some cases, modelers use spatial-distributed models that are fed by GeoTIFF maps. Moreover, the GIS technicians of the stakeholders require spatially accurate maps and/or reports. Therefore, it is aimed to satisfy all the technical requirements.
Alternative Solution	If the resources are insufficient to produce high-quality maps, simple Thin Plate Spline or bilinear techniques can be applied to obtain a finer grid than the original raw grid of the climate model considered (or from the set of point time-series products).
Unique Value Proposition	As a more understandable and usable product for stakeholder GIS technicians, the kind of product is essential to assess the impact on the specific region of interest with a spatial solution to identify the assets' location and the impact on them.

OER #2.5	FICLIMA climate change spatial projections - FIC
Target Audience	Scientific community (mainly hazard/impact modelers), stakeholder GIS technicians and general advanced end-users.
Exploitation Type	Non-Commercial
IPR Considerations	
Background IPR	Yes, Licensing agreement. Have used the FIClima statistical downscaling method to produce this result.
Foreground IPR	No
IPR beyond the project	No protection

Table 12 - OER#3.1 Pluvial Flooding and Storm Surge

OER #3.1	Pluvial Flooding and Storm Surge - AQUATEC
Main Features	Hydrodynamic 1D/2D model to assess the hazard of pluvial floods associated to extreme rain events in the metropolitan area of Barcelona. Results are maps of water depth and velocity in flooded areas.
Problem	Need for a regional scale assessment of pluvial floods hazard combining 1D/2D aspects, because very local models based only on 1D are not so useful to understand effects on critical infrastructure that serve the whole region. Customers can be local and regional governments, city councils, civil protection departments, plan developers.
Alternative Solution	Similar models with a smaller extent.
Unique Value Proposition	Large regional scale, great level of detail in flood mapping on terrain (accurate flood maps) as the model simulates both overland flow and water transport in sewer systems. It can also help assess the limitations of sewer networks.
Target Audience	Local and regional administration.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	Yes, the model uses sensitive data under NDAs with data providers.
Foreground IPR	No
IPR beyond the project	No

Table 13 - OER#3.2-3.7 Multi-Hazard modelling tools

OER #3.2-3.7	Multi-Hazard modelling tools (Flooding, Extreme Wind, Forest Fires, Drought, Heatwave) - NCSR
Main Features	Multi-hazard tools. Assessment of drought, wildfire, temperature and winds and the derivation of pertinent indicators.
Problem	Lack of detailed quantification of hazards and their likelihood of occurrence, making it difficult to accurately assess potential risks and develop appropriate mitigation strategies.
Alternative Solution	Similar approaches with different models, climate simulations do exist.
Unique Value Proposition	High resolution process from climate simulation to scenario.
Target Audience	Policy makers, city planners, civil protection, disaster managers, first/second responders.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No

OER #3.2-3.7	Multi-Hazard modelling tools (Flooding, Extreme Wind, Forest Fires, Drought, Heatwave) - NCSR
Foreground IPR	No
IPR beyond the project	No

Table 14 - OER#3.8 Scenario Selection and Join Probability of Compound Events

OER #3.8	Scenario Selection and Join Probability of Compound Events - UNEXE
Main Features	Development of framework and tools to aid in the selection of input data/parameters for multi-hazard models and defining their respective probabilities.
Problem	While compound hazards can occur due to potential interdependencies, their joint probability may not simply be the product of their individual probabilities. The developed framework will guide the selection of parameters for compound events based on the desired return periods to be modelled.
Alternative Solution	There is a range of pre-existing methodologies for assessing Joint Probabilities of compound events such as statistical analysis and the use of Copulas.
Unique Value Proposition	The potential UVP of what is developed will be an adaptable methodological framework that could be adopted by others for use in their scenario selection for multi-hazard events.
Target Audience	Regional authorities and other decision makers, experts on climate risk/resilience assessment.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes, know-how
IPR beyond the project	No protection

Table 15 - OER#4.1 Storm Surge

OER #4.1	Storm Surge (Water sector – Wastewater) - AB
Main Features	Development of a vulnerability model that allows for the estimation of potential damage per linear meter of a main sewer parallel to the coastline in varying sewer protection scenarios in relation to some oceanographic variables. The model is a useful tool for decision-making regarding the implementation of adaptions measures.
Problem	The vulnerability assessment provides a method for estimating the potential damages that could be caused by a storm surge at any coastline sewer. The addressed problem is the absence of data that would facilitate informed decision-making.
Alternative Solution	There are not studies in the existing literature that are as specific as this one.
Unique Value Proposition	Novel and specific solution.
Target Audience	Water management entities, wastewater systems management entities, water research groups, coastal engineering research groups, port entities, coastal engineering companies, local administrations, Aigues de Barcelona, Cetaqua, Aquatec, other partners related to the water environment.

OER #4.1	Storm Surge (Water sector – Wastewater) - AB
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes – scientific paper. Developed in collaboration with a student from the Universitat Politecnica de Catalunya as part of his Bachelors' Thesis.
IPR beyond the project	No protection

Table 16 - OER#4.3 Drought (Electricity)

OER #4.3	Drought (Electricity) - IREC
Main Features	A specialised module designed to incorporate the effects of drought into the electrical grid, enabling more accurate forecasting, risk assessment, and adaptation strategies to endure the grid's resilience under water-scarce conditions.
Problem	The need of multiple tools and management of different datasets.
Alternative Solution	Own tools from electrical systems operators.
Unique Value Proposition	Novel modules to be considered.
Target Audience	SCADA developers.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes, Know-How.
IPR beyond the project	Registration. License to a spin out/Start up. All rights reserved.

Table 17 - OER#4.5 Drought (Water sector-wastewater)

OER #4.5	Drought (Water sector – wastewater) - AB
Main Features	The main exploitable outcome is the quantification of the economic costs associated with the drought period 2021-2024 in the wastewater treatment plants of the Barcelona Metropolitan Area and the proposal of adaptation measures to reduce this impact. This result can be extrapolated to the other facilities with similar characteristics.
Problem	Economical losses in drought periods in wastewater treatment plants operator (Aigues de Barcelona).
Alternative Solution	The problem has been identified but has not been thoroughly studied and solutions have not been explored so far.
Unique Value Proposition	New or initial studies.
Target Audience	Water management entities, wastewater treatment facilities management entities, Aigues de Barcelona, Cetaqua, other partners related to the water environment.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes – scientific paper.
IPR beyond the project	No protection

Table 18 - OER#4.6 Floods (Water sector-wastewater)

OER #4.6	Floods (Water sector – wastewater) - AB
Main Features	The first results are the flood maps of the wastewater treatment plants and their surroundings. This is the first time that this type of study has been carried out for wastewater treatment plants in Barcelona Metropolitan Area. Other important results are the vulnerability assessment model: a new tool to evaluate and quantify (in euros) the physical damage of a flood event in a wastewater facility.
Problem	Hazard maps utilisation enables Aigues de Barcelona to identify the flood exposure of the wastewater treatment plants under their management. The vulnerability assessment provides a method for estimating the potential damages that could be caused by a flooding at any wastewater plant.
Alternative Solution	The problem is not solved by any other alternative method so far.
Unique Value Proposition	Unique and novel solution.
Target Audience	Aigues de Barcelona and other entities in the professional environment of AGBAR group, technicians from the municipalities where the facilities are located. Water management entities, wastewater treatment facilities management entities, water research groups, Cetaqua, Aquatec.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes – scientific paper.
IPR beyond the project	No protection

Table 19 - OER#4.7 Floods (electric sector)

OER #4.7	Floods (electricity) - IREC
Main Features	Specific module to include floods impacts into electrical grid.
Problem	The reliance on multiple tools and the management of diverse datasets creates complexity and inefficiency in data handling.
Alternative Solution	Own tools from electrical systems operators.
Unique Value Proposition	Novel modules to be considered.
Target Audience	SCADA developers.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes, Know-How.
IPR beyond the project	Registration. License to a spin out/Start up. All rights reserved.

Table 20 - OER#4.8 Floods (Natural area: agriculture)

OER #4.8	Floods (Natural area: agriculture) – CETAQUA
Main Features	Development of methodology and application of assessment of tangible impacts and damages of floods in the agricultural sector.
Problem	The lack of knowledge of the impacts caused by floods in previous events and the potential increase caused by climate change, prevents from effective adaptation plans and investments. Increasing this knowledge can help make better decisions in policy making, sectoral investments and insurance.
Alternative Solution	The estimates made by the insurance sector.
Unique Value Proposition	Science-based knowledge, adaptable to different areas.
Target Audience	Public authorities, agricultural sector stakeholders (communities, unions, etc).
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes – Scientific Paper
IPR beyond the project	No Protection

Table 21 - OER#4.9, 4.10 Floods (planning and land use)

OER #4.9, 4.10	Floods – AQUATEC
Main Features	Flood impact assessment methods applied to the AMB region to help managers decide on urban planning and adaptation measures at regional scale
Problem	The need for a regional scale assessment of pluvial floods risk. Customers can be local and regional governments, city councils, civil protection departments, emergency plan developers.
Alternative Solution	Similar models with a smaller extent.
Unique Value Proposition	Large regional scale risk maps for regional risk management and adaptation plans.
Target Audience	Local and regional administration.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	No
IPR beyond the project	No

Table 22 - OER#11 Floods (Transport)

OER #4.11	Floods (Transport) - UNEXE
Main Features	Development of methodological framework and tools for assessing potential impacts of flooding and compound flooding on traffic networks.
Problem	Development of an analytical approach for assessing potential flood hazards to the transport network.
Alternative Solution	There is a variety of methods for assessing potential impacts to traffic networks from flooding. Two common approached disruption:

OER #4.11	Floods (Transport) - UNEXE
	1. GIS based analysis: Spatial analysis of flood depths along road network is assessed to determine potential disruption 2. Loosely coupled flood and traffic model: Flood model outputs serve as inputs to road network.
Unique Value Proposition	There is no direct USP for the traffic impact assessment as standardised approach. However, the linking of transport assessment in context of cascading effects could add value to USP of other components in ICARIA modelling framework.
Target Audience	Regional authorities and other decision makers, asset and service managers, experts on climate risk/resilience assessment, citizens, general audience.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes, know-how.
IPR beyond the project	No protection

Table 23 - OER#4.12, 4.13, 4.17, 4.18 Climate-related multi-risk tangible impact assessment method

OER #4.12, 4.13, 4.17, 4.18	Climate-related multi-risk tangible impact assessment method (Floods, Forest fires, Wind) - NCSR
Main Features	Impact models for wildfire hazard on different critical assets.
Problem	Impact assessment with spatial characteristics.
Alternative Solution	Different vulnerability functions and GIS based tools.
Unique Value Proposition	Simplicity
Target Audience	Policy makers, city planners, civil protection, disaster managers, first/second responders.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	No
IPR beyond the project	No

Table 24 - OER#4.14 Heat wave

OER #4.14	Heat wave (Electricity) - IREC
Main Features	A dedicated module designed to account for the impacts of heatwaves on the electrical grid.
Problem	The need of multiple tools and management of different datasets.
Alternative Solution	Own tools from electrical systems operators.
Unique Value Proposition	Novel modules to be considered.
Target Audience	SCADA developers
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	Yes, Know-How
IPR beyond the project	Registration. License to a spin out/Start up. All rights reserved.

Table 25 - OER# 4.15 Heat Wave

OER #4.15	Climate-related multi-risk tangible impact assessment method - Heat Wave (People) - UNINA
Main Features	The model provides an estimate of health impacts associated with heat wave events (increase in mortality and hospitalisation costs) in relation to climate change, considering the effect of urban climate in relation to urban morphology, green/blue infrastructure and surface characteristics of buildings and open spaces.
Problem	The Heat Wave Local Effect Model (HWLEM) is designed to simulate heat wave hazard with respect to climate respect to climate change scenarios coupled with urban microclimate features, and the associated impacts on human health in terms of mortality increase and hospitalisation costs. The integration of information that can be deduced from climate projections (regions/city level) with small variations (district/block/building level), allows to better understand Urban Heat Island conditions and support the identification of suitable adaptation strategies and measures.
Alternative Solution	Several tools exist to assess Urban Heat Island conditions, but none found in literature allows the quantification of potential health impacts at city and district scale. Relevant tools, such as ENVI-MET and SOLWEIG are able to characterise heat wave hazard, but do not allow to include specific exposure and vulnerability information about population, thus limiting their use in a multi-hazard/impact framework.
Unique Value Proposition	The UPV of the Heat Wave Local Effect Model lies in its full integration and with Geospatial Information Systems, widely used in the context of regional and urban planning. A database of adaptation measures, which include performance and cost information, is seamlessly integrated in the model, thus supporting the identification and prioritisation of solutions suitable and sustainable in the local context, by analysing and confronting alternative scenarios with different spatial and temporal resolutions. Furthermore, the model enables an integrated assessment of mitigation and adaptation potential of planning scenarios, providing critical information to assess measures that, by acting on both urban morphology and land cover, reduce heat wave hazard and impact while delivering socio-economic (e.g. reduction in energy consumption), and environmental (e.g. CO2 storage from vegetation) co-benefits.
Target Audience	Urban planners, researchers.
Exploitation Type	Non-Commercial
IPR Considerations	
Background IPR	Yes, the model is owned by UNINA-PLINIVS.
Foreground IPR	No
IPR beyond the project	No protection, with free access rights to the consortium partners once the project is over for more than 5 years.

Table 26 - OER#4.19 Gridwatch

OER #4.19	GRIDWATCH - IREC
Main Features	An easy-to-use tool, integrated and multidisciplinary.
Problem	The need of multiple tools and management of different datasets.
Alternative Solution	Own tools from electrical systems operators.
Unique Value Proposition	Unique specific tool dealing with extreme events and electrical grid.
Target Audience	SCADA developers, DSOs.
Exploitation Type	Other
IPR Considerations	
Background IPR	Yes, GRIDWATCH is a tool for studying and identifying potential risks on the electrical grid due to extreme weather conditions. IREC has this tool already registered through BOIP iDEPOT.
Foreground IPR	No
IPR beyond the project	Copyright. License to a spin out/Start up. All rights reserved.

Table 27 - OER#5.1 Holistic Resilience Assessment Framework and tool

OER #5.1	Holistic Resilience Assessment Framework (RAF) and tool (RAF-app) - LNEC
Main Features	Framework and web application that provides a holistic resilience diagnosis of the regions, cities and strategic urban sectors regarding climate change, following an objective-driven approach. It identifies data gaps and areas for resilience improvement, guides the development of an assessment tailored to each urban service, region or city, supports risk-informed decision-making, by comparing the contribute to resilience of different measures and strategies, monitors the progress of resilience over time and facilitates the communication among stakeholders. Several urban services can be assessed: water, wastewater, storm water, waste, energy, mobility and natural areas.
Problem	Resilience encompasses many dimensions. Focusing on a single aspect (governance, spatial risk, social aspects, service or infrastructure), while performing a sectoral assessment might disregard relevant aspects for integrated resilience building. A city or a region cannot be considered climate resilient if its residents, tourists, buildings, streets, services, policies, finances etc., are not resilient both now and in the future. A holistic assessment ensures that every resilience objective is addressed, cascading effects are considered, and planning for resilience pathways is supported without neglecting critical areas. Resilience is a complex concept that needs to be deconstructed to be acknowledged and perceived by all stakeholders, as all of them have a role to play in enhancing resilience and securing necessary funding. Visualising the areas for improvement is a significant step forward.

OER #5.1	Holistic Resilience Assessment Framework (RAF) and tool (RAF-app) - LNEC
Alternative Solution	Solutions for resilience assessment exist for specific sectors, or even for holistic assessments, but these are mostly not publicly available or don't provide a standardised assessment. In other words, the metrics are not uniformly graded on the same scale, which hinders the ability to diagnose and compare progress over time.
Unique Value Proposition	The RAF App will be publicly and freely available after the project concludes. It facilitates a step-by-step assessment, allowing for a more detailed evaluation based on the user's level of expertise. The app offers both an objective-driven overall resilience assessment and service-specific evaluations. The framework follows a tree structure, with each section graded on a 0-3 scale, making it easy to identify strengths and weaknesses.
Target Audience	Region, city and services managers; multilateral organisations (e.g. NGOs), scientific community (researchers, university professors and students); resilience officers; urban planners; consultancy companies.
Exploitation Type	Non - Commercial
IPR Considerations	
Background IPR	Yes. The ICARIA RAF and RAF App were upgraded from the results of other projects. The RESCCUE RAF and RAF App.
Foreground IPR	No
IPR beyond the project	The RAF and RAF App are publicly and freely available, but users have to register and acknowledge RESCCUE. Education and free use and it will be available to the consortium after the end of the project for more than 5 years.

Table 28 - OER#5.2 Resilience Assessment Tool for critical infrastructure

OER #5.2	Resilience Assessment Tool (RAT) for critical infrastructure - NCSR
Main Features	Performs a user-driven assessment of the resilience capabilities for anticipation, absorption, coping, restoration and adaptation of services of the analysed critical entities to the analysed climate hazards.
Problem	Resilience of critical assets.
Alternative Solution	Project based resilience assessment tools, not any standard tool yet.
Unique Value Proposition	Easiness and accuracy.
Target Audience	Policy makers, city planners, civil protection, disaster managers, first/second responders.
Exploitation Type	Scientific
IPR Considerations	
Background IPR	No
Foreground IPR	No
IPR beyond the project	No

*Regarding the OERs for which input has not been provided, as the primary focus is on the exploitation of the KERs, the respective partners have provided justifications for their omission detailed in Table *29*.

Table 29 - Justifications for missing OERs

OERs	Justifications
2.6 – Spatially downscaled climate projections (2RCMs)	"Spatially downscaled climate projections" have been described by AIT as open source, with no additional input required for this data. It will be used as-is, although there may be some bias correction applied.
4.2 – Drought (Agriculture, Economic sectors, Natural area)	The methodologies used to estimate the tangible damages on these sectors are existing published methods, adapted to the trials and data available. Therefore, it is not possible to exploit these results, although publications and the deliverable will be made available for knowledge transfer and applicability to other territories.
4.4 – Drought (Water sector)	"Drought (Water sector)": Risk is assessed based on threshold values defined by the regional government, making the method CS specific and not easily transferable to other regions. Therefore, this sub-KER can be excluded from the plan.
4.16 – Wind (Electricity + Trees)	It will be used in the impact assessment and potentially in other contexts as well. The vulnerability functions currently being developed will be utilised for the decision support system (DSS).

5. Exploitation Strategies

This section aims to present the overall strategy followed for the ICARIA exploitation planning. It provides an overview of the approach taken to ensure that the project's results are effectively utilised across various domains, including commercial, non-commercial, and scientific avenues. By outlining this exploitation strategy, the section highlights how each type of exploitation will contribute to maximising the impact of the ICARIA project ensuring long-term sustainability and relevance of its results.

5.1 Overall Plan

The primary goal is to ensure that the exploitation of ICARIA's results extends well beyond the project's lifespan and remains sustainable in the long term. Specifically, the objective is to maximise the impact of the project's results by leveraging them through various channels, including scientific research, commercial applications, and societal benefits. This approach aims to secure the enduring relevance and utility of ICARIA's contributions across multiple sectors.

To achieve this goal, the ICARIA exploitation plan takes a three-dimensional exploitation approach, including three types of exploitation. **Commercial** exploitation, **Non-commercial** exploitation and **Scientific** exploitation.

Additionally, ICARIA's exploitation plan will involve both individual and joint efforts to maximise scientific, social and economic impacts. This approach will ensure the commercialisation of some of the project results, allowing them to benefit all partners and contribute to the broader economy.

Individual Exploitation: This involves each partner leveraging the ICARIA project results for their own activities. Essentially, each partner will apply the project's results within their own businesses and operations.

Joint Exploitation: This involves partners collaboratively leveraging the project's results as a unified business entity. This could take the form of a joint venture for commercial activities or a consortium for non-commercial endeavours, allowing the partners to exploit the results collectively.

5.2 Commercial Exploitation

The commercial exploitation of ICARIA's results pertains to the pursuit of business opportunities that may arise after the project's completion. The project partners may investigate diverse strategies and opportunities to effectively leverage the results produced during the project's execution.

At this stage, it is important to highlight that the plans and strategies for commercial exploitation will undergo further evaluation and refinement in the upcoming deliverable (D4.5 – Final Plan). This follow-up deliverable will present a more detailed and comprehensive plan for commercial exploitation, incorporating new insights gained during the project's implementation. This will help to ensure that the project's results are effectively disseminated and utilised, and that any potential commercial opportunities are fully realised.

Table 30 - KER#7 DSS

KER #7	DSS (Decision Support System)
Project Partners Involved	DRAXIS

KER #7	DSS (Decision Support System)
Exploitation Rights and Responsibilities	Single ownership / Single responsibility for retailing.
Exploitation intention & actions	The DSS may go through additional development rounds in the context of other European projects, adapting it to meet diverse requirements and demonstrating its practical value. The DSS will be available to customers as a service. Possible strategic partnerships through European or other projects to expand the client base, marketing, piloting.
Exploitation pathway	Individual Exploitation
Target customers/end-users	Primarily civil society, researchers and public sector
Early adopters	Regional authorities, citizens, researchers.
Go to market – Use model	The ICARIA DSS will be put to use primarily through the provision of a service model, offering access via a web-based platform. This will include direct industrial use and strategic partnerships, supported by contract research and targeted training sessions to ensure effective adoption and impact.
Target market	Regional authorities and other decision makers, Asset and service managers, Experts on climate risk/resilience assessment, citizens and general audience
Ways of exploitation	Civil society can employ the DSS to advocate for resilient planning, and education on climate risks and impacts; researchers could use the DSS as part of assessing and visualising risk/impacts of hazards on specific regions and risk receptors, and to prioritise adaptation solutions; the public sector could review the assessments completed through the DSS to plan for hazard mitigation, select adaptation strategies and inform policy decisions.
Competition / Strengths & Weaknesses compared to DSS	Competitors: Esri – ArcGIS, QGIS Dev Team – QGIS, GRASS Dev Team – GRASSA GIS, Sourceforge – SAGA GIS, Google – Google Earth Pro, Supergeo Technologies – SuperGIS, Pitney Bowed – MapInfo Pro. Strengths: popular solutions like ArcGIS (by Esri), QGIS and similar ones, which already have an established user base, extensive data and proven track record. Weaknesses: high cost, high complexity meaning they are typically only used by experts.
Barriers and obstacles	Limited awareness among target users, integration challenges with existing systems.
Market Opportunities, drivers and trends	Improvement of climate planning on regions and strategic assets, heightened awareness of climate change impacts, risk reduction provided by cost-effective adaptation solutions.
Risks	Ineffective reach to user/client base, competitive pressure from established platforms, privacy concerns with regards to critical infrastructure.
Mitigation Measures	From strategic partnerships with key stakeholders, implement targeted marketing campaigns, conduct demonstrations and workshops, and use testimonials and case studies from early adopters to increase visibility and credibility.

5.3 Non-Commercial Exploitation

This subsection focuses on the non-commercial exploitation of the ICARIA project's results, which can create significant value by facilitating knowledge exchange and enhancing educational opportunities. Promotion of these results can be achieved through multiple avenues, such as offering open access, presenting at conferences and networking events, publishing on the project website, developing communication materials, and utilising social media platforms.

Table 31 - OER#2.5 FICLIMA climate change spatial projections

OER #2.5	FICLIMA climate change spatial projections
Project Partners Involved	FIC
Exploitation Rights and Responsibilities	Single ownership / Single responsibility for retailing.
Exploitation intention & actions	Published in open repositories such as ZENODO. A summary will be published in peer-viewed scientific journals.
Exploitation pathway	Joint Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 32 - OER#4.15 Heat Wave

OER #4.15	Climate-related multi-risk tangible impact assessment method/Sub-result Heat Wave (People)
Project Partners Involved	UNINA
Exploitation Rights and Responsibilities	Single responsibility for an agreement with external distributor.
Exploitation intention & actions	The Heat Wave Local Effect Model is an on-demand service-based tool, and users can deliver city plans and architectural drawing through any kind of software. The recommended software is Q-GIS for the 2D city plans and Rhinoceros (McNeel) for 3D models. Detailed user guide and video tutorials include tips to collect data, implement baseline and adaptation scenarios according to the model taxonomy.
Exploitation pathway	Joint Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 33 - OER#6 Portfolio of adaptation solutions

KER #6	Portfolio of adaptation solutions
Project Partners Involved	CETAQUA
Exploitation Rights and Responsibilities	Single ownership / No responsibility
Exploitation intention & actions	Dissemination of knowledge, potentially including it in digital tools, such as DSS.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

5.4 Scientific Exploitation

This subsection covers the scientific exploitation of the project's results, which involves advancing research through additional studies, publishing scientific articles, and contributing to the broader progress of the research community.

Table 34 - KER#1 Holistic modelling framework

KER #1	Holistic modelling framework (Project framework)
Project Partners Involved	UNINA
Exploitation Rights and Responsibilities	No ownership
Exploitation intention & actions	The application of the ICARIA modelling framework to project trials and mini-trials is expected to showcase its flexibility with respect to different complex multi-hazard contexts.
Exploitation pathway	Joint Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 35 - OER#2.1, 2.2, 2.3 Climate scenarios methods and results - corrected weather observations

OER #2.1, 2.2, 2.3	Climate scenarios methods and results – corrected weather observations
Project Partners Involved	FIC
Exploitation Rights and Responsibilities	No ownership / Joint responsibility for an agreement with an external distributor.
Exploitation intention & actions	Shared with modelers through the FIClima/ICARIA server
Exploitation pathway	Joint Exploitation with the entities which have provided the data used in the refinement process.
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 36 - OER#2.4 FICLIMA climate change projections at local scale

OER #2.4	FICLIMA climate change projections at local scale
Project Partners Involved	FIC
Exploitation Rights and Responsibilities	Single ownership / Single responsibility for retailing
Exploitation intention & actions	Published in open repositories such as ZENODO. A summary will be published in peer-reviewed scientific journals.
Exploitation pathway	Joint Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 37 - OER#3.1 Pluvial Flooding and Storm Surge

OER #3.1	Pluvial Flooding and Storm Surge
Project Partners Involved	AQUATEC

OER #3.1	Pluvial Flooding and Storm Surge
Exploitation Rights and Responsibilities	Single ownership for retailing-licensing / Single responsibility for an agreement with external distributor.
Exploitation intention & actions	Publication on scientific journals.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 38 - OER#3.2-3.7 Multi-Hazard modelling tools (Flooding, Extreme Wind, Forest Fires, Drought)

OER #3.2-3.7	Multi-Hazard modelling tools (Flooding, Extreme Wind, Forest Fires, Drought)
Project Partners Involved	NCSR
Exploitation Rights and Responsibilities	Single Ownership / No responsibility
Exploitation intention & actions	Scientific Publications
Exploitation pathway	Joint Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 39 - OER#3.8 Scenario Selection and Join Probability of Compound Events

OER #3.8	Scenario Selection and Join Probability of Compound Events
Project Partners Involved	UNEXE
Exploitation Rights and Responsibilities	Joint ownership / Joint responsibility for retailing (Case Study + UNEXE)
Exploitation intention & actions	Provide insights into the joint probabilities of compound hazard events.
Exploitation pathway	Joint Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 40 - OER#4.1 Storm Surge (Water sector- wastewater)

OER #4.1	Storm Surge (Water sector- wastewater)
Project Partners Involved	AB
Exploitation Rights and Responsibilities	Single ownership / No responsibility
Exploitation intention & actions	Dissemination of knowledge. Providing it to interested entities. Publications.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 41 - OER#4.3 Drought (Electricity)

OER #4.3	Drought (Electricity)
Project Partners Involved	IREC
Exploitation Rights and Responsibilities	Single Ownership / Single responsibility for retailing.
Exploitation intention & actions	Potential transfer of the tool and/or spin off creation.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 42 - OER#4.5 Drought (Waste sector - wastewater)

OER #4.5	Drought (Waste sector – wastewater)
Project Partners Involved	AB
Exploitation Rights and Responsibilities	Single ownership / No responsibility
Exploitation intention & actions	Dissemination of knowledge. Providing it to interested entities. Publications.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 43 - OER#4.6 Floods (Waste sector - wastewater)

OER #4.6	Floods (Water sector – Wastewater)
Project Partners Involved	AB
Exploitation Rights and Responsibilities	Single ownership / No responsibility
Exploitation intention & actions	Dissemination of knowledge. Providing it to interested entities. Publications.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 44 - OER#4.7 Floods (Electricity)

OER #4.7	Floods (Electricity)
Project Partners Involved	IREC
Exploitation Rights and Responsibilities	Single Ownership / Single responsibility for retailing
Exploitation intention & actions	Potential transfer of the tool and/or spin off creation.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 45 - OER#4.8 Floods (Natural area: agriculture)

OER #4.8	Floods (Natural area: agriculture)
Project Partners Involved	CETAQUA
Exploitation Rights and Responsibilities	Single ownership/ Single responsibility for an agreement with external distributor.
Exploitation intention & actions	Dissemination of knowledge, potentially including it in digital tools, such as DSS.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 46 - OER#4.9, 4.10 Floods (Natural area)

OER #4.9, 4.10	Floods (People, infrastructure)
Project Partners Involved	AQUATEC
Exploitation Rights and Responsibilities	Single ownership for retailing-licensing / Single responsibility for an agreement with external distributor.
Exploitation intention & actions	Publication on scientific journals.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 47 - OER#4.11 Floods (Transport)

OER #4.11	Floods (Transport)
Project Partners Involved	UNEXE
Exploitation Rights and Responsibilities	Joint ownership / Joint responsibility for retailing (Case Study + UNEXE).
Exploitation intention & actions	Provide insights into the potential risks that are flooding, and compound events pose to traffic networks.
Exploitation pathway	Joint Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 48 - OER#4.12, 4.13, 4.17, 4.18 Climate-related multi-risk tangible impact assessment method

OER #4.12, 4.13, 4.17, 4.18	Climate-related multi-risk tangible impact assessment method
Project Partners Involved	NCSR
Exploitation Rights and Responsibilities	Single Ownership / No responsibility
Exploitation intention & actions	Scientific Publications
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 49 - OER#4.14 Heat

OER #4.14	Heat
Project Partners Involved	IREC
Exploitation Rights and Responsibilities	Single Ownership / Single responsibility for retailing.
Exploitation intention & actions	Potential transfer of the tool and/or spin off creation.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 50 - OER#4.19 Gridwatch

OER #4.19	GRIDWATCH
Project Partners Involved	IREC
Exploitation Rights and Responsibilities	Single Ownership / Single responsibility for retailing
Exploitation intention & actions	Potential transfer of the tool and/or spin off creation
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 51 - OER#5.1 Resilience Assessment Framework and Tool

OER #5.1	Resilience Assessment framework and tool
Project Partners Involved	LNEC
Exploitation Rights and Responsibilities	Single ownership for retailing/licensing – Single responsibility for retailing
Exploitation intention & actions	Promote the educational and scientific use of the tool and consider incorporating it into future consultancy and training sessions regularly offered by LNEC or other research and academic organisations.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 52 - OER#5.2 Resilience Assessment Tool for critical infrastructure

OER #5.2	Resilience Assessment Tool (RAT) for critical infrastructure
Project Partners Involved	NCSR
Exploitation Rights and Responsibilities	Single Ownership / No responsibility
Exploitation intention & actions	Scientific Publications
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 53 – KER#8 Trial Guidance Methodology

KER #8	Trial Guidance Methodology
Project Partners Involved	AIT
Exploitation Rights and Responsibilities	No IPR restrictions
Exploitation intention & actions	Promote the use of Trial Guidance Methodology in future EU projects for Climate Change adaptation, mitigation and related domains (e.g. Crisis and disaster management, energy transition, sustainability), and as a method for gathering actionable information on the merits of different solutions for specific user and usage types, for specific organisations and across different projects and initiatives.
Exploitation pathway	Individual Exploitation
Target customers/end-users	N/A
Early adopters	N/A
Go to market – Use model	N/A

Table 54 - KER#9 ICARIA cookbook: recipes for data gap filling

KER #9	ICARIA cookbook: recipes for data gap filling
Project Partners Involved	CERTH, UNINA, FIC
Exploitation Rights and Responsibilities	No IPR restrictions
Exploitation intention & actions	Promote the use of ICARIA modelling framework by delivering actionable methodologies to address data gaps filling and uncertainty treatment. ICARIA has compiled a variety of methodologies for addressing data gaps and managing data uncertainty into a "cookbook." This resource details different data gap categories, requirements, templates, and sources, highlighting the potential for replicating these methods in case studies or lab settings. The cookbook offers a range of strategies for handling data gaps and uncertainties, such as automated downscaling, extrapolation, and synthetic data generation, with a focus on data-driven techniques and their practical applications. The ICARIA cookbook is provided as a web resource hosted on a GitHub repository for easy access, updates, and modification by case study facilitators. The link to the Jupyter Book is: https://georgiti.github.io/ICARIA-book/content/recipes/introduction/introduction.html.
Exploitation pathway	Individual exploitation
Target customers/end-users	Scientists, modelling experts
Early adopters	ICARIA followers
Go to market – Use model	N/A

5.5 Joint Exploitation

The ICARIA project is focused on enhancing disaster resilience and climate adaptation across Europe. The Business Model Canvas elaborates on the project's critical elements, such as key partnerships, essential activities, and necessary resources. It also addresses the cost structure, revenue streams, and the project's eco-social impacts. A central feature of this canvas is its emphasis on joint exploitation among project partners.

The goal of joint exploitation is to ensure that the diverse results and innovations developed throughout the project are effectively integrated and utilised. Specifically, the ICARIA project aims to combine all individual outcomes into three primary platforms: the Climate Resilience Assessment Tools, the Portfolio of Adaptation Solutions, and the Decision Support System (DSS).

By facilitating joint exploitation, ICARIA promotes collaboration among partners to optimise the use and impact of the project's results. This collaborative approach allows for the sharing of resources, expertise, and data, thereby enhancing the overall effectiveness of the tools and solutions developed. The Business Model Canvas illustrates how this integration strategy will support the long-term sustainability of the project's impacts and contribute to building a more resilient and adaptive European climate framework.

Table 55 - Initial Business Model Canvas

KEY PARTNERS	KEY ACTIVITIES	VALUE PROPOSITION	CUSTOMER RELATIONSHIPS	CUSTOMER SEGMENTS
• Consortium partners (research institutions, universities, private companies, government agencies). • Local and regional authorities involved in disaster management. • Non-governmental organisations (NGOs) focused on disaster	• Developing and implementing disaster resilience and adaptation technologies. • Designing and testing early warning systems and response protocols. • Engaging with stakeholders and communities for feedback and collaboration. • Disseminating findings and best practices through reports, publications, and conferences.	• Innovative solutions and tools to enhance disaster resilience and adaptation across Europe. • Enhanced infrastructure and service reliability in the face of extreme weather events.	• Collaborative partnerships with stakeholders and end-users for co-development and feedback. • Engaging with communities through outreach and educational initiatives. • Regular updates and communication through reports, workshops, and conferences.	• Government agencies and local authorities responsible for disaster management. • Communities affected by or at risk of natural disasters. • Emergency response teams and healthcare providers. • Research and academic

<table>
<tr>
<td>relief and recovery.
• Technology providers.
• Academic and research institutions.</td>
<td>KEY RESOURCES
• Expertise and knowledge from consortium partners and researchers.
• Technological infrastructure and development tools.
• Financial resources and funding from grants and sponsors.</td>
<td></td>
<td>CHANNELS
• Direct engagement with government agencies and stakeholders through workshops and meetings.
• Online platforms for disseminating research findings and project updates.
• Publications in academic journals and industry reports.
• Conferences and seminars for knowledge sharing and networking.
• Collaborative tools and platforms for partner communication and coordination.</td>
<td>institutions focusing on climate adaptation and disaster resilience.
• Private sector organisations in infrastructure and technology solutions.</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
• Research and development expenses for technology and solutions
• Personnel costs for project team and researchers.
• Operational costs (travel, materials, administrative support).
• Costs associated with testing, deployment, and training of new systems.
• Communication and dissemination expenses for outreach and stakeholder engagement.</td>
<td colspan="3">REVENUE STREAMS
• Funding from grants and public sector investments.
• Contributions from partner organisations and sponsors.
• Licensing/commercialisation of developed technologies and solutions,
• Fees for training and consultancy services related to project’s outcomes.</td>
</tr>
<tr>
<td colspan="3">ECO-SOCIAL COSTS
• Environmental impact of implementing new technologies.</td>
<td colspan="3">ECO-SOCIAL BENEFITS
• Enhanced community resilience and reduced vulnerability to natural disasters.
• Improved public health and safety through better disaster preparedness and response.
• Strengthened infrastructure and reduced economic losses from extreme weather events.
• Increased awareness and engagement in disaster risk reduction and climate resilience efforts.</td>
</tr>
</table>

6. Sustainability Planning

This section outlines the ICARIA CSFs' intentions to implement or sustain the project's results in each case study after the project's conclusion. CSFs were asked to detail their specific project's results, the ultimate aim, the main stakeholders involved, and the potential benefits these stakeholders might receive. Additionally, the section covers planned activities for implementation or continuation, including estimated timelines and required resources. However, given the limited detail in this section, sustainability will be thoroughly examined in the next deliverable, as most CSFs will have a clearer understanding of what they will maintain, replicate, or extend beyond the project.

Table 56 – Case Studies

Case Studies	Country
Region of South Aegean	Greece
Salzburg Region	Austria
Barcelona Metropolitan Area	Spain

Table 57 - Region of South Aegean

Region of South Aegean	
Result to be implemented/maintained after the end of project	Wildfire – extreme risk assessment
Partners involved	To be defined
Aim of the implementation/continuation	Provide support to SAR for building climate resilience and better disaster management preparedness.
Main stakeholders	Public Sector
Main benefits	-
Obstacles, Barriers	-
Activities for the implementation/continuation	Results can continue to be sent to SAR without any specific requirements.
Time Period	Less than 1 year
Resources Needed	N/A
Replicability	N/A

Table 58 - Salzburg Region

Salzburg Region	
Result to be implemented/maintained after the end of project	The data produced (e.g. climate projections, vulnerability curves, etc.) if compatible with their local data network, DSS if deemed useful.
Partners involved	In case the DSS is implemented, depending on needed steps – DRAXIS.
Aim of the implementation/continuation	To enable adaptation to future extreme events, based on scientific data and findings.
Main stakeholders	Public Sector
Main benefits	If implemented in a user-friendly manner for stakeholders and end-users, it should enable the investigation of potential future impacts of extreme events and the benefits of adaptation measures, thereby facilitating informed decision-making regarding the implementation of these measures.

Salzburg Region	
Obstacles, Barriers	The main point emphasised so far is that the tools need to be complementary to or integrated into the existing working system.
Activities for the implementation/continuation	This will become clearer with the availability of the DSS, its usability for stakeholders, and the identification of gaps that need to be addressed to ensure sustainable implementation.
Time Period	2 years
Resources Needed	Financial resources and stakeholders' time.
Replicability	Climate data and the DSS can be replicated, but there may be challenges with the vulnerability data. However, if other regions are interested, replication can still be achieved.

Table 59 - Barcelona Metropolitan Area

Barcelona Metropolitan Area	
Result to be implemented/maintained after the end of project	-RAF tool -RAT tool -Portfolio of Adaptation measures -DSS
Partners involved	RAF tool – LNEC as main developer and owner of the tool. RAT tool – NCSR DEMOKRITOS as main developer and owner of the tool. Portfolio of Adaptation measures – CETAQUA as main developer and owner of the tool. DSS – DRAXIS as main developer and owner of the tool.
Aim of the implementation/continuation	Support climate adaptation plans developed by local/regional authorities or practitioners/consultants who develop these kinds of plans.
Main stakeholders	Public Sector
Main benefits	Better tools to design climate adaptation measures.
Obstacles, Barriers	None in particular
Activities for the implementation/continuation	Communicate their existence to relevant stakeholders, as being done via the CS CoPs.
Time Period	2 years
Resources Needed	TBD
Replicability	The tools are designed to be replicable in other geographical areas after the project end.

7. Conclusion and Way Forward

This deliverable outlines the initial Exploitation and Sustainability Plan for the ICARIA project, focusing on strategies to maximise and sustain the impact of its results. As a preliminary report, it provides an early framework of how the project's results are aimed to be utilised and maintained. According to the input provided by partners, it is indicated that 65% of them intend to individually exploit their results, suggesting a preference for tailoring the results to their specific contexts, which could enable for more targeted and possibly innovative uses of the results. On the other hand, 35% of them intend to exploit their results jointly, reflecting a strategy to share resources, expertise and enhance the overall impact of the project's outcomes through combined efforts.

The Exploitation Plan provides a detailed characterisation of the project's results, outlining how these can be utilised by disaster management authorities—the primary target market for all KERs. It describes the potential for individual exploitation of each identified result and sub-result, ensuring that all the results will contribute to and support the final three KERs on the list: the RAF & RAT tool, the portfolio of adaptation measures, and the DSS. These components will be the focal points in the subsequent deliverable, D4.5 Final Plan.

In parallel, the Sustainability Plan details the intentions of ICARIA CSFs for implementing or continuing the results beyond the project's end in each case study. By focusing on these aspects, the plan aims to secure the long-term benefits of the ICARIA project, ensuring that its results continue to address environmental and infrastructural challenges in each case study area.

Based on the market analysis, it is evident that climate change is expected to increase the frequency and intensity of natural hazards, such as floods and extreme temperatures, posing significant risks to Europe. These climate-related disasters have already led to substantial economic losses with projections indicating further rises, if no effective action is taken. The ICARIA project embodies this approach by integrating technology to enhance disaster resilience and economic stability across diverse regions. Through these collaborative strategies, the project aims to build sustainable frameworks that not only address the immediate impacts of disasters but also support long-term economic recovery and growth.

To refine and finalise this plan, a series of workshops will be conducted following the submission of this initial version of the Exploitation & Sustainability Plan. These workshops will serve as collaborative platforms for partners to engage in in-depth discussions, share insights, and align on key strategies. The goal is to ensure that the final version not only accurately reflects the collective intentions of the consortium but also consolidates and strengthens the strategies for each KER. By facilitating this collaborative process, the workshops will help create a well-rounded, actionable plan that supports the long-term impact and sustainability of the project.

Finally, the next deliverable, D4.5 – Final Plan, will provide a comprehensive review of the progress and implementation of the results. It will detail the finalised strategies, their ongoing application, and the efforts towards replication. Ultimately, all ICARIA models, tools and methods will contribute to a comprehensive DSS for climate resilience planning. While many individual results may not be directly exploitable, their true value lies in collaborative integration. According to the GA, the most commercially viable results will be the technological ones, particularly the DSS, which integrates all methods and tools developed in the project. This integrated approach will enable the DSS to compare adaptation measures effectively, identifying the most suitable, sustainable, and cost-efficient solutions for each specific case.

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ANNEX A: Useful terms on Exploitation & IPR

Table 60 incorporates commonly used terms related to exploitation in this document with the goal of creating a shared understanding.

Table 60 - Useful terms on exploitation

Term	Definition/Description
Main Features	Interesting/important part or characteristic of the exploitable result.
Problem	The problem potential users have.
Alternative Solution	How the customer has solved the problem so far.
Unique Value Proposition	Competitive advantages, innovative aspects compared to similar solutions.
Target audience	People/organisations that make them concrete use of the project's results.
Exploitation Type	Commercial/Non-commercial/Scientific
Exploitation Rights	1 - No ownership of a result – The partner will own no rights with regard to the Icaria result. 2 - Joint ownership of a result – Multiple partners will own joint rights with regard to the Icaria result. The exact sharing of the rights of this Foreground result is the subject of a separate agreement. 3 - Single ownership of a result – A single partner will own rights with regard to the Icaria result. Should sharing of rights be required with individual partners for a given result, it will be the subject of a separate agreement. 4 - Joint ownership of a result for retailing/licensing – Multiple partners will own the Icaria exploitable result for producing and retailing, licensing and/or actively come to an agreement with a third-party company capable of producing and retailing the result. 5 - Single ownership of a result for retailing/licensing – A single partner will own the Icaria exploitable result for producing and retailing, licensing and/or actively come to an agreement with a third-party company capable of producing and retailing the result.
Exploitation Responsibilities	1 – No responsibility of the result – The partner will hold no exploitation responsibility of the result. 2 - Joint responsibility for retailing/licensing the result – Multiple partners will produce and retail, license and/or actively come to an agreement with a third-party company capable of producing and retailing the "Icaria result", taking any reasonable provision that it is designed and produced in good quality, at competent cost and at the required by the Market volumes. 3 - Single responsibility for retailing/licensing the result – A single partner will produce and retail, license and/or actively come to an agreement with a third-party company capable of producing and retailing the Icaria exploitable

Term	Definition/Description
	result, taking any reasonable provision that it is designed and produced in good quality, at competent cost and at the required by the Market volumes. 4 - Joint responsibility for an agreement with an external distributor – Multiple partners will use reasonable endeavours to license and/or actively come to an agreement with a distributor capable of producing and exploiting and licensing the "Icaria result", taking any reasonable provision that it is designed and produced in good quality and licensed against a reasonable license fee. 5 - Single responsibility for an agreement with an external distributor – Partner A will use reasonable endeavours to license and/or actively come to an agreement with a distributor capable of producing and exploiting and licensing the "Icaria result", taking any reasonable provision that it is designed and produced in good quality and licensed against a reasonable license fee.
Exploitation intention and actions	Type pf exploitation intended to pursue
Exploitation pathway	1-Individual Exploitation: the exploitation of results on the basis of each partner's activities. 2-Joint exploitation: joint exploitation of Icaria outputs as a common line of business for all involved partners.
Target customers/end-users	Potential customer segments that will uptake the result and will be interested
Early adopters	The customers to address first.
Go to market – Use model	How the KER will be put in use (made available to customers).
Target market	The potential market in which the product/service will be used.
Barriers & Opportunities	Barriers: Unfavourable market conditions that might affect negatively the uptake of the result. Opportunities: Favourable market conditions or trends that may affect positively the uptake pf the result(s).

Intellectual Property Rights

According to the European IP Helpdesk report, safeguarding intellectual property is essential in project management to ensure that the knowledge and expertise generated are properly managed and protected. This protection is vital for creating an environment where partners can freely share their ideas and insights, assert ownership of their results, evaluate potential commercial benefits, and prevent unauthorised use.

To create a shared understanding of the IPR agreement, Table 61 provides a glossary of terms related to Intellectual Property and Rights that are referenced throughout this deliverable.

Table 61 - Useful terms on IPR

Term	Definition/Description
Background IP	Refers to any IP that is held by project beneficiaries before entering into the agreement and that is needed to implement the project or to exploit project results.
Foreground IP	Any tangible or intangible output of the project, such as, data, knowledge or information that is generated during the project, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it including IPR. Results that are produced outside of the project are not considered as foreground.
IP	Refers to the creation s of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commence.
IPR	Private legal rights that protect the creation of the human mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce.

The importance of protecting intellectual property IP rights is widely recognised by large businesses worldwide. Effectively leveraging these rights can bolster a company's strategic position and create new revenue opportunities. Additionally, examining IP rights for project results—especially those with commercial potential—can be exceptionally valuable.

ANNEX B: Questionnaire (Exploitation & Sustainability plan)

EXPLOITATION (ERs)
A. Exploitable Result Description
A1. Describe Exploitable Results in few lines (main features and target audience).
A2. Describe the problem your result is addressing.
A3. What is the alternative solution so far?
A4. What is the Unique Selling Point (USP) - Unique Value Proposition (UPV) of the result?

B. Type, Rights and Responsibilities
B1. What is the intended type of exploitation (e.g. commercial, scientific, non-commercial, other).
B2. Please elaborate how do you intend to exploit the result.
B3. Please select the most suitable exploitation rights option.
B4. If Joint ownership please indicate the other partners.
B5. Please select the most suitable exploitation responsibility option.
B6. If Joint responibility please indicate the other partners.
B7. What is the intended exploitation pathway?

INTELLECTUAL PROPERTY (KERs)
A. Backgroung IP
A1. Is there any background Intellectual Property (IP) asset related to the exploitable result?
A2. If yes, Please describe backround IP
A3. Is your background IP asset protected with some form of Intellectual Property Right (IPR)?
A4. If yes, please indicate how
A5. If other, please specify

B. Foreground IP
B1. Do you plan to develop or be involved in the development of new IP within the project?
B2. If yes, please choose the type of asset.
B3. If other, please specify
B4. Do you plan a mutual development of IP with other consortium partners?
B5. If yes, please specify the other partner(s)
B6. Is there any external to the project party involved in any of your IP (relevant to the project)?
B7. If yes, please provide some details regarding their involvment.

C. IP Beyond the Project
C1. Do you intend to protect your result with some form of Intellectual Property Right (IPR)? Please select how?
C2. If other, please specify partner(s)
C3. What is the intended exploitation of generated IPR?
C4. If license, please select
C5. If other, please specify
C6. As an owner of an IPR will you enable free access rights to the consortium partners once the project is over?
C7. If yes, for how long? (use years)

CASE STUDIES SUSTAINABILITY
A. Description of the CS
A1. Which project result(s) is (are) aimed to be implemented/maintained at your case study area after the project end? Please provide a description.
A2. Are there any other partners that should be involved in the implementation of this project result after the project end? Please explain briefly their contribution/role.
A3. What is the ultimate aim of the implementation/continuation of this project result at your case study area?
A4. Who are the main stakeholders who could exploit/benefit from the implementation of the project result?
A5. What are the benefits for the stakeholders/end-users, environment, local economy & society from the implementation of the project result at the case study area?
A6. Are there any rules/regulations that you will have to abide by for the implementation of the project result at your case study area? Have you identified any other obstacles/barriers?

More info: **www.icaria-project.eu**

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