D2.1– CoPs, Co-designed User Requirements

Project name

Asset Level Modelling of RISKs In the Face of Climate Induced Extreme Events and ADAPTtation (RISKADAPT)

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Deliverable leader	Winnubst, M.H. (UU)
Contributing partners	Mata Frondistou, Inke Hussels (RISA) Dimitrios Bilionis, Alexis Camarinopoulos (ERRA) Stergios Aristoteles Mitoulis (UoB)
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	Reviewer Name	Organisation	Date
Peer review 1	Lea Randazzo Carmen Candido	MTr	11/09/2023
Peer review 2	Günter Becker	RISA	11/09/2023

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0.2	28/06/2023	UU	Description of methods, literature review and content analysis of Pilot 3.
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0.6	13/09/2023	UU	Final version of deliverable.

1.0	13/09/2023	ERRA	Quality Reviewed version ready for submission

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List of Abbreviations and Acronyms

Abbreviation	Meaning
BIBM	Federation of the European Precast Concrete Industry
BIM	Building Information Modelling
BME	Budapest University of Technology and Economics
BMS	Building Management Systems
CC	Climate Change
CI	Critical Infrastructure
CLW	Cloud Liquid Water
CoP	Community of Practice
CRED	Centre for Research on the Epidemiology of Disasters
DLR	Dynamic Line Rating system
DMS	Document Management System
EERI	Earthquake Engineering Research Institute
EPCIP	European Programme for Critical Infrastructure Protection
FMI	Finnish Meteorological Institute
GCM	Global Climate Model
HICLAM-AROME	High-Resolution Climate Model
INSETE	Institute of the Association of Greek Tourism Enterprises
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IS	Information Systems
IWAIS	International Workshop on Atmospheric Icing of Structures
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LWC	Liquid Water Content
MIS	Model Information System

MOSCOW	Must-have, Should-have, Could-have, Will not have
MVD	Mean Volume Diameter
NGO	Non-governmental organization
OECD	Organization for Economic Cooperation and Development
PLN	Polish Zlotych
PPC	Public Power Corporation
RCM	Regional Climate Models
RH	Relative Humidity
RSL	Recovery Service Level
SLW	Supercooled Liquid Water Content
UHC	Universal Health Coverage
UNDRR	United Nations for Disaster Risk Reduction
UPS	Uninterruptible Power Supply
WISLINE	Wind, Ice and Snow Load Impacts on Infrastructure and the Natural Environment
WP	Work package
WRF	Weather Research and Forecasting

Executive Summary

RISKADAPT will provide, in close cooperation with the end-users and other stakeholders, a novel, integrated, modular, interoperable, public and free, customizable user-friendly platform (PRISKADAPT), to support systemic, risk-informed decisions regarding adaptation to Climate Change (CC) induced compound events at the asset level, focusing on the structural system. PRISKADAPT will explicitly model dependencies between infrastructures, which, inter alia, will provide a better understanding of the nexus between climate hazards and social vulnerabilities and resilience. Moreover, this project will identify gaps in data and propose ways to overcome them and advance the state of the art of asset level modelling through advanced climate science to predict CC forcing on the structure of interest, structural analyses, customized to the specific structure of interest, that consider all major CC induced load effects in tandem with material deterioration, novel probabilistic environmental Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) of structural adaptation measures and a new model to assess climate risk that will combine technical risk assessment with assessment of social risks. PRISKADAPT will provide values to a set of indicators for each asset of interest, quantifying primary parameters and impacts, in the form of a Model Information System (MIS) that will provide all required information for adaptation decisions. PRISKADAPT will be implemented in the Pilots that involve specific assets, however, it will permit customization with local values of parameters and data, so it can be applicable throughout Europe for CC adaptation decisions involving assets of similar function, exposed to multiple climate hazards. The aim of this report is to: (a) identify and engage relevant stakeholders and form Communities of Practice (CoPs); (b) collect and identify the social impacts and user needs; as well as (c) specify the user requirements, that will be translated into technical specification in Task 2.2.

1. Introduction

Climate Change (CC) poses a significant global challenge with wide-ranging implications, including its impact on infrastructures. Extreme weather events associated with CC, such as extreme temperature and precipitation, can have critical consequences for long-lasting infrastructural assets like buildings and bridges [1]. The failure of a single infrastructure asset can trigger a chain reaction of failures across interconnected systems, resulting in substantial economic losses, loss of life, and compromised security for millions of people worldwide [2]. The urgency to address these challenges is underscored by the Paris Agreement's target to limit the global temperature increase to well below 2°C above pre-industrial levels, with a striving ambition to limit it to 1.5°C [3]. It is important to recognize that infrastructures themselves significantly contribute to Climate Change, in terms of greenhouse gas emissions. Accounting for a staggering 79% of global emissions, infrastructures, including energy, buildings, and transportation, play a major role in exacerbating climate risks [4]. Consequently, infrastructures shall play a central role in strategies aimed at managing these risks and minimizing the adverse impacts of climate change.

Adaptation is a critical response to the anticipated negative effects of Climate Change. It involves proactive measures to prepare for and adjust to current and projected climate impacts while also identifying and capitalizing on potential opportunities [5]. Acknowledging the crucial role that infrastructure plays, numerous sustainable development initiatives have emphasized its importance in effectively addressing the climate crisis [6]. Given the extended lifespan of infrastructures, integrating Climate Change considerations into both the adaptation planning process for existing structures and the design and planning process for future infrastructures becomes paramount. Neglecting investments in prevention, CC adaptation, and disaster risk reduction only exacerbates the challenges faced. This urgency is particularly evident in critical physical infrastructures such as health, transport, and energy transmission networks, which are essential for the smooth functioning of society [7].

1.1 Purpose of the deliverable

"D2.1 – CoPs, Co-designed User Requirements" is one of the two Deliverables of WP2 "User Requirements, Architecture" and is related to Task 2.1 "Stakeholders' Identification and Engagement, Co-decision on Impacts of Interest/User Requirements". This Task is concerned with the identification and engagement of relevant stakeholders and the formation of the CoPs, as well as the collection and specification of the social impacts, end-users needs and requirements.

Attainment of the objectives and explanation of deviations

This Deliverable is related to RISKADAPT Milestone 2 "Co-defined User Requirements". The specific objective has been achieved in full with some deviation in the actions conducted. More specifically, after the commencement of the RISKADAPT project, a sensitive and critical situation emerged for Pilot 1 (Polyfytos bridge) that led to the complete bridge closure (03/2023) and to a reopening with partial traffic capacity (06/2023). This led to delays in the data collection process and difficulties in organising the CoPs and relevant meetings. Moreover, despite the efforts made and the actions completed (as explained in the following Sections), the unforeseen circumstances and the fact that more arrangements and communications between partners were requested for the identification and conducting of alternatives to data collection methods, led to this Deliverable's submission delay.

1.2 Structure of the deliverable

The Deliverable has been structured as follows:

- Section 1. Describes RISKADAPT's aim as well as this document's purpose, intended audience and structure.

- Section 2. Describes the methodology followed in this Deliverable.
- Section 3. Presents the Communities of Practice formed, as well as the end users' needs and impacts, as identified per Pilot.
- Section 4. Identifies and presents the end users' requirements.
- Section 5. Concludes the Deliverable by summarising the main outcomes and referring to future work.

1.3 Intended audience

As the dissemination level of this Deliverable is characterised as "Public", it will be openly available to all stakeholders, such as public authorities, infrastructure owners and operators, researchers and technology providers, as well as decision and policy makers interested in a report presenting the end users' needs and requirements of the RISKADAPT system. This system will enhance the resilience and support systemic, risk-informed decisions regarding adaptation to CC induced compound events at the asset level, focusing on the structural system. This Deliverable is also specifically intended for all RISKADAPT partners as it analyses social impacts, end-user needs and requirements.

2. Methodology

In this Section the research methodology selected and applied for the social impacts, end users' needs (Section 2.1); and requirements (Section 2.2) identification and specification are explained.

2.1 End user needs and social impacts identification and specification methodology

A suitable research methodology that acts as the blueprint for **the identification and specification of the end user needs** was developed. This methodology is based on three development stages namely: (a) stakeholder identification and engagement (so-called Communities of Practice (CoPs)), (b) data collection (such as scientific literature, media clippings, reports, meetings, questionnaire, interview, focus groups etc) and (c) data analysis. The analysis of the collected data led to the identification of impacts and user needs, some of which will be translated into user requirements.

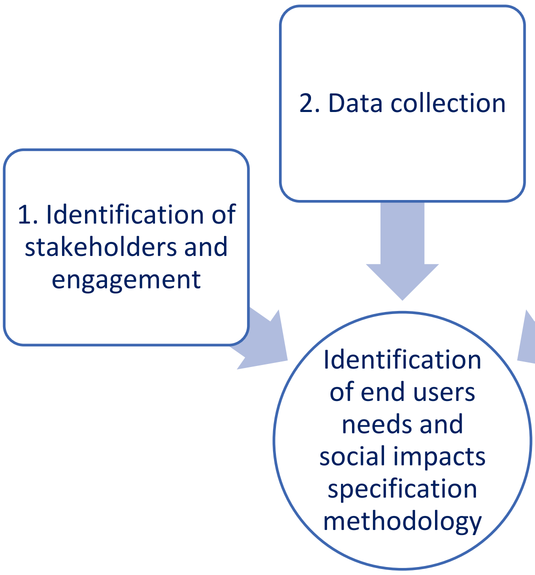

Figure 1.Overview of user needs specification methodology.

In the following sections, the methods used per phase will be described.

2.1.1 Identification of stakeholders and engagement

In the respect of RISKADAPT project, several key stakeholders were involved in the three Pilots (Pilot 1 (The Landmark Polyfytos Road Bridge, Greece), Pilot 2 (Energy Transmission Grids, Finland) and Pilot 3 (Cattinara Hospital in Trieste, Italy). They were organised in Communities of Practice (CoPs), which are groups of people (e.g. experts, practitioners, and citizens) that were informed about the project, participated in meetings, as well as supported the identification and definition of the user needs, infrastructure impacts and possible indicators to be considered for developing PRISKADAPT. They also provided comments, guidance and advise on project actions and results.

2.1.1.1 Communities of Practice

More specifically, for each RISKADAPT Pilot, a CoP leader was responsible to form and manage the CoPs, as well as the respective activities, e.g. meetings, webinars, workshops etc. Depending on the Pilot, as it will be explained below, the CoPs were organised per stakeholder group, e.g. government, local agencies, business, NGOs, practitioners, and civil society (citizens, associations, small business, clubs). The group size of a CoP was from 8 to 12 participants, which means that at least 20 or 25 potential participants were invited to join each CoP, considering the fact that some of them will not be available.

2.1.2 Data collection

A research method to gather data as required by the units of analysis, was then developed. The data collection tools that will be used in the respect of RISKADAPT are presented below.

2.1.2.2 Scientific literature

Scientific literature is one of the data sources that was used as input for the empirical data gathering methods, such as questionnaire, interview and focus group. For each Pilot, a review of the normative literature was conducted that was related to CC induced weather events. The main objective of the review was to identify and to gain insight into social impacts and needs of stakeholders related to critical infrastructure and buildings, which also resulted in the identification of topics and questions for the questionnaire, interviews and/or focus groups.

2.1.2.3 Other findings from media clippings, videos etc.

Further to the literature review, findings collected from other sources, such as websites, documents, reports and media clippings, were used as input for empirical data gathering methods including questionnaire, interview and focus group. In similar lines with the literature review, the objective of the content analysis was to identify social impacts and stakeholders needs related to critical infrastructure and buildings that led to topics and questions that were used for questionnaires, interview and/or focus group.

2.1.2.4 Meetings (organisation)

Wherever possible, meetings were organised to engage and discuss with identified stakeholders. Meetings were a relevant data source for understanding social impacts and needs of stakeholders.

2.1.2.5 Questionnaire

A questionnaire is an empirical data gathering method and consists of a list of questions that support the collection of information related to social impacts, needs and user requirements among others.

2.1.2.6 Interview

Interviews with relevant stakeholders was another data collection method used to gather information on social impacts, needs and user requirements. For the interviews, a topic list was designed that was based on insights from the literature review and content analysis.

2.1.2.7 Focus group

Another empirical data gathering method that was used in the respect of RISKADAPT project, was the focus group. In a focus group, stakeholders discuss upon a particular subject, e.g. social impacts, needs and user requirements. The discussions of each focus group were guided by a topic list that was prepared based on insights from the literature review and content analysis.

2.1.3 Data analysis

The data collected from the several data sources (per Pilot), as explained above, were analysed and used for the definition and identification of impacts and needs of stakeholders, as well as the user requirements for the development of PRISKADAPT system. Based on the above-mentioned data collection methods user needs were identified of which some – relevant for the development of PRISKADAPT – were translated to user requirements.

2.2 End users' requirements identification and specification methodology

The end users' requirements identification was based on the user needs identified (using the aforementioned methodology). For the collection and description of the end-user requirements, a template was created, shared and agreed upon with partners. This template was based on ISO 29148:2018 (ISO, 2018) and consists of several sheets, which are described below:

- Sheet 2 "User Requirement Types": The User Requirement Types list and their description/definition. This list was used in Sheet 4.
- Sheets 3-7 "User Requirement per Type": The Users Requirements (per type) identification and description was provided here.

Moreover, guidelines for filling-in the requirements were provided, as described below:

- Requirements are mandatory binding provisions and use 'shall'. Avoid using terms such as 'shall be able to'.
- Use positive statements and avoid negative requirements such as 'shall not'.
- Use active voice: avoid using passive voice, such as 'it is required that'.
- Non-requirements, such as descriptive text, use verbs such as 'are', 'is', and 'was'. It is best to avoid using the term 'must', due to potential misinterpretation as a requirement.
- Statements of fact, futurity, or a declaration of purpose are non-mandatory, non-binding provisions and use 'will'. 'Will' can also be used to establish context or limitations of use.
- Preferences or goals are desired, non-mandatory, non-binding provisions and use 'should'. They are not requirements.
- Suggestions or allowances are non-mandatory, non-binding provisions and use 'may'.

To effectively and efficiently collect the required information, and based on ISO 29148:2018 (ISO, 2018), the requirements were grouped in the following categories:

Functional Requirements (FR): Functional requirements describe the system or system element functions or tasks to be performed by the system. Performance is an attribute of a function. A performance requirement alone is an incomplete requirement. Performance is normally expressed quantitatively.

Non-Functional Requirements (NFR): Include several 'ilities' in requirements, for example: transportability, survivability, flexibility, portability, reusability, reliability, maintainability, and security. Quality requirements (e.g., "ilities") should be identified prior to initiating the requirements activities. This should be tailored to the system(s) being developed. As appropriate, measures for the quality requirements should be included as well.

Interface Requirements (IR): Interface requirements are the definition of how the system is required to interact with external systems (external interface), or how system elements within the system, including human elements, interact with each other (internal interface). External interface requirements state characteristics required of the system, software or service at a point or region of connection of the system, software or service to the world outside of the item. They include, if applicable, characteristics such as location, geometry and what the interface is able to pass in each direction.

Usability Requirements (UR): Provide the basis for the design and evaluation of systems to meet the user needs. Usability/Quality-in-Use requirements are developed in conjunction with, and form part of, the overall requirements specification of a system. The dimensions of usability as recommended by ISO/IEC TR 25060:2010 and ISO 9241-11:2018 are the following: effectiveness (accuracy and completeness with which users achieve specified goals); efficiency (resources expended in relation to the accuracy and completeness with which users achieve goals); satisfaction (extent to which the product or service meets the user's needs and expectations).

Process Requirements (PR): These are stakeholder, usually acquirer or user, requirements. Process requirements include compliance with national, state, or local laws, including environmental laws, administrative requirements, acquirer/supplier relationship requirements and specific work directives.

For each one of the aforementioned categories, several fields that should be filled in by the relevant partners were identified, as described below:

- UID: Unique ID for each requirement.
- Version No: If a requirement changes, create a new row, that will have the same UID and another version number.
- Requirement Type: Requirement type is always the same in each sheet.
- Requirement Category: Main functions or tasks to be performed by the system.
- Requirement Name: Requirement name.
- Requirement Description: Requirement description.
- Priority: Prioritisation of requirements, using the MOSCOW technique (Must-have, Should-have, Could-have, will not have).
- Relative WP: WP that this requirement is related to.
- Relative Use Case/Scenario: Relevant use-case/scenario that this requirement is related to.

3. Identification and specification of end users' needs and social impacts (per RISKADAPT Pilot)

Based on the research methodology (described in Section 2.1) for **the identification and specification of the end user needs and social impacts**, in the following paragraphs, the data collection actions as well as their analysis (per RISKADAPT pilot) are presented. The results of the data analysis will be used for the identification of impacts and user needs, some of which will be translated also into user requirements (presented in Section 3.4.

3.1 Pilot 1 - The Landmark Polyfytos Road Bridge (Greece)

RISKADAPT Pilot 1 is related to the Landmark Polyfytos Road Bridge (Servia / Neraida High Bridge), the second longest bridge in Greece. It is a long curved prestressed reinforced concrete bridge that provides crucial connections between the cities of Kozani and Athens and is used for the daily transfer of people and goods between the busy local communities and towns. With a length of 1,372 m, it was designed by XEKTE SA and Prof. Riccardo Morandi. Its construction began in 1972 along with the artificial lake and was completed in 1975 [8].

The bridge has been severely deteriorated due to soil subsidence, exacerbated by climate change-induced severe fluctuations of the water level, the scour of its foundation (due to successive floods) and the corrosion of the prestressed tendons. Safety concerns about the bridge structural integrity were first raised in 2020 when traffic restrictions were enforced (1 lane open only, max load 500kN (50tn) and max speed 40 km/h aiming to reduce the dynamic loading of the deteriorated bridge). The bridge has been considered unsafe due to structural damage. It, therefore, has been closed on March 16, 2023 [9]. After 59 days and since mid of June 2023 the bridge was partially open to traffic with a reduced traffic capacity (1 of the 2 lanes is open and the maximum allowable vehicle weight is 3.5 tn, i.e. 35kN).

Figure 2. The Landmark Polyfytos Road Bridge.

The loss of bridge functionality (Pilot 1) affects negatively the transportation of finished goods (commerce), raw materials (industry) and people (employment, tourism) and the accessibility to important resources (e.g., shelters) and vital services (e.g., wheelchair lifts and accessible buses) in emergency situations. The above could result in economic losses and human hardships (i.e., psychological impacts, work disruption, additional commute times, etc.). In addition, bridge structural failure can lead to casualties, adverse impact on ecological habitats[14] and other environmental damage (e.g., emissions due to long deviations). *RISKADAPT will assess the above considering rerouting options, while in addition to technical measures, will suggest social measures, e.g., subsidies to enterprises affected by bridge downtime to retain employment at the same level, or subsidies to cover the extra* *transportation cost. It may also affect domestic migration, (e.g., families moving to the main city), reduction of the tourism in the area and reduction of agricultural production.*

In the following paragraphs, Pilot 1 data collection actions as well as their analysis are presented. The results of the data analysis will be used for the identification of impacts and user needs, some of which will be translated into user requirements (presented in Section 3.4.

3.1.1 Identification of stakeholders and engagement (Pilot 1)

For the stakeholders' identification and engagement process in Pilot 1, initially RWM was set as the COP leader. The CoP leader was responsible to form and manage the CoPs, as well as decide and conduct (with the Task Leader - UU and other participating Partners) the relevant to the Pilot activities, e.g., meetings, interviews, workshops etc. As regards Pilot 1, it is critical to mention that the bridge closure (mid of March 2023) led to a situation in the region that demanded urgent attention, so the information was difficult to be collected and it was not feasible to organise CoPs as planned. To tackle this issue, it was decided that the information would be collected with alternative to CoPs methods. Therefore, questionnaires were designed and distributed, as well as an interview and a focus group were conducted, as they will be further explained below.

3.1.2 Data collection (Pilot 1)

As regards Pilot 1, due to the bridge closure demanding situation, the respective information on user needs, social impacts and requirements was collected via the following methods:

- Literature review
- Content analysis of media clippings, videos, docs, news.
- Interview with the Mayor of Servia.
- Questionnaire distributed among citizens.
- Questionnaire shared with Sustainable City network (70 municipalities in Greece and Institutions).
- Focus group organisation among members of BIBM.

The first two (literature review and content analysis of reports, websites etc.), comprise methods to gather insights from literature and other sources, whether the last four (interviews, questionnaires and focus group) are empirical data gathering methods. The actions conducted per method used will be presented in the following paragraphs.

3.1.2.2 Scientific literature

Scientific literature was reviewed focusing on infrastructure disruptions one of which is bridge failure and the social-economic impacts.

3.1.2.3 Other content (media clippings, videos etc.)

Other content, such as websites, media clippings, videos, and documents, on the bridge closure and its impact were identified, collected and analyzed.

3.1.2.4 Interview with the Mayor of Servia

A topic list was designed and used during the interview **(see Annex 1**) focussing on information on the bridge closure, its impacts, information on the partial opening of the bridge and the impacts of the partial accessibility of the bridge. The topic list included open questions so that the respondent had the opportunity to highlight aspects of the bridge being closed and its partial opening.

3.1.2.5 Questionnaire

Complementary to the interviews, a questionnaire with the same topics and questions as the topic list for the interviews was distributed among citizens in the surrounding area of the bridge **(see Annex 2)**. Twenty-five citizens filled in the questionnaire.

Additionally, another questionnaire was designed using insights from the literature and discussions with partners. The questionnaire's aim was to address risks regarding Climate Change induced weather events relating to critical infrastructure and buildings **(see Annex 2).** The questionnaire was divided in two parts. The first was related to questions concerning risks and impacts, the second focused on suggestions and requirements for the development of the PRISKADAPT. It entailed open and close ended questions. The open-ended questions are questions that cannot be answered with a simple 'yes' or 'no', and instead require the respondent to elaborate on their points. The closed-ended questions are questions that can only be answered by selecting from a limited number of options, usually multiple-choice questions with a single-word answer, 'yes' or 'no', or a rating scale (e.g., from strongly agree to strongly disagree). The questionnaire was online and was circulated via e-mail. Before filling out the questionnaire, respondents were asked to sign an informed consent sheet.

Another one questionnaire was designed and was directed at risk managers and technicians, but also scientists, policy makers, and other staff. It was distributed among members of the Cities Network SUSTAINABLE CITY in Greece most of which are municipalities (over 70 municipalities from Greece and Cyprus). The network also consists of institutes, such as the Regional Association of Solid Waste Management Bodies of Peloponnese Region, the Institute of Environment and Sustainable Development of Cyprus, the Maniatakion Foundation and the National Technical University of Athens. Forty (40) experts replied to the questionnaire and the results are presented in Section 3.1.3.5.

3.1.2.6 Focus group

Moreover, a focus group was organised on the 18th of May 2023 and thirteen (13) members of the Technical Commission of the Federation of the European Precast Concrete Industry (BIBM) from 11 European countries were invited and participated. A topic list was developed **(see Annex 3)** and used to guide the discussions. Based on the topic list, the participants discussed the assessment of the structure, required knowledge for assessment, and features of concrete among others. The results of the focus group discussion are presented in Section 3.1.3.6.

3.1.3 Data analysis (Pilot 1)

Based on the methods used for data collection in Pilot 1 (as described in the previous section), in the following paragraphs the data collected will be analysed and presented. Moreover, the user needs and social impacts identified will be described.

3.1.3.2 Scientific literature analysis

Services such as energy, water, sanitation, transportation, and communications are necessary for social and economic activities. Critical infrastructures ensure those services for large populations through geographically extensive networks. They are also very interrelated, thus disruptions in one system frequently have an impact on other systems. Because of this, losses resulting from infrastructure systems disruption, are frequently significant and disproportionately enormous. For instance, the collapse of a single large bridge can cause traffic problems across a large area and obstruct emergency response, evacuation, commuter traffic, freight transportation, and economic recovery [10]. Another indicative example is the economic costs of the 41h closure of the Queensferry Crossing in United Kingdom [11]. The importance of understanding and considering the impacts of infrastructure disruptions is becoming increasingly recognized in public policy as many types of socioeconomic impacts, including health, social, economic, and environmental consequences are frequently caused or exacerbated in such events. Although understanding and consequently reducing infrastructure disruption impacts is well established, there are still significant research gaps. The existing research is quite scattered mainly due to the multilayered and multidisciplinary components constituting those impacts.

Studies are focused on different aspects and different levels of infrastructure disruption impacts. The economic impact of various events resulting in infrastructure loss of serviceability is the most common. Studies use each time the available data from past events, proposed models from literature and make educated assumptions where needed in order to quantify the economic cost and propose models that will assist pre-disaster risk assessment and post-disaster impacts quantification [11, 12, 13, 14]. Other studies show indexes and tools that will help pre- and post-disaster decisions to be made and prioritise critical infrastructures within a network [15]. Torti et al. (2022) are focusing on the spatial and temporal interdependency of the infrastructures of a large and complex road network [14].

A variety of information sources, including surveys, field observations, secondary data analysis, and computational models, provides insight into the consequences of infrastructure disruption. Impacts of infrastructure disruption can be measured in many different geographical (regional, national etc.) or social (individual, communal, business sector etc.) scales; in social, economic or environmental terms; can be classified as direct, direct consequential and indirect impacts; and can be studied under different associations with criteria such as the vulnerability of the infrastructure, how critical its position is in the wider network etc.

Transportation systems move people and goods both locally and across long distances. Road infrastructure systems are composed of surface roads, as well as bridges, tunnels, traffic signals, etc. In road networks, bridges are often the weak links. Network redundancy is an important characteristic of transportation networks that provides greater availability of alternate routes that can be used [16].

Chang (2016) states that in disaster events, infrastructure disruptions frequently cause or exacerbate many types of socioeconomic impacts, including health, social, economic, and environmental consequences. In terms of human health, infrastructure damage and disruption can cause human casualties [10]. For example, people can be killed or injured by infrastructure failures such as bridge collapses and gas pipeline breaks that cause fires. More indirectly, power outages cause loss of heating, lighting, and elevators, which have caused deaths and injuries from hypothermia, carbon monoxide poisoning (as people try to heat their homes with alternative heat sources), accidents (e.g., falls in the dark), and heart attacks (e.g., from exertion in climbing stairs) [17]. People can also become ill: power outages frequently cause food spoilage due to loss of refrigeration; damage to pipes can lead to contamination of tap water; and damage to wastewater systems can entail discharge of raw sewage.

In terms of social impacts, loss of infrastructure services—especially electric power, potable water, and sewerage - is a frequent cause of people being displaced from their homes in disasters. Even when residential buildings have survived the storm, earthquake, or other hazard event in intact condition, they may become uninhabitable without utility services. For example, one survey after the 1994 Northridge (Los Angeles) earthquake found that 14% of people in Red Cross shelters sought shelter there because their homes were uninhabitable, even though they had already been inspected and found to be structurally safe [18].

Infrastructure loss can also impede the delivery of emergency and social services in a disaster, just when they are critically needed. Fire-fighting requires sufficient volumes of pressurized water, without which urban fires can spread rapidly and cause human and property losses, as seen in the 1995 Kobe (Japan) earthquake. Disruption to road networks by bridge damage, debris blockage, landslides, or other causes can also impede emergency response; for example, the ability of fire-fighters, search-and-rescue crews, ambulances, and utility repair workers to reach places where they are needed. Hospitals are very dependent upon electric power for potable water and communications, without which they may need to curtail healthcare services, evacuate patients, or even temporarily shut down [19]. For example, in addition to lighting, heating, refrigeration of medical supplies, and operation of medical equipment, hospitals are also heavily reliant on electric power and communications for access to computerized medical records. Communications infrastructure systems are also required for warning and community alert systems, 911 and related emergency calls, dispatch of emergency responders, and general citizen information needs in a disaster. Social media, which require communications infrastructure, are being increasingly used in disaster response and recovery, both formally and informally [20].

According to Chang (2016) businesses can be disrupted by infrastructure loss in many ways, leading to economic impacts such as lost production and sales, reduced income for employees, reduced tax payments to governments, and temporary or even permanent closure [10]. Depending upon the type of business, loss of electric power, potable water, wastewater, or communications infrastructure may cause impacts ranging from minor inconveniences to immediate shutdown of operations. Transportation disruption can affect businesses by impeding employees' ability to come to work, customer access, delivery of supplies, and transport of products. There may also be economic costs of response, repair, and cleanup, for example, the cost of disposing of and replacing spoiled foods in power outages. Business interruption losses can be experienced directly as a result of infrastructure loss, or indirectly as a result of linkages with other businesses that have suffered loss. For example, even if a factory has no on-site damage or infrastructure disruption in a disaster, it may be idled if it cannot receive supplies from or sell its products to other businesses that have been affected by the disaster. Indeed, with modern supply chains, the effects of disasters can be felt across the globe: in the 2011 Great East Japan triple disaster, disruption to parts producers in northeastern Japan caused automobile manufacturers as far away as the United States and Europe to curtail production.

Infrastructure disruption can cause environmental impacts, especially through waste generation and contaminant releases. Damaged infrastructure such as rubble from earthquake-damaged bridges contributes to the problem of disaster debris. Food spoilage and food waste is a common consequence of power outages. Damage to wastewater pipelines and treatment facilities, as well as power outages, often leads to spillage of raw sewage into the environment. In coastal storms, damage to fuel storage tanks, harbor facilities, and related waterfront industry can release hazardous materials and other contaminants [10].

Many factors influence the severity of infrastructure disruption impacts. The location and spatial extent of outages directly influence the number of people affected. Duration of outage is also very important; a few hours without electric power may merely entail inconveniences, but outages that last weeks can cause more severe impacts, such as people being displaced from their homes or businesses closures. The time of year in which the disaster occurs also matters. In many regions of the world, for example, loss of electric power or natural gas for heating can be life-threatening in winter.

It is important to note that impacts are related to the disruption of infrastructure services, rather than necessarily to infrastructure damage itself. If an electric power line is damaged but the utility company can reroute electricity flows around it, there may be no loss of service to the population and no impacts, other than repair costs to the utility. If a bridge is damaged but alternate routes are intact, transportation services may be only minimally disrupted; however, if the damaged bridge provided the only path across a river or the only access to a remote town, transportation disruption would be very high and the consequences severe. If electric power is lost at an airport control tower but backup power is available from a generator, there may be no disruption to air transportation services. Similarly, potable water can be brought in by tanker trucks to alleviate shortages caused by damage to the piped water network. At the other extreme, infrastructure services can be disrupted in ways that involve no physical damage at all, such as in cases of road gridlock during mass evacuations before a hurricane, labor strikes, or terrorism threats that entail precautionary shutdowns [10].

Rapid restoration of infrastructure services after disasters is important not only for minimizing impacts to affected customers but also to enable reconstruction and recovery. Infrastructure systems are interdependent in the reconstruction phase of a disaster; for example, utility crews making repairs need to be able to access damaged areas using the road network. Cleaning up damage, removing debris, and other post-disaster restoration and recovery activities are also facilitated by functional road networks and availability of electric power, water, wastewater, and communications. Service restoration must, however, be coordinated. For example, because electric sparks can cause fire ignitions in the presence of natural gas leaks following earthquakes, it may be necessary to delay electric power resumption while broken gas mains are being inspected and repaired.

In general, infrastructure service disruptions in disasters are usually short-term in duration, typically lasting from hours to weeks. While their socioeconomic impacts may be acute, they are usually short-term and do not entail fundamental socioeconomic changes, such as population relocation or changes in regional economic structure. In some cases, however, infrastructure outages can extend for months, years, or even indefinitely. For example, in a catastrophic earthquake or tsunami, extensive damage to ports, buried pipeline networks, and major bridges can take months to repair. Some facilities may never be repaired if authorities decide to take the opportunity to enact long-term changes, as in the case of the demolished Embarcadero Freeway in San Francisco after the 1989 earthquake or the residential “red zones” in Christchurch, New Zealand, after the 2012 earthquake.

To sum up, infrastructure systems are vital to the disaster resilience of people and communities. Numerous disasters have demonstrated the physical vulnerability of electric power, gas and liquid fuels, water, wastewater, and communications systems—and the societal consequences of their disruption, ranging from human casualties and displaced populations to business disruption and supply chain losses. The vulnerabilities associated with infrastructure interdependencies are being increasingly understood, even as they may be growing. Reducing the likelihood of damage through pre-disaster mitigation would help.

Focusing on the closure of a bridge, it may have significant consequences that impact various aspects of transportation, economy, and community life [21].The severity and extent of these consequences depend on factors such as the importance of the bridge, the location, the availability of alternative routes, and the duration of the closure. Some of the main consequences that can arise from a bridge closure are listed below [10]**.**

Disrupted Transportation: [22] [10]

- Traffic congestion: Closure of a major bridge can divert traffic onto alternative routes, leading to congestion and increased travel times.
- Limited accessibility: Communities or areas that heavily rely on the closed bridge may experience reduced access to essential services, businesses, and resources.
- Detours: Alternative routes may be less efficient or longer, causing inconvenience and potential delays for commuters and businesses.

Economic Impact: [10]

- Business disruptions: Businesses located near the closed bridge may experience decreased foot traffic and reduced customer visits, potentially leading to financial losses.
- Supply chain disruptions: The movement of goods and supplies can be hindered, affecting manufacturing, distribution, and retail operations.

- Increased transportation costs: longer routes and increased fuel consumption can lead to higher transportation costs for businesses and consumers.

Emergency Response Challenges: [23]

- Delayed emergency services: Closure of a bridge can impede the response time of emergency services (firefighters, police, ambulances) to incidents on the other side of the bridge.
- Evacuation difficulties: In case of emergencies requiring evacuation, the closure can complicate evacuation routes and slow down the process

Social and Community Effects: [10]

- Isolation: Communities located on opposite sides of the bridge may feel isolated from one another, impacting social interactions, events, and relationships.
- Reduced quality of life: Increased traffic, noise, and pollution from diverted traffic can negatively affect the quality of life for residents living near alternative routes.

Tourism and Travel Industry:

- Tourism decline: Popular tourist destinations connected by the closed bridge may experience a decrease in visitors due to reduced accessibility.
- Travel disruptions: Travel plans that involve crossing the closed bridge may need to be altered, affecting tourism and travel-related businesses.

Infrastructure Strain:

- Increased wear on alternative routes: Diverted traffic can lead to accelerated deterioration of roads and infrastructure not designed to handle high volumes of traffic.
- Maintenance challenges: If the bridge closure is due to maintenance or repairs, postponing these activities could lead to further deterioration and potentially more costly repairs in the future.

Environmental Impact: [10]

- Air quality: Diverted traffic can lead to increased air pollution and emissions, contributing to environmental and health concerns.

Project Costs and Delays: [10]

- Bridge repair or replacement costs: The closure may be necessary for repair or replacement work, incurring costs and potentially causing delays in completion.

Politics and Public Relations:

- Political fallout: Bridge closures can lead to public dissatisfaction and criticism of local governments and transportation authorities.
- Public relations challenges: Communication and transparency become important to manage public expectations and provide updates on the closure's progress.

In summary, a bridge closure can have wide-ranging consequences that affect transportation, the economy, emergency response, communities, and more. Efforts to mitigate these consequences include timely communication, efficient alternative routes, proper planning, and effective management of repair or replacement projects.

3.1.3.3 Other content (media clippings, videos etc.) analysis

The Polyfytos or Servia High Bridge is part of the national highway network connecting the region with the adjacent regions [24] [25]. Apart from the immediate consequences, such as the interruption of the usual traffic paths and the need for alternative routes, there are several and multilevel other consequences that affect mostly the local communities [26].

Local Agricultural Cooperatives are facing difficulties to obtain packaging materials, fertilisers and other business-essential materials. As the bridge is either completely closed or closed for heavy vehicles the supplies come through smaller, narrower local roads and farmers have to follow the alternative routes every day, back and forth to their fields. This raises various issues: [27] [28] [29].

- longer transportation routes (approximately 40-50km more), higher transportation time (as the local network is narrow and designed for lower speed traffic an average of 45m more is mentioned in general) and cost (gas and drivers reaching the max continuous hours they are allowed to drive) along with a consequential higher environmental impact [30] [31] [32].
- most of the products exported are fresh fruits/vegetables which adds to the importance of the overall time needed for transportation [33].
- safety issues as local roads pass through villages and residential areas and are not initially designed to serve heavy vehicles/tankers etc. [34] [31] [29].

The same applies to the export of the local products process as well as to the supply of local businesses/ stores and the construction and maintenance of infrastructure [35]. A mayor let know that infrastructure companies faced problems transporting materials for an ongoing maintenance project [33].

People who have to use the alternative routes on a daily basis include employees and students (on a broadcast 40 students were mentioned to be undergoing this routine) residing in the surrounding towns and villages [34] [36]. The longer alternative routes not only contribute to higher transportation costs and time but to higher environmental impact as well [36].

Additionally, due to the rise in transportation costs, the continuous and profitable operation of the Prosilio mine and the carriers that deliver the lignite to PPC is particularly precarious and the consequences will not be only local if the situation continues [37].

One indicative example emphasizing the importance of the full functionality of the bridge and how the alternative options are not meeting the needs of the locals is the intercity bus company that in order to avoid the alternative road options, for the period that the bridge was open only for low weight vehicles, deployed smaller buses and minivans just to carry the passengers over the bridge who then continue their trip on the regular buses [38] [31].

The impact of the bridge being closed on local tourism is also mentioned. There are no quantitative data so far regarding the incoming tourist flow being directly linked to the state of the bridge. Based on published data from the Institute of the Association of Greek Tourism Enterprises (INSETE), the region overall is in the 13th place and has reduced visits in comparison with last year [39]. Although the metrics for the months during which the bridge was completely inaccessible haven't been published yet, there is not enough data to link the drop with the bridge. We could assume that there will be indirect consequences, especially if the bridge will remain closed during the summer. An indirect link regarding this aspect could be deduced considering that since 2018 there are several actions taken aiming at the promotion of tourism in the area and thus, the region being cut from the national road network could be a setback [40].

The local police authorities make a monthly announcement regarding the incidents that occurred in the area. Although traffic was served by local roads there was no increase in accidents [41].

Local authorities have mentioned that the surrounding areas don't have quick access to the central hospital of Kozani in case of an emergency and the movement of the doctor that services the rural veterinary stations in villages has been more difficult due to the current situation. No incident is mentioned regarding this aspect [42] [34].

3.1.3.4 Interview results analysis

The Mayor of Servia emphasized that the main effect of the bridge closure was the social bisection of the municipality, which spreads on both sides of the lake. Citizens were cut off or faced greater difficulty to access public services or social events and as a result, had to be serviced from Kozani. According to the same interviewee, there was damage to the social bonds of the local society as citizens felt isolated from their local communities and the main city of Kozani. The second major effect was the economic impact on local businesses and agricultural cooperatives as the costs of transporting goods increased significantly. The municipality itself had increased costs as access to some parts for several services was difficult, i.e., bin lorries, and students going to school who had to use longer and time-consuming alternative routes. The mayor mentioned that the municipality would have liked to have been informed in advance about the bridge closure and decisions regarding the preparation and planning of the closure. Additionally, he would have had regular updates from technical experts. He stressed the importance of multidisciplinary experts being involved in any decision made regarding the state and the future of the bridge and the regular involvement of local administrators throughout time.

3.1.3.5 Questionnaire results analysis

As mentioned above, the questionnaire distributed among citizens were filled in by 25 respondents. The main results are the following.

From 25 respondent, 48 percent were men, 52 percent were women. Most of them (60 percent) fell in the category 31-50, while 24 percent of the respondents were between 18-30. A much smaller group (12 percent) were between 51-60 and elderly people (over 65) were less represented (4 percent).

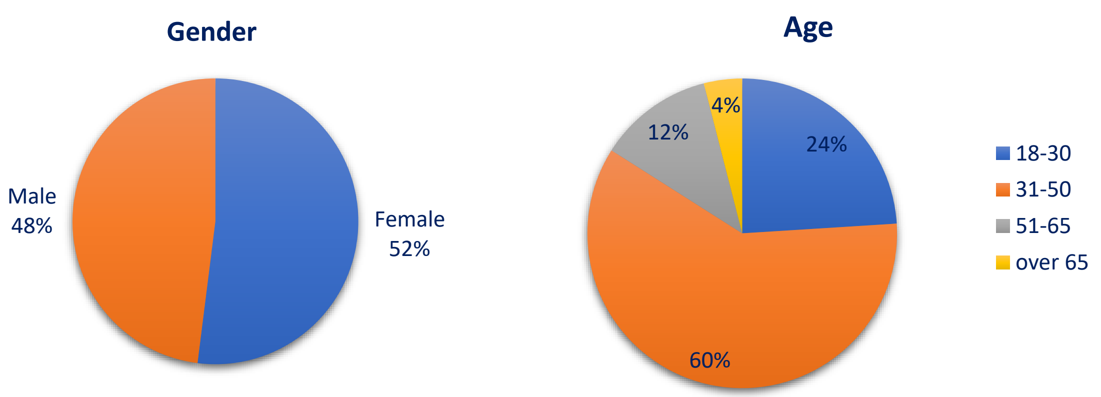

Figure 3. The Landmark Polyfytos Road Bridge - questionnaire respondents demographics

Most respondents live in Kozani (52 percent - 13), while 16 percent (4) of the respondents live in Velventos. Other respondents live in Grevena (8 percent - 2), Servia (4 percent - 1), and Ptolemaida (4 percent - 1). one respondent did not fill in their place of residence.

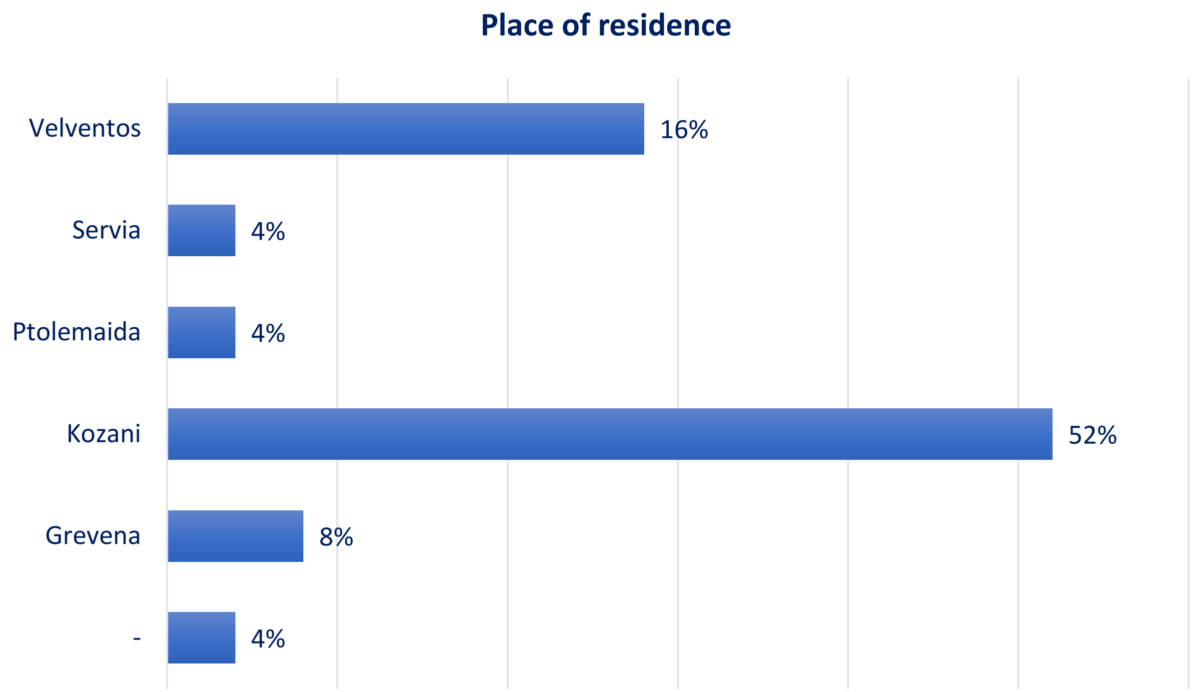

Figure 4. The Landmark Polyfytos Road Bridge - questionnaire respondents place of residence.

The main source of information on the bridge closure and its partial opening were the media (30 percent). To a lesser extent, respondents used other sources, like internet (17 percent), district announcements (13 percent), local media (13 percent) and family (4 percent). 9 percent of the respondents did not fill in a source of information.

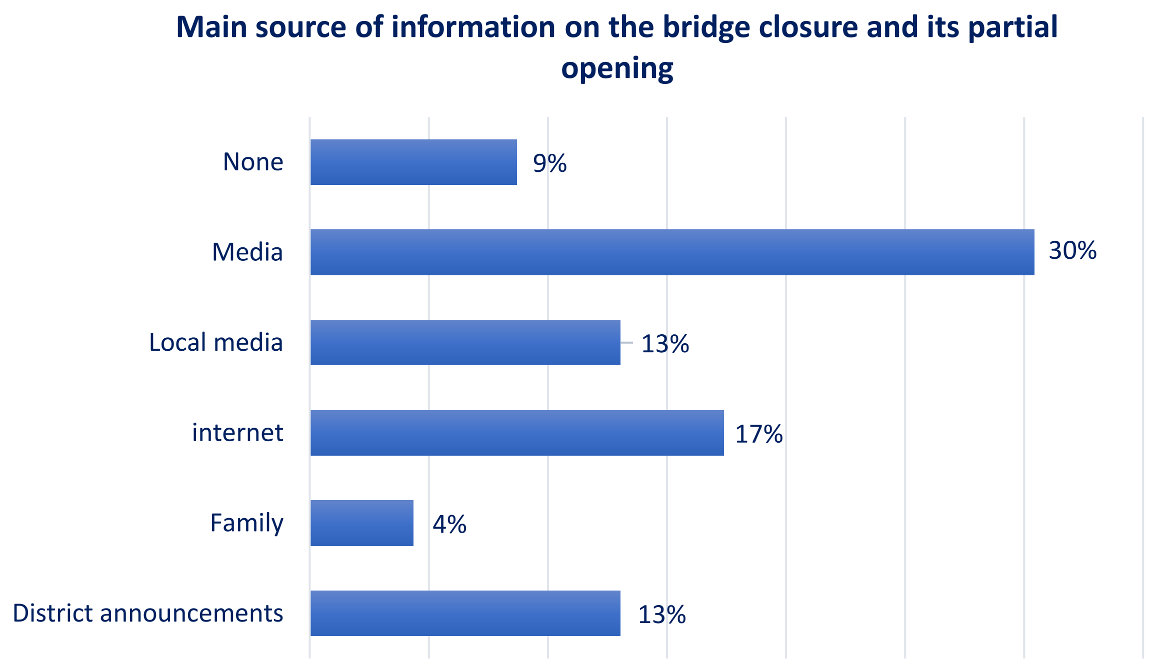

Figure 5. The Landmark Polyfytos Road Bridge - questionnaire responses on information channels.

In general, respondents would like to have had more information regarding the current state of the bridge and its capability to withstand loads (preferably from experts) and in the future. They often associated the requested technical information with concerns regarding the safety of the bridge. Occasionally, this was also associated with questions regarding the partial opening of the bridge only for vehicles up to 3.5 tn. Responders expressed their concerns regarding the general safety of the bridge, whether the maintenance of the bridge will be sufficient, and whether the solutions provided are temporary or final solutions. Consequently, respondents have worries about a bridge closure in the future. Some respondents are unsure about the suitability of the alternative routes for traffic and the provisions made regarding the diversions. Responders prefer to have been informed on the bridge closure before it actually happened and they would like to be frequently updated regarding the progress of the maintenance. The majority of the respondents wanted to know when the bridge would be fully accessible again.

Regarding the effects of the closure of the bridge on their everyday life, residents of Kozani were least affected as they did not pass through the bridge regularly. However, residents of Servia and Velventos had difficulties moving to and from Kozani for work and other social purposes. It was difficult for them to access healthcare facilities and public services located in Kozani, to find land workers and to transport fresh fruits from local cooperatives to the region, the rest of the country and abroad, to supply local business and to transport construction materials. As the municipality of Servia spreads on both sides of the lake, citizens felt isolated.

The majority of the respondents expressed the need for regular and better maintenance of the bridge in order to avoid bridge closure and its impacts in the future. Respondents stressed timely notification of the closure of the bridge as well as prevention measures.

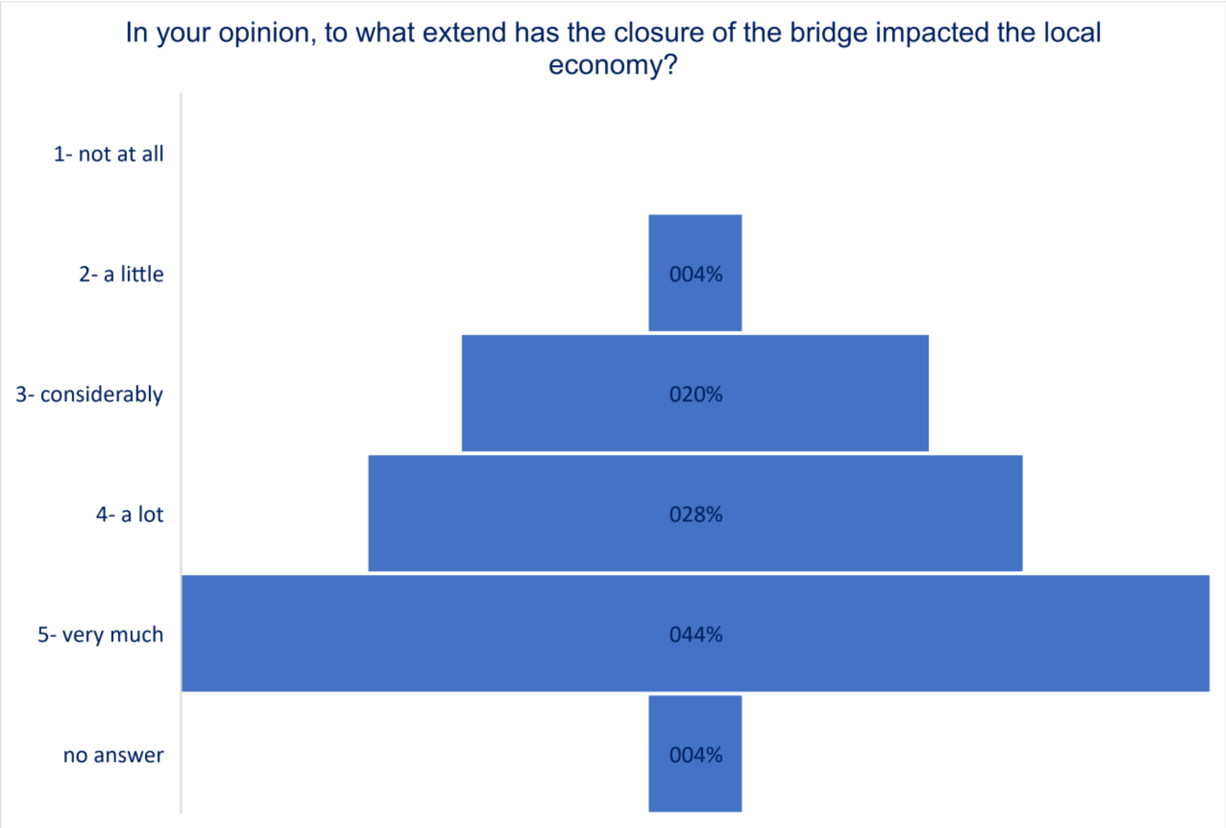

Figure 6. The Landmark Polyfytos Road Bridge - questionnaire responses on impact.

Less than half of the respondents (44 percent - 11) found that the local economy has been majorly impacted by the bridge closure. One respondent didn't evaluate the impact of the closure of the bridge on the local economy. The majority (92 percent – 23) agree on the local economy being notably impacted. One respondent thought the impact of the bridge closure on the local economy was not that much important.

When asked about the impact of the closure of the bridge on the local environment there were 2 respondents who didn't answer. More than half of the respondents (72 percent – 18) recon that the closure has indeed impacted the local environment. The fact that 4 people considered that there was no impact at all or very little on the local environment due to the closure of the bridge may indicate the importance of the public being frequently and extensively informed and updated regarding the multilevel impacts of the bridge closure and the disruption of infrastructure in general. The direct impacts are evident to the people involved but the secondary indirect ones may not be as clear to people with different and perhaps not expert backgrounds.

The closure of the Servia High Bridge, part of the national road network, has had multilevel effects on people. Primarily and more evidently, the local economy has been affected in many ways. Citizens from Velventos and Servia were the most affected as the Polyfytos bridge was their main way of accessing Kozani, the capital of the region and consequently the centre for many economic, social and other activities; whereas citizens of Kozani stated that their everyday life was not that much affected. The longer alternative routes entail increased travel times and increased costs not only for individuals going to work or other social obligations but for business owners, either for resupplying their business or for transporting their goods, as well as for local administration who had to continue servicing areas on the other side of the lake. Local agricultural cooperatives faced the same increased costs for transporting their goods and continue to do so as the bridge is still inaccessible to vehicles weighing more than 3.5 tonnes. Indirectly, as mentioned in the content analysed, businesses from adjacent regions may have been impacted as they transport their goods and supplies through the region.

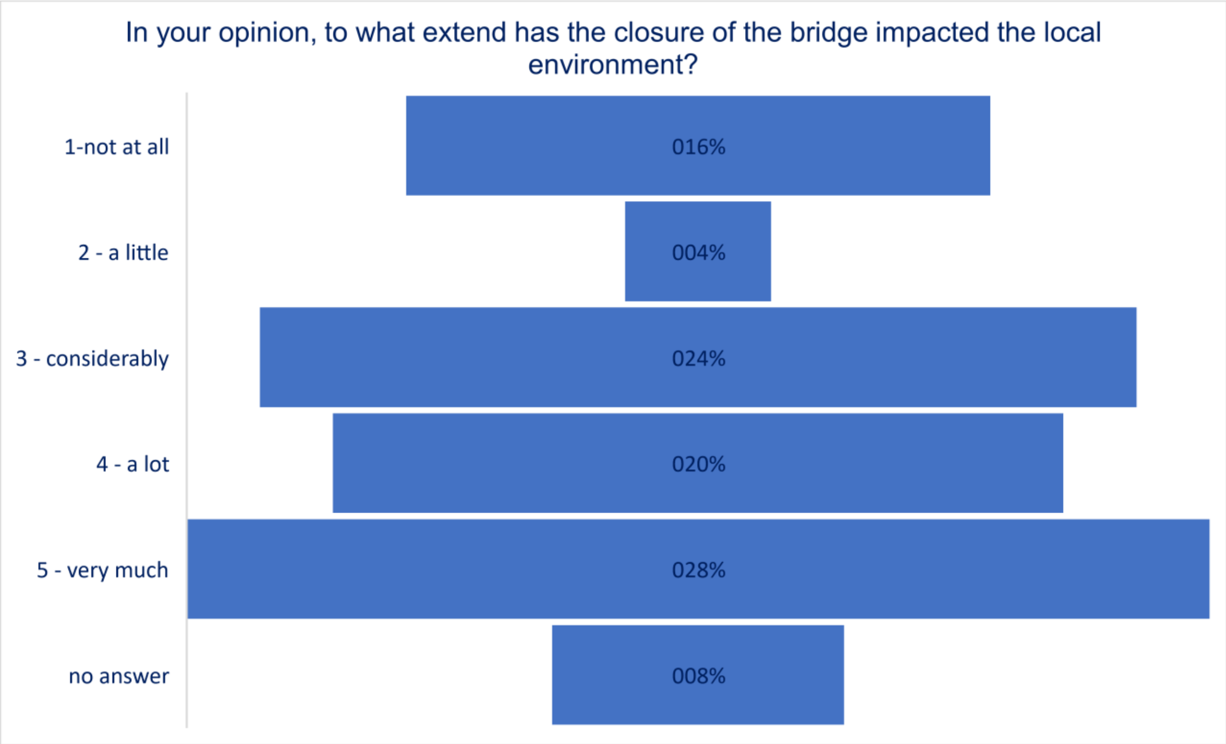

Figure 7. The Landmark Polyfytos Road Bridge - questionnaire responses on impact.

Given that the majority of the traffic is diverted to longer routes, it can be deduced that there should be significant impacts on the local environment and the fact should be further investigated.

The social impacts of the bridge closure are evident. The municipality of Servia spreads on both sides of the lake and with the bridge closed it is significantly more difficult to access family, friends, public services and social events or it is needed to go to Kozani, leading citizens to feel disconnected from the rest of their community.

Moreover, the sudden closure of the bridge has created concerns about safety among the respondents who intensively expressed the need to have formal, regular and detailed updates not only from local authorities but from technical experts as well. There is also a general concern that the maintenance is only a temporary solution and the bridge will have to close again in the future, perhaps for a longer period of time. As a consequence, the inconvenience caused by the bridge closure will be prolongated.

In short, the main impacts due to infrastructure disruption mentioned in the literature review are observed in the case of the closure of the Polyfytos road bridge (economic, social, environmental) and mostly understood by the respondents. The findings from the literature review, content analysis, interview and questionnaire show that the impact of a bridge closure in North Macedonia is very different and varies from low to high. The direct and indirect impact of the bridge closure is perceived differently than assumed from literature review.

As described in Section 3.1.2.5, another questionnaire for risk managers and technicians was distributed among members of Sustainable City in Greece most of which are municipalities. The network also consists of institutes, such as the Regional Association of Solid Waste Management Bodies of Peloponnese Region, the Institute of Environment and Sustainable Development of Cyprus, the Maniatakion Foundation and the National Technical University of Athens. The forty (40) respondents of the questionnaire were mainly risk managers and technicians of Greek municipalities, and individual Engineers as well.

The questionnaire results were analyzed by coding the responses based on the respondents' criteria regarding the risks related to critical infrastructure and buildings, their concerns, approaches to address the risks and features that should be included in the RISKADAPT platform. The results are presented below.

Assessing the risks concerning critical infrastructure and buildings earthquakes were considered most important due to the high seismic activity in Greece resulting in extensive destruction of buildings and loss of human lives. Other major risks were fires as a result of human intervention and floods due to climate change. Regarding floods, climate change leads to increased rainfall in many areas which can cause either erosion of structures or major issues due to flooding problems in the drainage network and damage to the power infrastructure (see Figure below).

The main problem and risks in infrastructures and buildings in Greece are often the lack of adequate maintenance and/or inspection that may indicate new deterioration or decay and decline of existing ones. The lack of knowledge, and consequently the failure to repair any damage of infrastructure or building can lead to even bigger problems in the future, especially in cases of accidental events such as earthquakes. The above is also directly related to poor workmanship or deviations from the design guidelines during construction. Proper maintenance of infrastructure and buildings includes interventions to timely adapt them to new conditions and regulations in order to lower the vulnerability of structures to severe weather events or natural disasters.

The main concern of the respondents is climate change that is increasingly evident, affecting the entire planet resulting in unexpected triggering of (and perhaps unprecedented for a region) high-intensity weather events, leading to disasters before anyone can predict them. Climate change may lead to extreme weather events that will result in loads that were not foreseen during the design phase or considered due to the existence of inadequate design regulations. Extreme weather phenomena due to climate change, e.g., rapid inland and coastal flooding, extreme temperatures, affect reinforced concrete structures by altering their structural characteristics. The biggest concern is the impact of extreme events on the resilience of critical infrastructure. These events could affect concrete structures. Heavy rainfall and flooding could cause concrete-reinforcement corrosion due to moisture. The effect of high temperatures could alter the compressive, tensile strength and modulus of elasticity of concrete and cause thermal deformations. Concrete structures are also significantly affected by earthquakes due to the age of the structures and the cumulative effect of previous years' earthquakes that have reduced structural adequacy due to lack of maintenance.

Most respondents have experienced severe weather events, such as earthquakes and extreme temperatures in recent years. Climatic conditions - both large and small scale - that are outside design standards (e.g. prolonged heat waves leading to excessive energy consumption and use of water resources, severe storms leading to flooding) have been occurring more regularly and in an unpredictable manner. There are also extreme weather events, such as heavy hailstorms, which did not occur in Greece in the past. As earthquakes are a common occurrence in Greece construction standards of infrastructure and buildings are improved. For safety reasons all infrastructure needs to be checked so that necessary interventions can be made to cope with the new conditions. Therefore, a change of the legislative framework is required, including updating outdated regulations and specifications to modern standards. New regulations should guarantee safe constructions that may cope with the effects of climate change. Other suggestions are to conduct studies focussing on improved design and training of technical staff in terms of knowledge and skills for design and monitoring during the preparation and implementation of studies among others. Moreover, understanding the complex socio-physical mechanisms that trigger catastrophic events may result in insight into the design of safe structures and a more resilient built environment. Regarding the construction materials and systems that are part of infrastructure and buildings, it is important to consider the following: (a) performance and technical papers; (b) material's life cycle; (c) maintenance of operation; (d) rational use when referring to systems; and (e) integration of monitoring systems (Building Management Systems - BMS). Obstacles for the abovementioned improvements are high costs, limited experience of services in the field of construction, the age of the infrastructure and lack of resources.

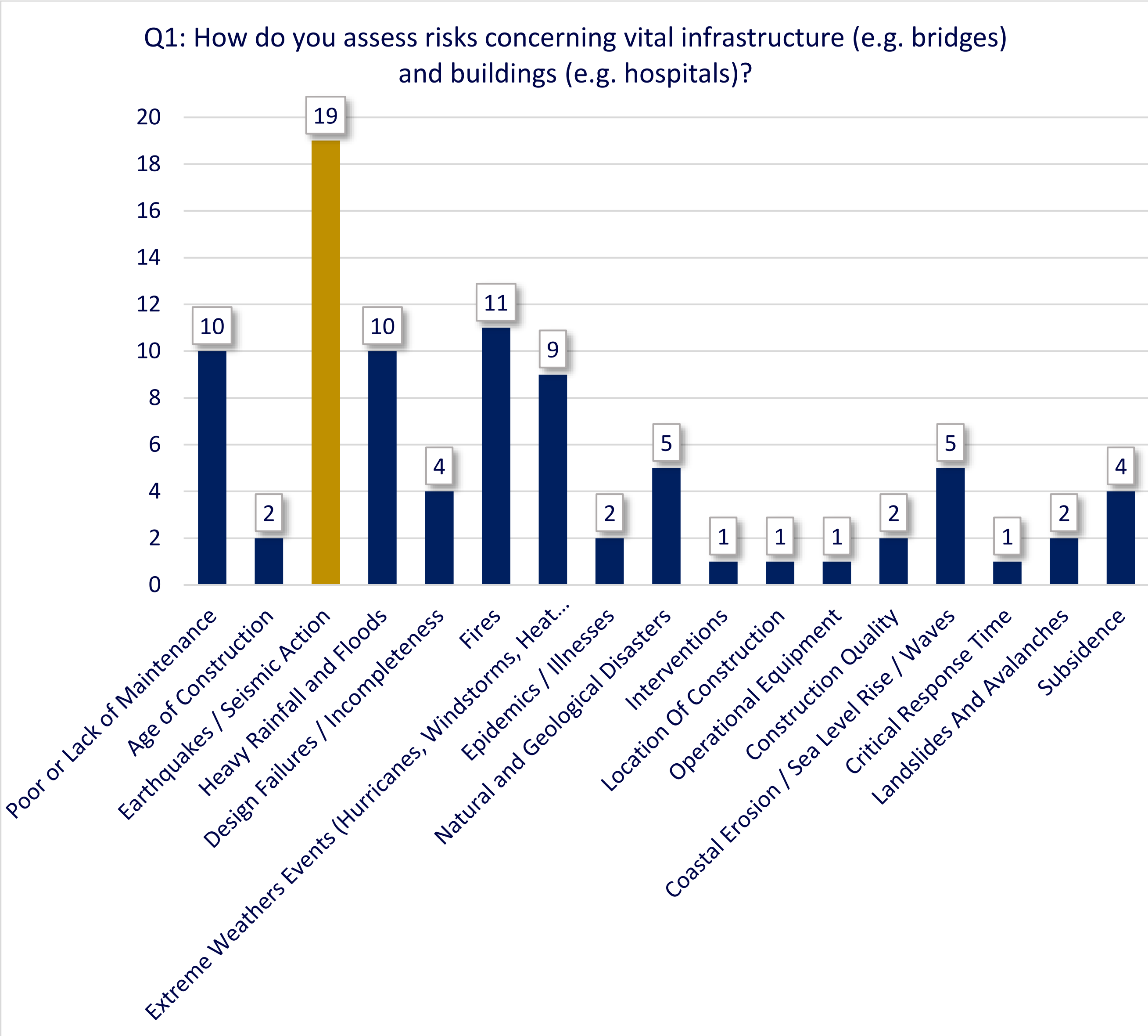

Figure 8. Risk assessment of critical infrastructure and buildings.

In training and studies attention has to be paid to the application of circular economy principles. In the construction sector this will lead to a reduction of excavation waste and the development of sustainable construction using recycled materials. Incentives, such as giving engineers/builders a reward for reusing resources and building materials, and to familiarise them with new, more environmentally friendly materials and methods would also help.

Until today concrete is dominant in construction and most widespread building material in Greece. Concrete is the material with the highest resistance to extreme weather conditions. Concrete could be improved to become an ecological or "green" building material. Although it is quite durable, it has a negative impact on the environment compared to other construction materials such as steel and wood. In particular, when a concrete building completes its life cycle and is to be demolished, the excavation waste cannot be recycled, which is not the case for buildings made by steel or wood.

Several alternative materials could be used instead of concrete, although not enough know-how is available. For example, metal structures (for which there is a high initial cost, but it is a material that can be recycled at the end of the building's life), recyclable materials, 3D printed bioplastics, nature-derived materials, wood, soil, and other innovative materials. For choosing the appropriate material various parameters need to be considered, such as the location of the building, its harmony with the landscape, etc., on a case-by-case basis. The state should ensure that the sector takes sustainability and environmental protection into account through subsidies, tax breaks or more innovative actions.

In short, the following can be concluded. The overall concern of users, in terms of the risks considered to be significant and related to vital infrastructure, is the intensification of extreme weather events and disasters and the lack of maintenance. Concerning the first, the intensification of extreme weather events is clearly due to climate change. The impact of climate change is particularly important for infrastructure, given its long-life cycle and high initial costs, as well as the essential role it plays in the functioning of our societies and economies. Infrastructure and buildings may be vulnerable to climate change due to their design (e.g. low storm resilience due to outdated regulations) or their location (e.g. in areas prone to flooding, landslides, etc.). They can be damaged or rendered unsuitable for use by any changing climatic conditions or extreme weather events: earthquakes, fires, sea level rise, extreme rainfall and flooding, heavy snowfall, strong winds etc. All these reflect the negative effects on their shell and structure. The lack of government care indicates the weakness of the monitoring mechanism as well as the lack of financial resources to improve, reconstruct and maintain the infrastructure.

PRISKADAPT

PRISKADAPT needs to address the above-mentioned risks, including geological and hydro-meteorological disasters, extreme weather events, floods, earthquakes and seismic action, hailstorms, extreme temperatures, prolonged drought, prolonged heatwave, heavy rainfall, strong winds, soil erosion, fires, frosts, coastal and slope erosion, etc. Here, a division of the risks can be made between construction risks, operational risks, reduction of lifetime risks, and lack of maintenance risks. Risks are important not only because they affect the vulnerability of structures, but because they drastically reduce their lifespan, have a large economic impact, and pose a significant risk of loss of life. These hazards should be included in the platform.

The features of PRISKADAPT should be accuracy and completeness of the results on the basis of which effective decisions are made. The reliability of the platform is also a key issue as well as a dynamic design of the platform. Other features of the platform include the possibility of adding new data, the adaptability of the platform of the inclusion of data to future development and the availability of an archive (for texts and photos), a library (of material, interventions, regulations and legislation, best practices etc.), and a database. Practitioners are able to extract technical reports, and to find funding opportunities, cost information, potential solutions and innovations regarding new material and sustainable structures. In addition, a link from the risk of critical infrastructure to possible funding, by setting up a committee of experts, which would closely monitor the data submitted and advise on solutions for the maintenance, repair and reopening of the structure in question and by seeking appropriate funds for this purpose, would be recommended. Additionally, a user-friendly interface, the documentation of data, the efficiency and the accuracy of the platform, the tools and the data provided, and also the available information regarding costs are considered essential. If possible, interconnection and correlations between factors would be relevant, as well as the creation of a system of durability indicators and achievement indicators, a comparison of methods, average environmental stats, a risk degree usage and factual data. Most important feature were the accuracy of information, continuous feedback, improvement, and maintenance of the platform and to ensure that the data remain relevant, accurate and reliable.

3.1.3.6 Focus group results analysis

During the focus group organized on the 18th of May 2023, where 13 members of the Technical Commission of the Federation of the European Precast Concrete Industry (BIBM) from 11 European countries were invited and participated, several issues were discussed (as presented in Section 3.1.2.6. The results of the focus group discussion are presented in the following paragraphs.

As regards the assessment, of the structure, the participants mentioned that after an extreme event (meteorological, accidental, natural etc.) the performance of a structure will be assessed with regard to maintenance of strength, maintenance of stability, and determination of the remaining capacity. Concerning strength, it depends on the magnitude of the "event". For some events, no significant damage would be expected (no need for repairing or minor restoration), for other events a partial collapse would be expected which asks for repairing and/or restoration. If an event is large enough total collapse may not be considered disproportionate (see EN1991-1-7). As far as stability is concerned, this is key due to the risk of collapse after an extreme event. Determination of the remaining capacity is important if the infrastructure of building or parts of it will be used after an extreme event. Main focus of the assessment is the evaluation of the compressive strength of which results will be used to decide to demolish or repair.

For the assessment of the structure two types of information were identified as relevant: (a) information about the event (e.g. wind speed, amount of water etc.), its magnitude and duration and; (b) information about the structure (e.g. material used, Recovery Service Level (RSL), etc.). Additionally, information on materials and signs of deterioration (other than due to the event) is important. The Eurocode standard EN 1992-1-1 (presently under revision) provides the following information.

See prEN 1992-1-1, annex I "Assessment of existing structures", I.4.1.2):

"In case of concrete structures affected by deterioration, where applicable the assessment should take into account the following effects: reduced concrete section due to delamination and spalling; reduction of cross sectional area and ductility of the reinforcement; stress concentration due to localized corrosion (e.g. prestressing steel); stress corrosion (e.g. prestressing steel); reduced concrete-steel bond; loss of mechanical properties of concrete (e.g. sulphate attack, AAR and DEF, frost attack, leaching and acid attack); cracking or expansion of concrete (swelling due to AAR and DEF)."

See prEN 1992-1-1, I.5.2.1:

"The investigation of concrete should aim mainly to determine the compressive strength in specific areas of the structure."

See prEN 1992-1-1, I.5.3:

"Where the characteristic values of the properties of reinforcing steel are assessed from testing samples extracted from a structure, the number, location and size of the test specimens should be selected to be representative of the members being assessed. In this case, the properties of reinforcing steel should be tested in accordance with EN ISO 15630 (all parts)." This also applies to prestressing steel.

There are several methods to verify the ultimate limit state of a structure, see prEN 1992-1-1, I.8 or Serviceability Limit States (see prEN 1992-1-1, I.9 and the detailing of reinforcement and post-tensioning tendons, see prEN 1992-1-1, I.11).

Characteristics of concrete that would best contribute to the resilience of a construction work are (1) long-term durability, high fire resistance, low maintenance requirements, while still remaining adaptable to changing uses; (2) normally continuity of the elements which comes naturally in well detailed insitu concrete but can be provided in well designed precast systems as well; (3) water resistance in case of flooding; and (4) a good performance at high temperature if fire is at issue. A structure is considered "robust" (i.e. able to avoid disproportionate collapse due to an initial damage) if normally continuity and the ability to develop secondary load paths are possible as well as if the structure sustains an extent of localised failure from an unspecified cause without disproportionate collapse and sustains a limited extent of damage or failure without collapse. A structure is considered "resilient" (i.e. able to adapt to and recover from the effects of changing external conditions) if resilience is defined as 'lack of sensitivity'. Compared to some other construction materials concrete is not sensitive to water, at least in the short term, damage due to fire can be relatively light meaning repair is relatively simple and can be implemented quickly.

3.1.3.7 Summary of key impacts identified

Based on the various sources, varying from literature review, content analysis to interviews, questionnaires and focus group, the key impacts as identified in Pilot 1 are elaborated below.

Transportation and mobility impacts

- Traffic congestion, as alternative routes are used.
- Alternative routes which take more time and have impacts on inhabitants living along these routes.
- Traffic problems, such as obstruction of emergency response, commuter traffic, free transportation.
- Affects negatively accessibility of communities to essential services.

Social impacts

- People are displaced due to the fact that they are pared down from their community and living far away from work and schools.
- More time needed for transportation, less time for other daily activities.

Health and safety impacts

- Safety issues as local roads pass through villages and residential areas and are not initially designed to serve heavy vehicles etc.
- Healthcare services might not be available or might face operating difficulties.
- Access to hospital is difficult due to alternative routes which take more time and cost more fuel (if there are no buses available)
- Emergency response services might not be available or might face operating difficulties.
- People can be injured or killed by bridge collapse.

Economic and financial impacts

- Businesses, industry and government might not be able to function (or they might malfunction).
- Loss of production and sales.
- Transport of products becomes difficult and more expensive due to logistics problems.
- Customer access is difficult due to alternative routes which are time consuming and costly.
- Delivery of supplies is problematic due to logistics problems.
- Increased cost of disposing of and replacing spoiled foods.

- Reduced tax income to government.
- Reduced employees' income.

Environmental impacts

- Waste generation due to difficulties to pick up and transport garbage.
- Food spoilage and food waste because logistics takes more time.
- More fuel needed for longer transportation routes.
- Decrease of air quality because diverted traffic leads to air pollution and emissions.

Agricultural impacts

- Longer transportation routes (approximately 40-50km more), more transportation time (as the local network is narrow and designed for lower speed traffic an average of 45m more is mentioned in general) and cost (gas and drivers reaching the max continuous hours they are allowed to drive) along with a consequential higher environmental impact (see also above).
- Most of the products exported are fresh fruits/vegetables which adds to the importance of the overall time needed for transportation (see also above).

Political impacts

- Political fallout: public dissatisfaction and criticism of local governments and transportation authorities may have political consequences.
- Public relations challenges: how to manage public expectations and how to provide updates on the renovation progress of the bridge.

At this point, it is important to mention that as the project evolves; the impacts list might get updated. If updates and/or changes occur, the final list will be presented in D2.2.

3.2 Pilot 2 – Energy Transmission Grids (Finland)

RISKADAPT Pilot 2 is related to the Energy Transmission Grids in Finland. Safe electricity is secured by transferring electricity in the main grid, on the "highways" of the electricity system, i.e. in the high-voltage network from production plants to industry and electricity companies. The national grid is the backbone of electricity transmission, which has been joined by large electricity producers, factories that consume a lot of electricity, and electricity distribution networks. Electricity production and consumption must be constantly balanced.

The related tasks within the RISKADAPT project are: Task 4.2 "Material Degradation and Structural Vulnerability of Adaptation Options for New/Existing structures" focusing on estimating the vulnerability of power transmission lines against wind and icing conditions and Task 4.4 "Atmospheric Icing for Energy Infrastructure" focussing on the possible future change of icing (along with wind) conditions. The research concentrates on changes in the long-term climatology, in time scales that effect the planning and maintenance of the relevant infrastructure.

Loss of power due to structural damage of the electricity transmitting powers (Pilot 2) can induce a cascading series of human suffering. Running water, vital medical services, radio and television broadcasts and home heating and lighting are some of the indispensable services that face risk of failure. Power grid disturbances tend to have disproportionate effects on human livelihood in vulnerable communities [43]. The sick, especially those on medical equipment requiring electricity for their function, the elderly, minority groups, and low-socioeconomic groups are among those particularly exposed [44].

Figure 9. Energy Transmission Towers (source: FINGRID).

RISKADAPT will assess the implications of power loss to vulnerable societal groups and suggest, in addition to strengthening measures for the electricity transmitting towers and backup systems, social adaptation measures, such as, subsidizing the purchase of generators for vulnerable groups.

In the following paragraphs, Pilot 2 data collection methods as well as their analysis are presented. The results of the data analysis were used for the identification of impacts and user needs, some of which were translated into user requirements (presented in Section 3.4).

3.2.1 Identification of stakeholders and engagement (Pilot 2)

For the stakeholders' identification and engagement process in Pilot 2, initially a CoP leader (RISKADAPT partner) was identified (FMI). The CoP leader is responsible to form and manage the CoPs, as well as decide and conduct (with the Task Leader – UU and other participating partners) the relevant to the Pilot activities, e.g. meetings, interviews, workshops etc. As Pilot 2 is about national energy infrastructure, technicians were the main stakeholder group from which information and data were collected. Technicians involved in the national energy infrastructure are working for Fingrid, Finland's transmission system operator (https://www.fingrid.fi/en/), associated partner in RISKADAPT. FMI has been in close cooperation with Fingrid about their user needs related to icing modelling and structural risks for energy transmission system. In addition, to long term effects on planning and construction, icing can have direct effect on power supply but also on traffic, most severely to aviation.

3.2.2 Data collection (Pilot 2)

In Pilot 2 data collection was conducted using research methods, such as literature review (desk research method), meetings and interviews (empirical data gathering methods). In the following paragraphs the results of the data collection are presented.

3.2.2.2 Scientific literature

In Pilot 2, an extensive literature review was performed in order to specify the social and economic impacts of power grid failures. In specific, published papers especially in the fields of engineering, energy and climate were reviewed. Moreover, apart from the scientific papers, additional sources of information were elaborated such as: technical reports and websites. Since the objective of Pilot 2 is to examine the vulnerability of power transmission lines against extreme wind and icing conditions, special focus was given to the impacts of recorded power failures that were mainly caused by adverse weather events. During the review process, a large number of relevant papers were accessed and the summary of information related to social (i.e., number of people affected) and economic (i.e., estimated monetary costs and losses) impacts of major historical power outages was made. It should be mentioned that most of the information was mainly provided by engineering papers that were dedicated to the analysis of the structural behavior of power transmission towers and lines under wind and icing conditions. In this kind of papers, authors also provide some data regarding power failures and their impacts in the introductory section. Furthermore, some papers that were dedicated to a meta-analysis of historical power grid failure events, their causes and impacts were elaborated, while especially the quantitative information (e.g., number of people affected, etc.) were verified by looking into technical reports or other sources available online. Moreover, icing on power lines as one of power failures, has been highlighted in the literature review.

The results of the aforementioned literature review regarding the social and economic impacts of power grid failures triggered by severe weather events and icing in particular are presented in Section 0.

3.2.2.3 Meetings

Three meetings with technicians of Fingrid were organised on 15 February 2023, 17 February 2023 and 14 July 2023. The key points of discussion were the user needs and requirements related to icing modelling and structural risks for the energy transmission system **(see Annex 4)**.

3.2.2.4 Interview

Moreover, in Pilot 2 a duty meteorologist at FMI was interviewed to get background information on operational needs and challenges in the current icing forecasts model.

A topic list was designed and used to gather the relevant information on icing concerns **(see Annex 5)**. The topic list was based on the literature review and the meetings with technicians of Fingrid. The interview's aim was to address the kind and impact of severe events on their operations, as well as specific questions on icing phenomenon management. Before the interview started, the aim was explained to the interviewee and he was asked to sign an informed consent sheet.

3.2.3 Data analysis (Pilot 2)

Based on the methods used for data collection in Pilot 2 (as described in the previous Section), in the following paragraphs the data collected are analysed and presented. Moreover, the user needs identified in the literature, meetings and interview are described.

3.2.3.2 Scientific literature analysis

Electricity constitutes the backbone of today's society and economy. In modern countries even, a brownout (i.e., reduced voltage) of some minutes or a short blackout (i.e., complete failure of electricity) causes inconvenience at homes or work places. Longer blackouts that last for hours or even days have significant impact on daily activity and may affect the entire economy of a region or even a whole country. During a long or expanded blackout critical infrastructure such as transport and communication may be hampered, the heating and water supply to homes and industries may be interrupted, while production processes and trading may cease. Moreover, significant impact will be observed on the vital emergency services (i.e., fire, police or ambulances) due to the failure of communication network, while hospitals will be able to work only by using power supplied by auxiliary power generators. Finally, since there are many grid interconnections between different (adjacent) countries, an extensive blackout may not affect only a specific region or country but it can be escalated to the neighbouring countries [45].

Considering the above, the seamless supply of electricity plays a vital role in our modern society, thus the high reliability and resilience of the power grid is of special importance and has gathered significant attention by the current academic research and power industry.

A failure of the power grid can be caused by a number of various reasons as cited in the corresponding literature. Sroka and Zlotecka (2018) reviewed statistical data from more than 100 power grid failures occurred worldwide over a period of 50 years [46]. Their analysis considered the causes of failure, the number of people affected, the power losses and the duration of events. According to their findings the largest number of failures were observed in North America, especially due to the territorial extension and the frequent exposure to extreme weather conditions. Table 1 shows that the vast majority of the blackouts (74%) in North America was attributed to atmospheric phenomena (i.e., extreme weather). Similarly, atmospheric phenomena were responsible for the 62% of the blackouts in Australia and Oceania, while for South America the corresponding percentage was equal to 45%. On the other hand, regarding Europe and Africa although the corresponding percentages were lower, they were still equal to 33% meaning that the atmospheric phenomena were responsible for one out of three blackouts. Lastly, for Asia where the technical causes were responsible for the majority of events (44%), the atmospheric phenomena were responsible for the 24% of the events (i.e., one out of four).

Table 1. Causes of blackouts in power systems per continent [46].

Continent	Atmospheric Phenomena	Technical Causes	Human Factors	Undefined Causes
Africa	34%	33%	33%	0%
Asia	24%	44%	12%	20%

Continent	Atmospheric Phenomena	Technical Causes	Human Factors	Undefined Causes
Australia & Oceania	62%	15%	8%	15%
Europe	33%	37%	27%	3%
North America	74%	11%	9%	6%
South America	45%	44%	11%	0%

The relationship between extreme weather phenomena with power grid failures is also evident in Figure 10, which presents the seasonal dependence of causes of power grid failures on the north hemisphere. Based on Figure 10, weather conditions have the greatest share of the causes in all months of a year. However, the influence of weather conditions is found to be more intense during the summer and winter months when more adverse weather phenomena (e.g., high temperatures, gusty winds or cyclones during summer; and snowstorms and accumulation of hard rime on power lines during winter) are expected.

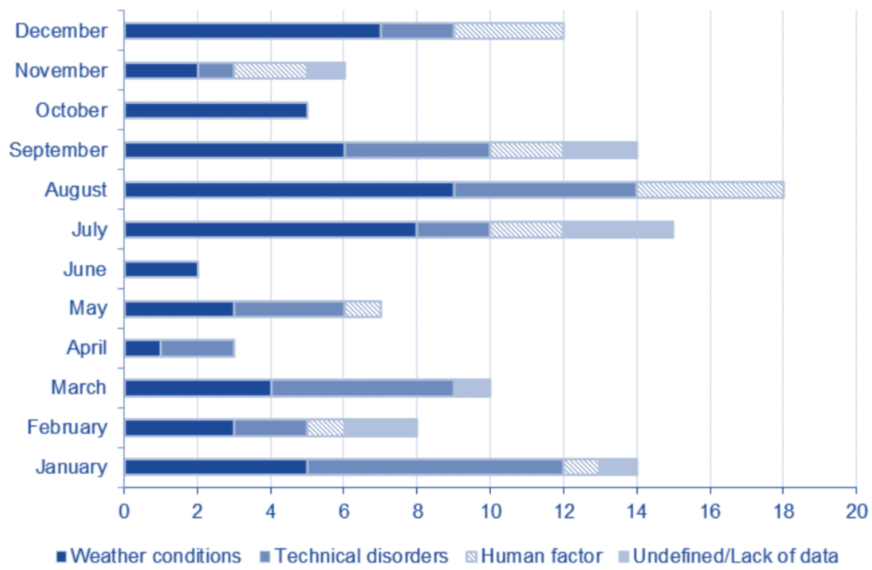

Figure 10. Seasonal dependence of causes of the power system failures on the north hemisphere [46].

In a similar study Behnert and Bruckner (2018) analysed the causes and impacts of 250 power grid failures that affected at least 70,000 people worldwide over the period from 1965 to 2012 [47]. According to their findings, extreme weather events were responsible for the 30% of the failure events they analysed. Furthermore, an additional 7% of failures was attributed to extreme temperature (either too low or too high) which caused either direct damage to the mechanical parts of the power network or failures caused by the increased demand of consumers (e.g., increasing need for heating during low temperatures or cooling during high temperatures) which exceeded the capacity of the network.

Figure 11 depicts the frequency and average duration of large-scale blackout events over the period from 1977 and 2012. Following the figure, there is a significant increase in the annual frequency of blackout events that were attributed to extreme weather conditions especially after 2000. A possible explanation to this trend might be the global climate change which has caused an increase in the probability of extreme weather events and consequently in grid failures.

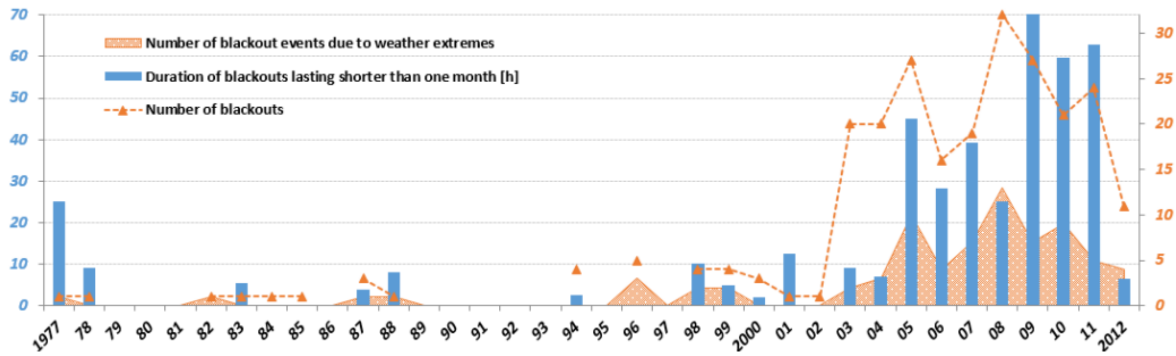

Figure 11. Frequency and average duration of large-scale blackout events over the period 1977-2012 [47].

In addition to the above, the association of weather with power grid failures is also evident byFigure 12 and Figure 13. Based on Figure 12, weather conditions were responsible for the vast majority of power grid failures in North and Central America and for a significant percentage in Europe. Although, the percentages might be different from those reported by Sroka and Zlotecka (2018), similar inferences regarding the effect of weather conditions on power grid failure per continent can be drawn.

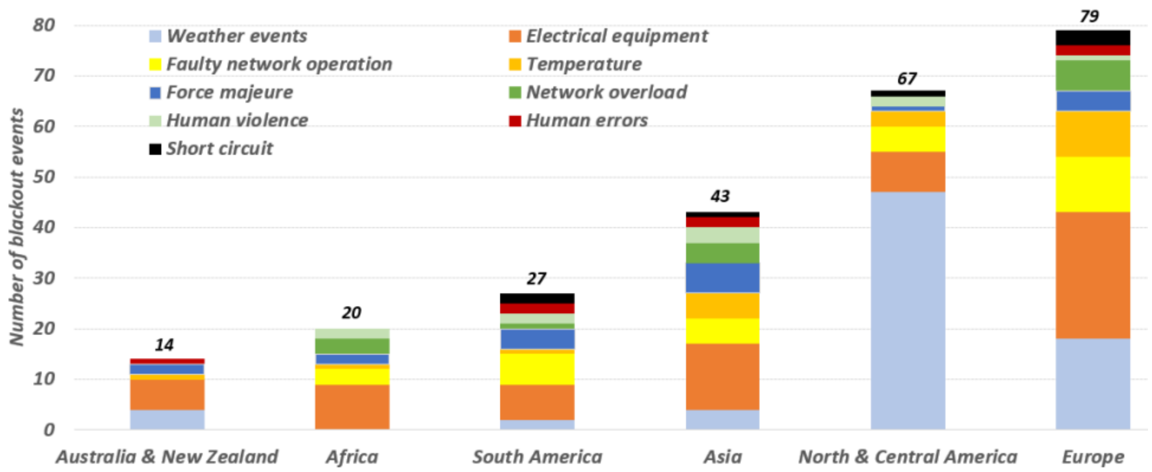

Figure 12. Distribution of power outage causes per continent [47].

Weather events are not only responsible for causing a black-out but they also seem to be responsible for long-lasting events (Figure 13). According to Behnett and Bruckner (2018) the average duration of a blackout caused by weather events is equal to 71.1 hours (i.e., almost 3 days) [47]. It is noteworthy that this value is the second largest after the average duration of power grid failures caused by force majeure which were significantly less frequent (only nine events during the period considered), while it is almost two times the third in order value of average duration which corresponds to events caused by human violence (average duration 36.4 hours).

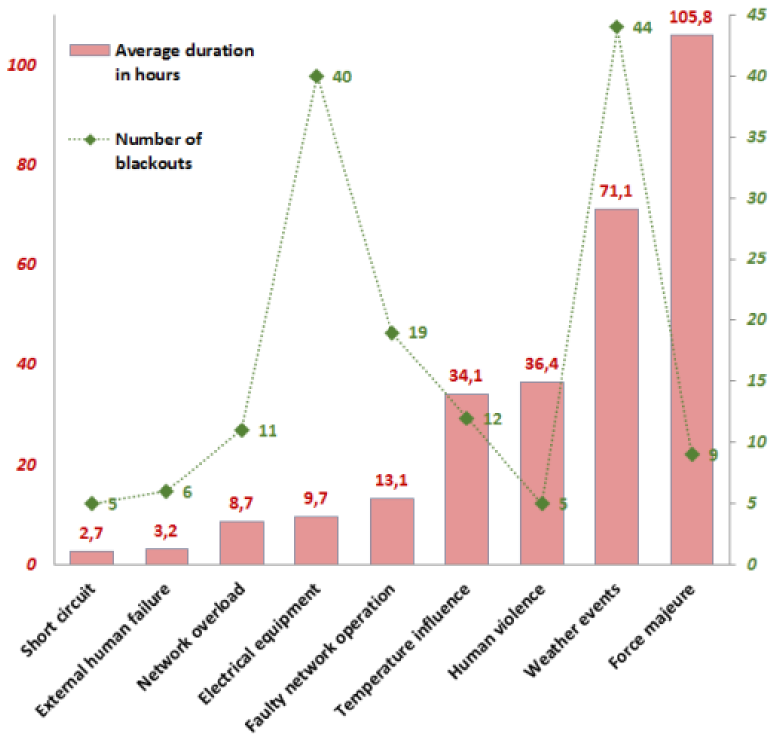

Figure 13. Average duration per cause for blackout events over the period 1977-2012 [47].

Noticeable Historical Events

A large number of events of adverse weather conditions which led to major grid failures with significant social and economic losses has been recorded worldwide. Some of the most noteworthy events are presented here.

1998 Ice storm in North America

An ice storm hit Canada (Ontario, Quebec) and several northeastern states of the USA in January 1998 [48]. According to Ontario Hydro the 31% of the distribution lines were damaged in the area of Ontario in addition to 130 transmission towers and 2,100 transformers which were destroyed. On the other hand, Quebec Hydro reported a loss of 600 transmission towers, 4,000 transformers, over 3,000 km of high voltage transmission lines, over 16,000 wooden transmission poles and over 2,000 additional supporting structures. The estimated costs of damages only for the power companies were 140 million of Canadian Dollars for Ontario Hydro, and 800 million of Canadian Dollars for Hydro-Québec [49, 50]. Regarding the social cost, it was estimated that more than 4 million people were left without electricity, most of them in southern Quebec, western New Brunswick and Eastern Ontario, some of them for an entire month. Finally, the damage of the grid was so severe that a major rebuilding was undertaken instead of repairing the failed lines [51].

2005 event in Münsterland and Osnabrück region, Germany

The event took place in November 25, 2005, due to a heavy snowfall event in Münsterland region of Germany. The interaction of coincident threats (strong winds reaching hurricane force, temperatures about 0°C, heavy snow load on the lines and rain) resulted in the collapse of over 80 transmission towers which led to the failure of seven 100-kV power transmission lines [47, 52]. It is noteworthy that according to expert reports no safety deficiencies, material defects or poor maintenance were identified concluding that the weather-related weight overload of snow on the power lines, which tremendously exceeded the design values provided by the technical regulations, caused the collapse.

The aftermath of the event included 250,000 people who faced electricity supply interruptions for nearly five days, while 600,000 people faced temporal power outage in the region of Osnabrück. The financial cost was estimated at about 13 million €. In addition to the above numbers the event caused a highway closure due to torn high-voltage power lines that fell down cutting off further lines for safety reasons, while emergency power generators were elaborated in order to cool down perishable goods or to operate milking parlors on the farms. Furthermore, a significant challenge for authorities was to coordinate the supply and care of the population as well as the operation of emergency power generators in hospitals, rest homes or at farms, since many households were poorly provided with food supplies.

2008 ice storm event in China

In January-February 2008, disastrous ice and snowstorms severely damaged the power grid in several provinces of China. According to the State Grid Corporation of China, at least 36,740 transmission lines, 5,420 steel towers, and 2,018 transformers were damaged, and at least 1,841 steel towers needed to be repaired. It was estimated that more than 200 million people (or 12% of the Chinese population) were affected by power outages. Especially in Hunan province more than 40 million residents were still without power two weeks after the ice storm, and it took almost a month to fully restore the power supply [53]. Finally, the direct economic loss due to the event was estimated to be more than $16 billion [54].

2008 ice storm event in Szczecin event, Poland

During the night of 7-8 April 2008, Poland faced the longest blackout in its history due to the combination of storm winds and heavy rain, which caused extensive damage to transmission lines supplying power to the Szczecin agglomeration and adjacent municipalities. In specific, a cascade of outages of four extra-high voltage lines supplying the left bank part of the city was triggered by the automatic disconnection of the 110 kV Recław-Moracz-Goleniów line, caused by the breaking of the arms of the power pylons. The blackout left more than half a million people without electricity for several hours, completely paralysing life in the city and causing chaos and serious problems in the functioning of the region due to the damage and temporary shutdowns of many network infrastructures (including the district heating system), transport disruptions, as well as the suspension of trade, banking, production and interruptions in the work of most state institutions [55]. Documented losses resulting from the failure amounted to over 50 million PLN, which was equal to 14.5 million € at that time [56].

All the aforementioned events indicate that adverse weather conditions, especially strong winds combined with large accretions of ice, can lead to major power blackouts with huge social and economic impacts. Except for the aforementioned events presented in detail, Table 2 lists some additional events of major power grid failures along with their social and economic impact (where available).

Table 2. List of major power failure events due to extreme weather

Location	Date	Duration	Social Cost (affected people)	Economic Losses	Impact on Power Grid	Reference
Mexico	Hurricane Odile in 2014		240 thousand	$800 million	Failure of 481 transmission towers, 7,971 utility poles, and 1,553 transformers	[57]
US northeastern sites	Hurricane Sandy in 2012	up to 2 weeks	8.2 million			[58]

Location	Date	Duration	Social Cost (affected people)	Economic Losses	Impact on Power Grid	Reference
Poland	January 2010	up to 9 days locally	80 thousand		Heavy rains and strong winds caused 3 transformers on a key high-voltage transmission line to short circuit	[56, 55]
Brazil & Paraguay	November 2009	25min to 7h	87 million			[45]
Poland	April 2008	several hours	500 thousand	14.5 Million €		[55]
China	January and February 2008		200 million	$16 Billion	Failure of at least 36,740 transmission lines, 5,420 steel towers, and 2,018 transformers were damaged, and at least 1,841 steel towers needed to be repaired.	[54, 53]
Germany	November 2005	Up to 5 days	850 thousand	13 Million €	collapse of over 80 transmission towers which led to the failure of 7 power transmission lines	[47, 52]
North America (Canada & USA)	January 1998	Up to 1 month	4 million	940 million Canadian Dollars	Ontario (Canada): 31% of the distribution lines were damaged; 130 transmission towers and 2,100 transformers were destroyed Ontario (Quebec): 600 transmission towers, 4,000 transformers, over 3,000 km of high voltage transmission lines, over 16,000 wooden transmission poles and over 2,000 additional supporting structures	[49, 50]
USA (West Coast	December 1982		over 5 million		A major 500-kV transmission towerfell into a parallel 500-kV line tower. The failure mechanically cascaded and caused three additional towers to fail on each line.	[58]

What is atmospheric icing?

Atmospheric icing has been studied for several decades, not only due to the hazardous consequences it can have to air traffic, but also due to the damage it can cause to human installations such as power lines, wind turbines, radio towers etc. Overhead structures that are built in mountainous regions at mid- and high latitudes are particularly vulnerable to the exposure of supercooled water in clouds.

Based on Ingvaldsen's thesis (2017) on atmospheric icing in western Norway during the 2015-2016 winter season the phenomenon can be defined as supercooled liquid water that is commonly found in the atmosphere at temperatures between −15◦C and 0◦C, both as cloud droplets and drizzle or rain [59]. The supercooled water particles freeze immediately upon impact if they hit aircraft, power lines, wind turbines or any other object. This particular process is referred to as rime-icing. Ice accretion on structures may also occur due to collection of wet snow particles (wet snow accretion) and by deposition of water vapor (hoar frost). Each of these processes are generally referred to as atmospheric icing, a phenomenon that has been studied extensively during the past decades. There are several examples in the literature portraying the potential harmfulness of atmospheric icing events. The most famous one is perhaps the freezing rain event in eastern Canada, 1998, also known as 'the Great Ice Storm of 1998' (see above). Massive damages to the power grid deprived more than four million people of electricity for weeks, as thousands of transmission towers collapsed due to heavy ice loads. The storm led to a total of 35 fatalities. In 1961, in Voss, Norway, rime ice coated power lines with ice loads of up to 305 kg/m. Similar events, though less extreme, are observed every year in many countries at mid- and high latitudes (see also above).

The complex nature of icing events makes them hard to predict, as calculations of cloud physical processes in atmospheric models rely on simplifications and parameterizations. This leads to uncertainties regarding the total availability of atmospheric water, and subsequently the abundance of Supercooled Liquid Water Content (SLWC). However, the computational power of today's super computers allows atmospheric models to apply increasingly more sophisticated microphysics schemes

As the climate is changing, and is expected to continue to do so, our understanding of atmospheric icing faces further challenges. How will the icing conditions be different in a future climate? Largely due to uncertainties regarding how a future climate may look like, this question is difficult to answer even with the most advanced tools available today. Nevertheless, it is a relevant question as power lines and other exposed structures are built to withstand ice loads up to a certain threshold and have a desired lifetime extending well into a period where the climate is expected to be different from what it is today. Although the exact outcome of climate change is difficult to predict, some climate variables are very likely not to change due to physical constraints. Important to the atmospheric icing conditions is the fact that the distribution of relative humidity in the troposphere is believed to remain more or less constant (Intergovernmental Panel on Climate Change, 2014; Allen and Ingram, 2002). Consequently, increased global temperatures would imply an exponential increase in specific humidity according to the Clausius-Clapeyron relation. Increased values of water vapor content are already evident from observations [60]. Numerical studies have shown that atmospheric icing in a changing climate may lead to higher precipitation rates in regions where precipitation rates are already high, including the mid- and high latitudes.

Climate induced risk related to power supply

The following background information concerning climate induces risk related to power supply in Finland, is based on Finnish National Risk Assessment 2023 [61]. Similar considerations are valid for other Nordic countries and even wider in Europe.

Disruptions in power supply in recent years have been caused mainly by trees fallen on power lines due to storms and packed snow. However, these events have been regional. Very extensive and violent storms occur in Finland approximately once or twice per decade but as more and more of the power grid is being converted into underground cabling, the impacts of strong winds on power supply are constantly decreasing. Other possible threats include extensive technical or human-caused disruptions in power generation, transmission or distribution. There may also be disruptions in the availability of power plant fuels or power import connections.

The progress of climate change can increase the risk of major disruptions in power supply, especially due to the reduction of ground frost and the increase in the exposure of trees to wind damage and packing of snow. Freezing rains are also likely to become more common. They increase the exposure of the power distribution infrastructure to damage.

Turvallisuuskomitea (2015) highlights that Finnish transmission grid consists of approximately 14,000 kilometres of power lines and 113 substations. In Finland, it is customary to have sufficient electricity. In recent years, the reliability of electricity supply in Finland has been at the same level as in Sweden. There are slightly more power outages in Finland than in sparsely forested countries in Central Europe, but fewer than in countries in Eastern and Southern Europe. From 1999 to 2004, Finland experienced a lot of power outages; among European countries, only Portugal had more outages than Finland during that time.

In Finland, there have been long power outages. During the Janika and Pyry storms in 2001, electricity was out for over 12 hours for 200,000 residents. In the summer and winter storms in the early 2010s, the longest outages lasted for six weeks. The new Electricity Market Act, which came into effect in 2013, obligates electric companies to improve the reliability of electricity distribution networks. According to the law, the network must be designed, constructed, and maintained in such a way that storms or snow loads do not cause power outages lasting more than 6 hours in urban areas. In other areas, outages must not exceed 36 hours. This requirement does not apply to islands without roads or ferries, nor to sparsely populated areas.

Electricity disruptions in Finland are mostly caused by adverse weather conditions, such as storms, strong winds, heavy snowfall, freezing rain, and lightning strikes. A significant portion of the electricity grid is exposed to the elements, making it vulnerable, for example, to trees falling during a storm. Storms cause disruptions in electricity distribution, particularly in the medium and low voltage grid. Only for the high voltage grid can a wide clearance space be cleared so that falling trees do not touch the wires and cause power outages.

The role of municipalities in preparedness is essential, as the provision of services to residents and the safeguarding of many vital functions are especially the responsibility of municipalities even in normal circumstances. The preparedness of municipalities is led by the municipal manager together with the municipal board. The Preparedness Act obliges not only various actors of the state but also municipalities to preparedness planning and advance preparation for activities during exceptional circumstances. Municipalities must ensure the smoothest possible performance of their tasks even during exceptional circumstances. The starting points for companies' preparedness are business justifications, agreements made with customers, and operational risk management. For example, the daily goods supply chain and financial sector are also obligated by legislation to be prepared for disruptions. Civil society organizations play a significant role in increasing practical safety. They also enhance society's resilience to crises through their activities. Civil society organizations have a long-standing experience in assisting authorities, for example, in organizing search and rescue, firefighting, and first aid operations.

3.2.3.3 Meetings results analysis

During the meetings held with technicians of Fingrid it became clear that they are interested in the future changes of the loadings caused by weather conditions, such as strong winds and icing, but especially by loadings by snow. The structural risk models of Fingrid are based on certain assumptions on the climatological loadings, and any changes in these will affect the planning. A life span of an electric tower can be up to 80 years. So, it is important to consider the risk induced by changes in the climate. For example, it has already been seen that the formation of frost on power lines and structures has changed in recent years.

It was pointed out that the build and construction of the electric towers is different in Finland and Scandinavia compared to that of other parts of Europe. In addition, all the Scandinavian countries have their own climatological and geographical special features that would need to be accounted for. Fingrid will provide the required information for structural assessment of typical lattice towers and the assessment of risk of power outage and support user requirements and evaluation of the results. RISKADAPT project partner ERRA will use the provided drawings and other relevant information to build algorithms for the wind and ice loading of lattice towers in task 4.2. For pilot 2, task 4.2 also estimates the risk of power outage for the power line. Fingrid has grid infrastructure vision for the years 2035-2045. Even for this period, there can be significant changes in the climatology of variables that affect, e.g., the amount of snow, icing conditions, and frost formation.

With regards to icing, e.g., formation of ice on power lines, special quantities of interest include the length of icing periods and how they might change in the future, and the vertical profile of icing. For power lines, the interest is at much lower altitudes than it is for the wind power turbines, whose peak height can be over 250 m (hub height + rotor blade length). One aspect of interest specially mentioned was the effect of atmospheric icing on wind power production. For this, wind power companies would be additional stakeholders. An example mentioned by Fingrid was a 2-week period in November 2022 where intensive ice formation occurred in those parts of Finland with large wind power farms. This affected electric markets, where there is a need to define the day-ahead prices based on forecasted production. For wind energy the main factor is the forecasted wind speed, but ice formation will affect the maximum power production. An accurate prediction of icing conditions would be useful. In RISKADAPT, which concentrates on future climatological changes, this would mean a study of intensity and lengths of icing periods in the future climate. Considering the time horizon of Fingrid's vision, i.e., 2035-2045, their interest is somewhat more pronounced as regards the icing climate of coming decades than that of the end of the century.

Discussion with Fingrid led to several useful requirements for the project. They were mostly technical and related to what features in the future climate will have most effect on the planning of future infrastructure. The meetings with technicians of Fingrid provided valuable insights into their needs and concerns regarding atmospheric icing and snow accumulation. The company recognizes the significance of these factors in their operations and seeks improved data, modelling approaches, and tools to assess and mitigate associated risks. The RISKADAPT project, and the developed portal, aligns with Fingrid's requirements and has the potential to enhance their decision-making processes related to climate change adaptation.

3.2.3.4 Interview results analysis

In the interview with duty meteorologists the main points for discussion whether interpretations of the findings from the literature review and how to find out the available models and data. A potential stakeholder of the data collection on icing is commercial aviation, but this is out of scope of the current project. The icing models that will be developed in this project would be useful to aviation, too.

3.2.3.5 Summary of key impacts identified

Energy is crucial for society and economy so an energy shortage or cut off has great consequences. Based on the literature review, meetings and interview the following key impacts are identified, which are not exhaustive:

Transportation impacts

- Transportation problems, such as obstruction of commuter traffic, free transportation.
- Gasoline shortage, and disruption in train, metro and tram traffic.
- Energy shortage, and disruption in train, metro and tram traffic.

Health and safety impacts

- Healthcare services might not be available or might face operating difficulties.
- Emergency response services might not be available or might face operating difficulties.
- People's health and safety might be affected due to energy shortage.

Economic and financial impacts

- Businesses, industry and government might not be able to function (or they might malfunction).
- Banking system might not be able to function (or they will malfunction).
- Loss of production and sales.
- Transport of products becomes difficult due to logistics problems.
- Delivery of supplies is problematic due to logistics problems.
- Increased cost of disposing of and replacing spoiled foods.
- Reduced tax income to government.
- Reduced employees' income.

Political impacts

- Political fallout: public dissatisfaction and criticism of local governments and energy authorities may have political consequences.
- Public relations challenges: how to manage public expectations and trust, as well as restoration of energy.

Local community impacts

- Disruptions in heating (winter) and cooling (summer).
- Disruptions in water supply and sewage management.
- The storage of food suffers when freezers and fridges do not function.
- Lack of communication channels.
- Communication difficulties.

At this point, it is important to mention that as the project evolves; the impacts list might get updated. If updates and/or changes occur, the final list will be presented in D2.2.

3.3 Pilot 3 - Cattinara Hospital in Trieste (Italy)

RISKADAPT Pilot 3 is related to Cattinara Hospital in Trieste (Italy) that was founded in 1984 and has a capacity of 565 beds. The hospital's facilities include two 15-storey towers. The city of Trieste is located on the Adriatic Sea and is surrounded by the Carsic hills that make the city particularly exposed to the Bora wind, which is an intense phenomenon characterized by sudden strong gusts that can reach 130-150 km/h. Therefore, tall buildings such as the hospital's towers are extremely vulnerable to high wind and wind-driven rain [62].

Structural failure of a hospital building (Pilot 3) could affect health services provision, as well as patients, personnel, suppliers, local drug stores and other hospitals in the area. RISKADAPT will assess social consequences and, in addition to structural measures and back up water, power and fuel supplies, will study social adaptation measures, such as emergency planning to increase efficiency in the remaining area, subsidies to local suppliers/drug stores to keep employment at the same level, provision of a field hospital to keep service provision at the same level.

In the following paragraphs, Pilot 3 data collection methods as well as their analysis are presented. The results of the data analysis were used for the identification of impacts and user needs, some of which will be translated into user requirements (presented in Section 3.3.4).

Figure 14. Cattinara hospital (source: commons.wikimedia.org)

3.3.1 Stakeholders' identification and engagement (Pilot 3)

For the stakeholders' identification and engagement process in Pilot 3, initially a CoP leader (RISKADAPT partner) was identified (MTr). The CoP leader was responsible to form and manage the CoPs, as well as decide and conduct (with the Task Leader – UU and other participating partners, I.e. UNIBO) the activities relevant to the Pilot, e.g. meetings, interviews, workshops, etc. Starting point for the stakeholder analysis was contact some partners, the Municipality collaborates with, to facilitate the identification of CoPs and stakeholder groups.

Thanks to the involvement of the Association of Engineers, the *Habitat Microaree* and the Trieste Paesc the Municipality was in contact with a first group of stakeholders representing technicians, practitioners, environment and energy experts, health and social services, Municipality offices. A first meeting was organised with the aim to share project info, explain project the importance of stakeholders' involvement and enlarge contactcs to identify the five CoPs, as requested by the approved proposal. The Association of Engineers includes all engineers of Trieste who may provide information on technical matters. Habitat Microaree is a project started more than 20 years ago to improve the quality of life of the citizens of Trieste, especially those who live in peripherical or critical areas. The project is based on a collaboration of the local health agency (ASUGI), the public housing agency (ATER), social cooperatives, associations of citizen, and the social services of the municipality to develop and implement social, cultural, and educational services. The urban area is divided in several Microaree, and in this first phase two of them closest to the hospital were contacted. Trieste Paesc is a group of stakeholders who is working for the Action Plan for Sustainable Energy and Climate (EU Covenant of Mayors) varying from the University of Trieste, research institutions, environmental, mobility and energy experts, the Port authority, and representatives of the private sector.

3.3.2 Pilot 3 - Data collection

In Pilot 3 data collection was conducted using various methods, including literature review, as well as meetings and questionnaire. The first is considered a desk research method, whilst the latter is an empirical data gathering method.

3.3.2.1 Scientific literature

The normative literature on heavy weather events and the consequences for health care services, in particular hospitals, and hospital resilience, was reviewed.

3.3.2.2 Meetings (organisation)

In Pilot 3, two meetings were organized to collect data. The 1st preliminary meeting was held online on the 30th of March 2023, and approximately twenty stakeholders participated. It aimed at introducing the RISKADAPT project to three stakeholder groups **(see agenda in Annex 6),** and knowing their willingness to be actively involved in the project. Technicians, the most active group, focused on technical aspects, while representative of social and health system and Paesc members, were less involved but provided some relevant suggestions about social aspects.

The 2nd meeting was a physical meeting and was held on 12th of May 2023 at Trieste Urban Center, in Corso Cavour 2/2. Forty-two (42) stakeholders representing technicians, practitioners, and civil society participated. During this meeting **(see agenda in Annex 7**), local stakeholders were informed about RISKADAPT's aim and objectives, the effects and possible consequences of extreme weather events, in particular wind and precipitation, assuming future scenarios, especially regarding possible impacts on buildings and infrastructures with functions of public interest. The speakers focused on the local pilot action explaining upcoming activities such as measurements and data collection for Cattinara Hospital and how information, integrated with the ones provided by the stakeholders, will be essential for designing the platform PRISKADAPT.

3.3.2.3 Questionnaire

A questionnaire was designed **(see Annex 8)** using insights from the literature and discussions with partners and stakeholders. The questionnaire's aim was to address risks and impacts regarding climate change induced weather events and it had a general part, for all participants, and specific parts for the different CoPs: technicians and technicians working at the hospital, practitioners, citizens and civil institutions.

3.3.3 Data analysis (Pilot 3)

Based on the methods used for data collection in Pilot 3 (as described in the previous Section), in the following paragraphs the data collected are analysed and presented. Moreover, the user needs identified are described.

3.3.3.2 Scientific literature analysis

A hospital can be considered a Critical Infrastructure (CI) based on the EC 114/2008 directive that defines as CI "the assets, systems, and networks located in Member States which are essential to maintain the vital economic and social functions such as **health**, food, transport, energy, information systems, financial services, etc." [63]. The EC recognizes that these infrastructures must be protected from the disruption might be caused by natural disasters and man-made threats, and as such has launched the European Programme for Critical Infrastructure Protection (EPCIP). CIs now more than ever, must be vigilant in establishing safeguards against physical threats, as it is imperative to have a solid understanding of the risks, vulnerabilities, security processes and technologies available [64]. The health sector is responsible for [64]: (a) delivering services that improve, maintain or restore the health of individuals and their communities; (b) protecting the population against health threats as well as consequences of ill-health and; (c) providing equitable access to people-centered care. The COVID-19 pandemic brought the health sector to the forefront and further illustrated the importance of protecting health services and medical data [65].

According to WHO, hospitals complement and amplify the effectiveness of many parts of the health system, providing continuous availability of services for acute and complex conditions [66]. Hospitals depending on their mission, offer different services such as pharmacy, pathology, radiology, nursing, acute (e.g. emergency department or specialist trauma centre, burn unit, surgery etc.); specialized (e.g. cardiology or coronary care unit, intensive care unit etc.) outpatient and chronic treatment etc. They are expected to provide appropriate and responsive care and; ensure acceptability and accessibility to its services. Moreover, several new technologies, ranging from Internet of Things (IoT), wearable external and implanted medical devices (skin patches, insulin pumps and blood glucose monitors), order entry and administrative Information Systems (IS) to laboratory and operation theatre IS, have been adopted in hospitals.

Any physical incident that causes loss of infrastructure or massive patient surge, such as natural disasters, could affect the health care services provision and could cause overwhelming pressure to the affected health systems. In the respect of RISKADAPT and taking extreme weather events as a point of departure, hospitals and other health care services could face damage to infrastructure (for example, power and water supply interruptions, damage to vital equipment, disruption of internal and external communication systems, blocked transport systems) that disrupts normal activities. In addition, health effects could occur indirectly from damage to infrastructure, ecosystems, food and water supplies or social support systems. They can be immediate or can appear days, weeks or months after a heavy weather event occurred.

They may also experience an increased influx of patients; this may include also patients that require particular specialized care or vulnerable people (e.g. children, pregnant women, people with chronic illnesses, people who rely on home care, elderly people, people with physical, sensory and cognitive impairments, homeless people, people from minority populations, and socially isolated people). Several factors render certain population groups or individuals at particular risk of suffering from health impacts of a heavy weather event: limited physical capacity, limited mobility, reliance on important medication and/or home care, reliance on regular care at a health facility, weak social networks, poor flood awareness, lack of resources, lack of access to information and warnings, staying in buildings at high risk from floods [67].

In fact, the importance of security and safety in healthcare, as they must remain vigilant in establishing safeguards against threats, which is why it's imperative to have a solid understanding of the risks and protections available [68]. While resilience is a theoretical concept that originally stems from ecology meaning the inherent ability to absorb various disturbances and reorganize while undergoing state changes to maintain critical functions, the concept is now applied to many disciplines. A relatively new concept is 'hospital resilience' that can be conceptualized by its components, capacities, and outcomes [69, 70]. The interdependence of the following six components influences hospital resilience:

(1) **space**: constructive and infrastructural resilience and agility in space reorganization.

(2) **stuff**: finance, logistics, and supply chain mechanisms.

(3) **staff**: qualified personnel.

(4 and 5) **systems and strategies**: utilizing adaptive leadership, management, and planning.

(6) **services**: maintaining hospital functionality, especially during surge capacity during emergencies and disasters.

Resilient hospitals utilize all following capacities, sometimes simultaneously, through prevention, preparedness, response, and recovery, within a risk-informed and all-hazard approach [70]:

- **Absorptive**: resist, prepare, or withstand the unforeseen shock of the emergency or impact of the disaster without loss of function.
- **Adaptive**: respond or can use alternate reserves or processes to maintain essential functions and meet immediate and acute community needs (ensure continuity of efficient, safe, high-quality, and person-centered health services).
- **Transformative**: recover from the disruption rapidly and at a sensible cost and reduce vulnerability to risk and improve readiness for future emergencies.
- **Learning**: reflect and review past actions and their effectiveness to inform future actions, question assumptions, challenge and change existing learning structures.

Further to the aforementioned, in the following paragraphs some key points that a hospital should consider before, during and after a heavy weather event are presented [67]:

Key issues to be considered by hospital stakeholders before a weather extreme event

- Planning should start well before an event by conducting a **hazard vulnerability assessment**. Best practice would be to do this building by building, because organizations may have regional hazards to consider or the age of the building.

- Knowledge on heavy weather events can be beneficial in the design of contingency plans to ensure the integrity of the facility as well as ensuring continued access to health care for patients.

- **Generic and case specific emergency preparedness and response plans** exist at a national level outlining basic incident response procedures and the establishment of necessary security measures [71, 72, 73, 74]. These operational plans in combination with specific legal provisions lying under the national laws or after the transposition of the relevant European legislative framework into the national legal system designate specific individuals or hospital agencies, bodies or committees that have the mandate to fulfil all the tasks and responsibilities related to the hospital emergency planning and response strategy. These tasks may refer to and include general or partial evacuation processes, security procedures application in order to protect the venue (e.g. emergency department, the triage area, other healthcare facilities, the morgue etc.) and other sensitive, critical or valuable assets and areas (e.g. computer room, central servers or blood bank, pharmacy etc.).

- **Cooperate with local and regional emergency organizations**. Participate in community planning and exercises, and get every single employee involved in exercises.
- When planning, organizations do not forget about **vulnerable populations like chronic care patients or the elderly** and their special needs, or the general community beyond the front door. Educate the community. Residents should also be prepared for a heavy weather event, which enables them to be resilient.
- Prepare a **staffing support, discharge and relief plan**. A heavy weather event can have traumatic psychological effects on staff, some of whom may have lose their homes and belongings.
- Facilities should consider **scenarios and preparation** – including side effects of heavy weather events, response and recovery steps into their emergency operations plan.

Key issues to be considered by hospital stakeholders during a heavy weather event.

- **Execute the emergency operations plan**. If necessary, prepare to evacuate patients with their records intact and with ways for their families to find them.
- Consider **setting up triage tents** in the parking lot to screen out patients who do not present with life-threatening emergencies, which can keep a partially closed hospital functioning without becoming overwhelmed. Consider consolidating functions like labs, radiology and surgery on one floor so the facility can continue to provide patient care.
- It is important to **partner with local or regional resources**. Try to respond together as a health care coalition versus trying to respond alone, e.g. routing patients to open beds. That routing keeps facilities from becoming overwhelmed and saved lives. Facilities should also work closely with suppliers on plans for resupply when roads are damaged.

Key issues to be considered by hospital stakeholders after a heavy weather event

- **Recovering** from a heavy weather event **takes coordinated effort**. Assemble a multidisciplinary team of experts. Have them assess the immediate damage and determine what is needed to bring the facility back into operational status.
- The facility will also need to work quickly to **repair damage and replace equipment and supplies as well as provide support to affected staff**. Facilities can recover more quickly when plans are in place to support staff with counselling, time off and resources.
- An **electricity shortage** means a situation where electricity production and imports are not enough to cover electricity consumption of a hospital. Consumption will then have to be restricted by cutting off electricity distribution.

It appears that, the efficient and timely identification of risks, threats and vulnerabilities of the health care sector infrastructures and services, requires communication, coordination, and cooperation at national level as well. This is important to deter, mitigate and neutralize any posed hazard and ensure the functionality, continuity and integrity of all affected assets and systems.

Hospital resilience improves access to comprehensive, high-quality, patient-centered health services [75], ultimately advancing Universal Health Coverage (UHC) and reducing health inequalities.

3.3.3.3 Meetings results analysis

The result of the 1st meeting with various stakeholder groups on 30th of March 2023 was positive in terms of participation and the interest of stakeholder groups in the project. At this initial stage of the project, it was difficult for most participants to understand their role. While technicians concentrated on technical aspects and possible applications of the project's results, the involvement of non-technicians appeared more complicated. The participants were willing to share the invitation for a public meeting with other stakeholders but they needed further information. Therefore, the municipality made a detailed plan for the public meeting including an explanation of the platform PRISKADAPT that will be developed, a rationale for stakeholder involvement and an explanation of the questionnaire.

On 12th of May 2023 in Trieste, the 2nd meeting was held at Trieste Urban Center, in Corso Cavour 2/2. For this meeting five Communities of Practice (CoPs) were created including t technicians and technicians working at the hospital, practitioners, citizens and civil institutions. During this meeting, local stakeholders were informed about RISKADAPT's aim and objectives, the effects and possible consequences of extreme weather events, in particular wind and precipitation, assuming future scenarios, especially regarding possible impacts on buildings and infrastructures with functions of public interest. The speakers focused on the local pilot action explaining upcoming activities such as measurements and data collection for Cattinara Hospital and how information, integrated with the ones provided by the stakeholders, will be essential for designing the platform PRISKADAPT.

Figure 15. Meeting's participants.

Figure 16. Meeting's participants.

Figure 17. Meeting's participants.

Moreover, participants were asked fill in the questionnaire **(see Annex 8**); and to provide their comments, suggestions, and valuable input related to the project's needs, which will be considered throughout the project. The questionnaire delivered during this meeting comprised questions about: (1) the kind of information that people wanted to be displayed in PRISKADAPT; (2) the social impacts that can be created by likely CC-induced damage to the Cattinara hospital; and (3) whether prevention, preparedness and adaptation strategies were already in place to reduce local CC risks and impacts associated with potential CC-induced damage to the Cattinara hospital. The questionnaire was organized into five different sub-set of questions each reflecting the respective CoP to which these sets of questions were addressed. The main findings that could be extrapolated from this questionnaire are described in the following Section.

3.3.3.4 Questionnaire results analysis

The questionnaire was distributed among participants of the 2nd meeting in Trieste and was directed at risk managers and technicians, but also scientists, policy makers, and other staff were part of the research group. The questionnaire had forty-one (41) responses which will be presented in the following Section.

All respondents have close ties to the hospital, either through their profession or because of personal visits. The respondent groups can be characterized by their occupation, age, gender, qualifications and hospital connection. A summary of these characteristics is provided in Table 3.

Table 3. General demographics of respondents

Variable	Proportion	Observations
Occupation		
Civil society I	0.12	5

Civil society II	0.20	8
Healthcare	0.15	6
Technicians I	0.07	3
Technicians II	0.46	19
Age		
18-30	0.12	5
31-50	0.49	20
51-65	0.37	15
Over 65	0.02	1
Gender		
Man	0.68	28
Woman	0.32	13
Qualification		
Secondary	0.15	6
Tertiary	0.59	24
Postgraduate	0.27	11
Hospital Connection		
First Aid	0.37	15
Short hospitalizations, visits	0.59	24
Both First Aid and visits	0.02	1
Unknown	0.02	1

Based on entire respondent group (n=41).

Occupation

Respondents' occupations are classified into five categories: 'Civil Society I'; 'Civil Society II'; 'Healthcare practitioners'; 'Technicians I'; and 'Technicians II'.

- Civil Society I corresponds to people who are active as policy makers or at companies, universities, or other organizations.
- Civil Society II corresponds to all other citizens.
- 'Healthcare' are social and health practitioners
- Technicians I involve engineers or technicians operating in the hospital,
- Technicians II are generalist technicians.

With a total of 22 respondents, technicians were best represented; civil society followed with 13 respondents in total. 6 respondents were social and/or health practitioners.

Age

In terms of age, the vast majority of the respondents fell between the ages 31-50 and 51-65. Together these account for 86% of the respondents in our sample (see Table 3).

Gender

Regarding gender, there seemed to be an over representation of males. These accounted for 68% of the respondents. The high rates of male respondents could be explained by an unbalance in female respondents within the Technicians' groups. While male/female ratio was about equal for the civil society groups and health care professionals, this was not the case for technicians who were largely over- represented by males.

Qualification

The respondents seemed to be highly educated. 59% of the respondents had a Master degree (or equivalent), 27% had a post-graduate diploma, and 15% had a secondary degree.

Connection with the Cattinara Hospital

In terms of hospital connections, most respondents were well acquainted with the Cattinara hospital because of having been hospitalized there, or because of visiting patients being hospitalized there. A significant other part of the respondents is linked to the hospital by their access to First Aid. One respondent fell into both categories. For one respondent this information remained unknown.

Where respondents come from

Most of the respondents came from Trieste city or its surroundings. 6 respondents were from outside the municipality of Trieste, including two respondents coming from Muggia and one respondent coming from Prosecco. Two respondents came from the same municipality district where the Cattinara hospital is located.

Desired Information to be displayed in PRISKADAPT

In order to get an understanding of what information the PRISKADAPT platform should contain, all respondents were provided with a list of information that could be displayed in the platform, and then asked how relevant they deemed such information. Topics of consideration were emergency plans (and alternative health care facilities available), people's vulnerability (related to hospitalized people, visitors, hospital's personnel and residents), hospital vulnerabilities, meteorological hazards and prevention plans. Table 4 highlights topic relevance by indicating the number of respondents -per occupation- that stated the topic to be relevant or very relevant (compared to not relevant, not very relevant and moderately relevant). Therefore, higher proportions suggest higher relevance. For example, a proportion of 1 indicates that every respondent within a subgroup deemed the topic to be relevant.

Table 4. Relevance of the information to be displayed

Name	Proportion	Observations
Civil society I (n=5)		
Emergency plans	1.00	5
People's vulnerabilities	1.00	5
Hospital vulnerabilities	1.00	5
Meteorological hazards	0.80	4
Prevention plans	1.00	5
Civil society II (n=8)		
Emergency plans	0.88	7
People's vulnerabilities	0.75	6
Hospital vulnerabilities	0.88	7
Meteorological hazards	0.62	5
Prevention plans	0.62	5
Healthcare practitioners (n=6)		
Emergency plans	1.00	6
People's vulnerabilities	1.00	6
Hospital vulnerabilities	0.67	4
Meteorological hazards	0.83	5
Prevention plans	0.83	5

Name	Proportion	Observations
Technicians I (n=3)		
Emergency plans	1.00	3
People's vulnerabilities	0.67	2
Hospital vulnerabilities	1.00	3
Meteorological hazards	0.33	1
Prevention plans	1.00	3
Technicians II (n=19)		
Emergency plans	0.89	17
People's vulnerabilities	0.74	14
Hospital vulnerabilities	0.74	14
Meteorological hazards	0.79	15
Prevention plans	0.79	15

Note: the observations and proportions of this table show the amounts of respondents per sub-group indicating the topic to be relevant or very relevant.

All information provided in the list were considered quite relevant to be displayed in PRISKADAPT. Nevertheless, considerable differences – in terms of the stated amount of relevance – occurred among topics and within occupation groups. On average, the provision of information regarding emergency plans and alternative health care facilities available was thought to be the most relevant (38 out of 41 respondents opted for relevant or very relevant), while information regarding meteorological hazards were considered the least relevant (30 out of 41 respondents opted for relevant or very relevant).

On average, information related to prevention plans, the vulnerability of the hospital system, and the vulnerability of the people living close by, or depending on it (e.g. hospitalized people, visitors, and hospital personnel), were deemed to be of the same relevance (per each of these categories 33 out of 41 opted for relevant or very relevant).

Information preferences per user group may be considered relevant for decision-making, especially to assess what information to provide, and for what kind of subgroups of people. Zooming into the different occupational groups highlights additional variations in preferences. On average, representatives of civil society seem to consider information related to meteorological events to be less relevant than all other information, while considering information related to the vulnerability of the hospital the most important, followed by information on emergency plans, and by information on the vulnerability of people connected to the hospital (residents living close by, hospitalized people, visitors, hospital personnel).

On average, representatives of technicians considered information on emergency plans the most important, followed by information on the vulnerability of people connected to the hospital, information on the hospital's vulnerability and by information on meteorological events. All 6 respondents from the social and health practitioners group considered information on the vulnerability of people connected to the hospital to be very relevant.

Preliminary Issues Scoping: Identifying social risks and impacts

In order to get a preliminary understanding of local people's perceptions, in the questionnaire, respondents were provided with a list of potential negative social impacts that could derive from CC-induced physical damage to the Cattinara Hospital. This list was developed by drawing on the literature on CC extreme events' impacts on hospitals, and by grouping the different potential impacts into 4 dimensions: health impacts (i.e. on hospitalized people's health; on hospital personnel's health; and on visitors' health); economic impacts (i.e. damage to the hospital's building); impacts on infrastructure and public services (i.e. impacts on access, impacts on logistics); and environmental impacts (i.e. hazardous waste and pollution). In the questionnaire, respondents were asked to assess the relevance of each social impact. They were also asked to add any potential social impact that in their opinion, is important to consider even if not included in the list.

Health impacts

In this context, health impacts are understood as being all kind of negative impacts that can derive from likely CC-induced damage to the Cattinara hospital and that can affect the physical and psychological health of people. In this questionnaire, respondents were asked to assess the relevance of such impacts in relation to different sub-groups of people: patients (hospitalized people), hospital personnel and visitors. As shown in Tables below, all respondents considered hospitalized people as being those most vulnerable and exposed to the health impacts that may be created by likely CC-induced damage to the Cattinara hospital, followed by hospital personnel.

Table 5. Technicians I – Relevance of Health Impacts

Variable	Proportion	Observations
On Patients' Health		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.00	0
4. relevant	0.33	1
5. very relevant	0.67	2
On Hospital Personnel' s Health		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.33	1
4. relevant	0.00	0
5. very relevant	0.67	2
On Visitors' Health		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.33	1
4. relevant	0.00	0
5. very relevant	0.67	2

Based on Technicians I (n=3)

Table 6. Technicians II – Relevance of Health Impacts

Variable	Proportion	Observations
Patients' Health		
1. not relevant	0.05	1
2. not very relevant	0.05	1
3. moderately relevant	0.16	3
4. relevant	0.11	2
5. very relevant	0.63	12
Hospital personnel's health		
1. not relevant	0.05	1
2. not very relevant	0.11	2
3. moderately relevant	0.32	6
4. relevant	0.26	5

Variable	Proportion	Observations
5. very relevant	0.26	5
Visitors' health		
1. not relevant	0.11	2
2. not very relevant	0.16	3
3. moderately relevant	0.42	8
4. relevant	0.26	5
5. very relevant	0.05	1

Based on Technicians II (n=19)

Table 7. Health and social care practitioners – Relevance of Health Impacts

Variable	Proportion	Observations
Patients' health		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.00	0
4. relevant	0.00	0
5. very relevant	1.00	6
Hospital personnel's health		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.33	2
4. relevant	0.00	0
5. very relevant	0.67	4
Visitors' health		
1. not relevant	0.00	0
2. not very relevant	0.33	2
3. moderately relevant	0.17	1
4. relevant	0.17	1
5. very relevant	0.33	2

Based on Health and social care practitioners (n=6)

Table 8. Civil Society I –Relevance of Health Impacts

Variable	Proportion	Observations
Patients' health		
1. not relevant	0.00	0
2. not very relevant	0.12	1
3. moderately relevant	0.00	0
4. relevant	0.12	1
5. very relevant	0.75	6
Hospital personnel's health		
1. not relevant	0.00	0
2. not very relevant	0.12	1
3. moderately relevant	0.25	2
4. relevant	0.38	3
5. very relevant	0.25	2
Visitors' health		
1. not relevant	0.12	1
2. not very relevant	0.25	2

Variable	Proportion	Observations
3. moderately relevant	0.50	4
4. relevant	0.00	0
5. very relevant	0.12	1

Based on Civil Society I (n=8)

Table 9. Civil Society II – Relevance of Health Impacts

Variable	Proportion	Observations
Patients' health		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.00	0
4. relevant	0.20	1
5. very relevant	0.60	3
Hospital personnel's health		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.00	0
4. relevant	0.60	3
5. very relevant	0.20	1
Visitors' health		
1. not relevant	0.00	0
2. not very relevant	0.40	2
3. moderately relevant	0.20	1
4. relevant	0.20	1
5. very relevant	0.20	1

Based on Civil Society II (n=5)

Economic impacts

In this context, economic impacts are those impacts that can derive from CC-induced damage to the Cattinara hospital and create a cost in terms of damage to the building, negative impacts on employment and on the whole supply chain associated with the hospital. On average, as showed in Tables below, respondents considered damage to the hospital building as being the most relevant economic impact that might be created by CC extreme events, followed by the impacts on the whole hospital's supply chain.

Table 10. Technicians I – Relevance of Economic Impacts

Variable	Proportion	Observations
Damage to the building		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.00	0
4. relevant	0.67	2
5. very relevant	0.33	1
Impacts on Employment		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.00	0

Variable	Proportion	Observations
4. relevant	0.67	2
5. very relevant	0.33	1
Supply Chain		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.33	1
4. relevant	0.33	1
5. very relevant	0.33	1

Based on Technicians I (n=3)

Table 11. Technicians II - Relevance of Economic Impacts

Variable	Proportion	Observations
Damage to the building		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.11	2
4. relevant	0.58	11
5. very relevant	0.32	6
Impact on employment		
1. not relevant	0.00	0
2. not very relevant	0.21	4
3. moderately relevant	0.26	5
4. relevant	0.26	5
5. very relevant	0.26	5
Impact on Supply Chain		
1. not relevant	0.00	0
2. not very relevant	0.16	3
3. moderately relevant	0.21	4
4. relevant	0.47	9
5. very relevant	0.16	3

Based on Technicians II (n=19)

Table 12. Health care practitioners – Relevance of Economic Impacts

Variable	Proportion	Observations
Damage to the hospital building		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.00	0
4. relevant	0.50	3
5. very relevant	0.50	3
Impact on Employment		
1. not relevant	0.00	0
2. not very relevant	0.17	1
3. moderately relevant	0.17	1
4. relevant	0.50	3
5. very relevant	0.17	1
Impacts on Supply Chain		

Variable	Proportion	Observations
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.33	2
4. relevant	0.33	2
5. very relevant	0.33	2

Based on Health and social care practitioners (n=6)

Table 13. Civil Society I – Relevance of Economic Impacts

Variable	Proportion	Observations
Damage to the hospital building		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.38	3
4. relevant	0.25	2
5. very relevant	0.38	3
Impacts on employment		
1. not relevant	0.00	0
2. not very relevant	0.12	1
3. moderately relevant	0.38	3
4. relevant	0.38	3
5. very relevant	0.12	1
Impacts on Supply Chain		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.25	2
4. relevant	0.38	3
5. very relevant	0.38	3

Based on Civil Society I (n=8)

Table 14. Civil Society II – Relevance of Economic Impacts

Variable	Proportion	Observations
Damage to the hospital building		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.00	0
4. relevant	0.20	1
5. very relevant	0.60	3
Impacts on Employment		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.40	2
4. relevant	0.20	1
5. very relevant	0.20	1
Impacts on Supply Chain		
1. not relevant	0.00	0
2. not very relevant	0.20	1

3. moderately relevant	0.00	0
4. relevant	0.40	2
5. very relevant	0.40	2

Based on Civil Society II (n=5)

Impacts on infrastructure and public services

In this context, impacts on infrastructure and public services are those impacts that may derive from CC-induced damage to the Cattinara hospital and that affect infrastructure, including the hospital, especially in terms of their accessibility, and the public services, especially in terms of the logistics associated with the needs to transfer patients to other healthcare facilities and/or with the temporary closure of the hospital. On average, as shown in Tables below, respondents considered the impacts on the logistics associated with public services provision in relation to the likely need for transferring patients to other healthcare facilities and/or to the temporary hospital's closure as the most relevant.

Table 15. Technicians I – Relevance of Impacts on Infrastructure and public services

Variable	Proportion	Observations
Impacts on Access		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.33	1
4. relevant	0.33	1
5. very relevant	0.33	1
Impacts on Logistics		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant.	0.00	0
4. relevant.	0.33	1
5. very relevant	0.67	2

Based on Technicians I (n=3)

Table 16. Technicians II – Relevance of Impacts on Infrastructure and public services

Variable	Proportion	Observations
Impacts on Access		
1. not relevant	0.00	0
2. not very relevant	0.05	1
3. moderately relevant	0.21	4
4. relevant	0.21	4
5. very relevant	0.53	10
Impacts on Logistics		
1. not relevant		0
2. not very relevant	0.05	1
3. moderately relevant	0.16	3
4. relevant	0.26	5
5. very relevant	0.53	10

Based on Technicians II (n=19)

Table 17. Healthcare – Relevance of Impacts on Infrastructure and public services

Variable	Proportion	Observations
Impacts on Access		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.00	0
4. relevant	0.33	2
5. very relevant	0.67	4
Impacts on Logistics		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.00	0
4. relevant	0.17	1
5. very relevant	0.83	5

Based on Health and Social practitioners (n=6)

Table 18. Civil Society I – Relevance of Impacts on Infrastructure and public services

Variable	Proportion	Observations
Impacts on Access		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.62	5
4. relevant	0.25	2
5. very relevant	0.12	1
Impacts on Logistics		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.25	2
4. relevant	0.25	2
5. very relevant	0.50	4

Based on Civil Society I (n=8)

Table 19. Civil Society II – Relevance of Impacts on Infrastructure and public services

Variable	Proportion	Observations
Impacts on Access		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.00	0
4. relevant	0.20	1
5. very relevant	0.60	3
Impacts on Logistics		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.00	0
4. relevant	0.20	1
5. very relevant	0.60	3

Based on Civil Society II (n=5)

Environmental Impacts

In this context, environmental impacts are understood as being those impacts that derive from hazardous waste and/or from pollution (i.e. dust and noise), which both can be created either by likely CC-induced damage to the Cattinara hospital, or by likely post-event restoration work. As showed in Tables below, environmental impacts are not considered as relevant as other impacts, however, those impacts that may derive from rubble and hazardous waste are considered slightly more relevant than those related to dust and noise which may be created by likely restoration work.

Table 20. Technicians I – Relevance of Environmental Impacts

Variable	Proportion	Observations
Hazardous Waste		
1. not relevant	0.00	0
2. not very relevant	0.00	0
3. moderately relevant	0.67	2
4. relevant	0.33	1
5. very relevant	0.00	0
Pollution		
1. not relevant	0.00	0
2. not very relevant	0.33	1
3. moderately relevant	0.33	1
4. relevant	0.33	1
5. very relevant	0.00	0

Based on Technicians I (n=3)

Table 21. Technicians II – Relevance of Environmental Impacts

Variable	Proportion	Observations
Waste		
1. not relevant	0.05	1
2. not very relevant	0.16	3
3. moderately relevant	0.32	6
4. relevant	0.26	5
5. very relevant	0.21	4
Pollution		
1. not relevant	0.05	1
2. not very relevant	0.21	4
3. moderately relevant	0.37	7
4. relevant	0.26	5
5. very relevant	0.11	2

Based on Technicians II (n=19)

Table 22. Relevance of Environmental Impacts

Variable	Proportion	Observations
Waste		
1. not relevant	0.00	0
2. not very relevant	0.00	0

Variable	Proportion	Observations
3. moderately relevant	0.50	3
4. relevant	0.33	2
5. very relevant	0.17	1
Pollution		
1. not relevant	0.00	0
2. not very relevant	0.17	1
3. moderately relevant	0.33	2
4. relevant	0.17	1
5. very relevant	0.33	2

Based on Healthcare (n=6)

Table 23. Civil Society I – Relevance of Environmental Impacts

Variable	Proportion	Observations
Waste		
1. not relevant	0.00	0
2. not very relevant	0.12	1
3. moderately relevant	0.62	5
4. relevant	0.12	1
5. very relevant	0.12	1
Pollution		
1. not relevant	0.00	0
2. not very relevant	0.12	1
3. moderately relevant	0.50	4
4. relevant	0.25	2
5. very relevant	0.12	1

Based on Civil Society I (n=8)

Table 24. Civil Society II – Relevance of Environmental Impacts

Variable	Proportion	Observations
Waste		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.00	0
4. relevant	0.60	3
5. very relevant	0.20	1
Pollution		
1. not relevant	0.00	0
2. not very relevant	0.20	1
3. moderately relevant	0.20	1
4. relevant	0.40	2
5. very relevant	0.20	1

Based on Civil Society II (n=5)

Other likely social impacts

Respondents provided some suggestions about other social impacts. A common concern seems to be impacts on local infrastructure, which transferring hospitalized people and choosing alternative healthcare facilities for assistance, may create. Interesting to note is that a respondent highlighted the lack of a helicopter platform at the Maggiore hospital, which may create problems if transport of hospitalized people from the Cattinara hospital would demand use of helicopters. Another respondent highlighted the need of considering the impacts on people's health which climate change in general may create and which may affect actual hospital capacity.

Table 25. Other likely social impact suggested by respondents

Territorial social and health assistance may become **overloaded**
Traffic jam at of the nearest medical health facilities
Damaged structural elements such as degradation of the concrete and reinforcing bars, degradation of the roofs which could generate infiltrations and consequent degradation of the underlying structures, degradation of the foundational apparatus which can generate settlements capable of compromising the functionality of the structure
Evaluate the **impacts external to the building itself**, but related to the impacts of climate change on the health of citizens in general and how these can cause indirect impacts on healthcare facilities.
Social impact for people living in the area in case the hospital is no longer accessible
Impact on roads given the movement of public or private healthcare activities to other parts of the city with the consequent **creation of critical points and traffic jam**.
Damage to the image of healthcare, the city, Italy and the consequent impact on the perception of hospitals as a safe place
Impacts on the electricity service
City traffic
In the event of complete closure of the Cattinara hospital, **no helicopter platform for emergencies at the Maggiore hospital**
Social and atmospheric environmental impacts due to increased traffic jam because of moving healthcare facilities elsewhere.
Negative impacts on people's health that can be created **by CC, generally**, and that may affect hospital capacity.

3.3.3.5 Summary of key impacts identified

The actions conducted in Pilot 3, e.g. literature review, meetings and questionnaire, do not consider emergency plans of Cattinara Hospital which were not discussed with the stakeholders (technicians, practitioners, patients and visitors). Key impacts identified are presented below:

Health and safety impacts

- Healthcare services (for preventive, diagnostic or treatment care) might not be available or might face operating difficulties.
- Emergency response services might not be available or might face operating difficulties Limited or no access to health services.

- Healthcare data (for preventive, diagnostic or treatment care) might not be available or might face operating difficulties.
- People's and patients' health and safety might be affected due to lack of healthcare services provision.
- Unmet healthcare services need.
- Hospital personnel's health might get affected.
- Hospitals' visitors' health might get affected.

Economic and financial impacts

- Impacts on healthcare related employment.
- Impacts on Supply Chain.
- Increased cost of disposing of and replacing spoiled foods.

Impacts on infrastructure and public services

- Damage to the hospital building and or infrastructures.
- Impacts on access.
- Impacts on logistics.

Political impacts

- Political fallout: public dissatisfaction and criticism of local governments and health authorities may have political consequences.
- Public relations challenges: how to manage public expectations and trust, as well as restoration of hospital.

Environmental impacts

- Waste
- Pollution

At this point, it is important to mention that as the project evolves; the impacts list might get updated. If updates and/or changes occur, the final list will be presented in D2.2.

3.4 End users' requirements

As described earlier, the above list of social impacts and user needs are classified, prioritised and included in various types of user requirements including functional, non-functional, interface, usability and process. The weather situation and temperature, structural failure, social risks and impact, hazards fit in functional requirements. Software portability, secure communication between devices, data bases, models etc., software integration framework, and data storage are part of the non-functional requirements. The user interface matches with the interface requirement. User satisfaction, effectiveness and efficiency have to do with usability requirements. The platform needs to be in accordance with European law and regulations, e.g. Paris Agreement and the EU climate objectives which are part of process requirements. Therefore, in the following paragraphs the end-users' requirements (per requirement type), as identified and prioritised by end-users and partners, are presented.

3.4.1 Functional Requirements

The functional requirements of RISKADAPT platform are displayed below.

UID	FR-1
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Wind
Requirement Name	Weather situation
Requirement Description	Providing wind data (current, historical or projected considering the climate change).
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-2
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Temperature
Requirement Name	Weather situation
Requirement Description	Providing air temperature data (current, historical or projected considering the climate change).
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-3
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Rain
Requirement Name	Weather situation
Requirement Description	Providing rain data (current, historical or projected considering the climate change).
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-4
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Snow
Requirement Name	Weather situation
Requirement Description	Providing current snow data (current, historical or projected considering the climate change).

Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 2

UID	FR-5
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Water level
Requirement Name	Weather situation
Requirement Description	Providing current water level.
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-6
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Precipitation
Requirement Name	Weather situation
Requirement Description	Providing current precipitation data (height and intensity).
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-7
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Wind forecast
Requirement Name	Wind
Requirement Description	Direction and strength of wind must be known in advance on certain locations for a predefined time interval and updated with predefined frequency.
Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-8
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Temperature forecast
Requirement Name	Temperature
Requirement Description	Temperature should be known in advance on certain locations for a predefined time interval and updated with predefined frequency.
Priority	Could-have

Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-9
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Rain forecast
Requirement Name	Rain
Requirement Description	Rain should be known in advance on certain locations for a predefined time interval and updated with predefined frequency.
Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-10
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Snow forecast
Requirement Name	Snow
Requirement Description	Snow should be known in advance on certain locations for a predefined time interval and updated with predefined frequency.
Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 2

UID	FR-11
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Water level forecast
Requirement Name	Water-level
Requirement Description	Water level must be known in advance on certain locations, in a predefined time interval, and updated with predefined frequency.
Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-12
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Precipitation forecast
Requirement Name	Precipitation
Requirement Description	Type and volume of precipitation should be known in advance on certain locations for a predefined time interval and updated with predefined frequency.

Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-13
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Structural data
Requirement Name	Structural data
Requirement Description	The system should have information about low Carbon Structural Adaptation Options (Materials and Products).
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-14
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Modelling water level and flood arrival time for specified scenarios
Requirement Name	Flooding for specified scenarios
Requirement Description	Location, water level, time and duration of flood must be modelled for pre-defined scenarios.
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-15
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Modelling wind and ice accreation
Requirement Name	Modelling wind and ice accreation for specified scenarios.
Requirement Description	Modelling wind, speed and direction and ice accretion.
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-16
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Probability of structural failure
Requirement Name	Structural fragility
Requirement Description	The system shall access the structural fragility.
Priority	Must-have
Relative WP	WP3, WP4, WP5

Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-17
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Risk assessment
Requirement Name	Social risks and impacts
Requirement Description	The system shall assess climate risk that will combine technical risk assessment with assessment of social risks.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-18
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Risk assessment
Requirement Name	Social risks and impacts
Requirement Description	The system shall provide values to a set of indicators for each asset of interest, quantifying primary parameters and impacts, in the form of a Model Information System (MIS) that will provide all required information for adaptation decisions.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-19
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Users authorisation
Requirement Name	Users authorisation
Requirement Description	Only authorised users must access the system. Unauthorized access must be declined.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-20
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	User Management
Requirement Name	User Management
Requirement Description	Administrators must be able to manage users accounts.
Priority	Must-have

Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-21
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Users Roles Management
Requirement Name	Users Roles Management
Requirement Description	All users must have access to the role they are matched with.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-22
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Hazards assessment
Requirement Name	Hazard maps
Requirement Description	Definition of hazard maps from various fused data sources and streams
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-23
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Display and map hazard modelling outcomes
Requirement Name	Map
Requirement Description	User should receive simulation results, hazard (e.g., inundation extent and depth) and vulnerability information as well as elements
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-24
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Several related information services are available on one user interface.
Requirement Name	Common interface
Requirement Description	Users should receive a comprehensive 'picture' about all circumstances, which may influence their operational decisions, in an easy accessible and understandable way.

Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-25
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	Interactive map with all relevant information.
Requirement Name	Map
Requirement Description	Users should receive a comprehensive 'picture' with location data and visualization about all circumstances, which may influence their operational decisions, in an easily accessible and understandable way especially providing location-based information services with alerts and notifications. Different information types may be visualized on different layers of the map. E.g. wind layer, temperature layer, water level layer.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-26
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	The user interface design shall make the user's interaction with the system as simple and efficient as possible, in terms of accomplishing their goals.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	FR-27
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	Data must be represented in high resolution for critical, important and high impact (based on the end-users needs and input) assets, buildings and structures.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

3.4.2 Non-Functional Requirements

In the Tables below, the non-functional requirements of RISKADAPT platform are presented.

UID	NFR-1
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Security
Requirement Name	Secure communication
Requirement Description	The system should ensure secure communication, data exchange and data storage.
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	NFR-2
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Privacy
Requirement Name	Pseudonymisation mechanism
Requirement Description	The system should apply proper pseudonymisation mechanisms to ensure data protection and privacy.
Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	NFR-3
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Data storage
Requirement Name	Data storage
Requirement Description	The system should store all data-metadata needed.
Priority	Should-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	NFR-4
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Data storage
Requirement Name	Data storage
Requirement Description	The heterogeneous input data from satellite services, sensors, models, static and local data will be stored in a distributed and cloud-based Data Management System (DMS) in order to be used by the various modules.
Priority	Must-have

Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	NFR-5
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Models' output
Requirement Name	Models' format
Requirement Description	Models' output format should be in a commonly accepted format and resolution (e.g., shapefile, geoTiff, csv)
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	NFR-6
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Integration
Requirement Name	Software integration framework
Requirement Description	An appropriate software integration framework must be put in place for RISKADAPT, to make sure that all the components of the integrated platform are easily and safely integrated and tested before getting deployed at the pilots' environment.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	NFR-7
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Integration
Requirement Name	Software portability
Requirement Description	The RISKADAPT software components should be packaged in a way to ensure their portability and deployment across different hosting environments (e.g., development/testing environment versus pilots' execution environment).
Priority	Should-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	NFR-8
Version No	1.0
Requirement Type	Non-Functional Requirements
Requirement Category	Models' output

Requirement Name	Models' output
Requirement Description	All information regarding structures (materials and quantities) will be based on Building Information Modelling (BIM).
Priority	Must-have
Relative WP	WP4
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

3.4.3 Interface Requirements

The interface requirements of RISKADAPT platform are displayed below.

UID	IR-1
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	The front end will be generated by assimilating information from available PRISKADAPT sources (e.g. as-built drawings), fused and raw data from all measurements (e.g. climate data, inspection results, monitoring, etc.) and simulation results, as well as all elements and metadata in terms of GIS information layers and depicted in an advanced 3D visualization environment.
Priority	Must-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	IR-2
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	The front end must provide a common operational picture, enhance the situational awareness and support decision-making of operators.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	IR-3
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	The 3D visualization environment shall display also the damage produced by an extreme event and the damage severity in, say,

	green/yellow/red colors, with and without specific adaptation measures, as well as the affected geographic areas.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	IR-4
Version No	1.0
Requirement Type	Functional Requirements
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	The 3D visualization environment shall display to the user the expected impacts (e.g. economic impacts, environmental pollution, unemployment caused by asset unavailability) and how these change during implementation of the various adaptation options.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	IR-5
Version No	1.0
Requirement Type	Interface Requirements
Requirement Category	Interfaces
Requirement Name	User Interface
Requirement Description	The frontend also shall support customised views for the users and shall allow additional information in an appropriate format related to the user expertise/type.
Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	IR-6
Version No	1.0
Requirement Type	Interface Requirements
Requirement Category	Interfaces
Requirement Name	PRISKADAPT
Requirement Description	PRISKADAPT shall determine the level of risk. In doing so, it shall integrate and chain capacity losses and engineering adaptation solutions with modelling of social impacts and solutions and total risk assessment, including required simulations (e.g. traffic simulations for pilot 1) and combinations of social and engineering adaptation solutions that will be evaluated and estimated in terms of a set of primary parameters and impacts. The decision stakeholders will be able to input values determining the local value of the above indicators. Furthermore, they will be able to attribute weights to the impacts of interest.

Priority	Must-have
Relative WP	WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

3.4.4 Usability Requirements

In the Tables below, the non-functional requirements of RISKADAPT platform are presented.

UID	UR-1
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Efficiency
Requirement Name	Efficiency
Requirement Description	Tasks shall be easily accomplished.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-2
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Efficiency
Requirement Name	Efficiency
Requirement Description	Tasks shall be accomplished quickly.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-3
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Efficiency
Requirement Name	Efficiency
Requirement Description	Tasks shall be accomplished with few or no user errors.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-4
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Efficiency
Requirement Name	Efficiency
Requirement Description	The user shall be able to achieve expected goals.

Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-5
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The system shall be useful.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-6
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall be reliable.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-7
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall work accurately.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-8
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall be understandable.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-9
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The system shall be an improvement compared to similar systems.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-10
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The system shall be easy to use.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-11
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The system shall be simple to use.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-12
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The user shall feel felt comfortable using the system.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-13
Version No	1.0

Requirement Type	Usability Requirements
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The user shall recover easily and quickly whenever making a mistake.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-14
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The information (such as on-screen messages, and other documentation) provided with this system shall be clear.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-15
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	It shall be easy for the user to find the information needed.
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	UR-16
Version No	1.0
Requirement Type	Usability Requirements
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The system should have user-friendly interfaces that will be easy to use without prior experience
Priority	Should-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

3.4.5 Process Requirements

The process requirements of RISKADAPT platform are displayed below.

UID	PR-1
Version No	1.0
Requirement Type	Process Requirements
Requirement Category	Law/Regulation
Requirement Name	Law/Regulation
Requirement Description	The project shall be consistent with the Paris Agreement and EU climate objectives.
Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

UID	PR-2
Version No	1.0
Requirement Type	Process Requirements
Requirement Category	Law/Regulation
Requirement Name	Law/Regulation
Requirement Description	The project shall be consistent with the EU's digital strategy using Building Information Modelling (BIM).
Priority	Could-have
Relative WP	WP3, WP4, WP5
Relative Use Case	Pilot 1, Pilot 2, Pilot 3

At this point, it is important to mention that as the project evolves; the requirements list might get updated. If updates and/or changes occur, the final list of the requirements will be presented in D2.2.

4. Conclusions

In three pilots an explorative study (that incorporates literature review, content analysis, interviews, questionnaires and focus groups etc.) has been conducted to gather information on social impacts, user needs, and user requirements. The findings of data collection in Pilot 1, 2 and 3 show that social impacts and user needs differ, but in general access to services, and timely information after a climate induced disaster are needed. For Pilot 1 (the Polyfytos Road Bridge in North Macedonia in Greece) this means information on alternative routes, continuous access to public services, the state of the art of the bridge and the opening of the bridge. Concerning Pilot 2 (energy transmission grid in Finland) the consequences of a power failure have a huge impact on society and economy and information on future climatological developments, particularly on icing, are important. With regard to Pilot 3 (Cattinara Hospital in Trieste in Italy) access to health services are needed as well as information on public services, transportation and infrastructure. Further to this, the user requirements resulting from the pilots have been identified and analysed. The requirements have many similarities, such as addressing risks, access to the data base, user-friendly interface and reliable information. This will be used as the main input in T2.2.

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Annexes

Annex 1 – Pilot 1: Topic list for interviews

Point of departure of this topic list is the Polyfytos bridge, its closure mid March and its partial openness mid June 2023 to traffic with a reduced traffic capacity (1 lane and vehicles up to 3.5 tn). This interview agenda is partly based on the classification of the Hellenic Statistical Authority (ELSTAT), themes of the ELSTAT report Greece in figures April-June 2023 (ELSTAT, 2023), and other topics. Three stakeholder groups are distinguished, i.e. decision-makers, business/entrepreneurs and citizens. For each group questions are formulated.

<u>Decision-makers</u>

Economic activities

- Have the bridge closure had an impact on economic activities (in the city/region)?
- If so, what was/were the effect(s)? How did you know this/these effect(s) (people/media /organizations/business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to economic activities (in the city/region)?
- Could you explain what happened?
- How did you know that economic activities were (not) affected after the bridge was partially open (people/media/organizations/business and/or otherwise)?

Transport

- Did the bridge closure have an impact on transport (in the city/region)?
- If so, what was/were the effect(s) (in terms of alternative routes, time, fuel, cost and freight, safety)? How did you know this/these effect(s) (people/media /organizations/business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to transport?
- Could you explain what happened?
- How did you know that transport was (not) affected after the bridge was partially open (people/media/organizations/business and/or otherwise)?

Education

- Did the bridge closure have an impact on education (in the city/region)?
- If so, what was/were the effect(s)? How did you know this/these effect(s) (people/media /organizations/business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to education?
- Could you explain what happened?
- How did you know that education was (not) affected after the bridge was partially open (people/media/organizations/business and/or otherwise)?

Health

- Did the bridge closure have an impact on health (in the city/region)?
- If so, what was/were the effect(s) (in terms of time, fuel, cost, accessibility, health care services)? How did you know this/these effect(s) (people/media /organizations/business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to health?
- Could you explain what happened?
- How did you know that health was (not) affected after the bridge was partially open (people /media/organizations/business and/or otherwise)?

Community (services)

- Did the bridge closure have an impact on the community (services) (in the city/region)?
- If so, what was/were the effect(s)? How did you know this/these effect(s) (people /media /organizations/business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to the community (services)?
- Could you explain what happened?
- How did you know that the community (services) was/were (not) affected after the bridge was partially open (people/media/organizations/business and/or otherwise)?

Environment

- Did the bridge closure have an impact on the environment (in the city/region)?
- If so, what was/were the effect(s)? How did you know this/these effect(s) (people/media/organizations /business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to the environment?
- Could you explain what happened?
- How did you know that the environment was (not) affected after the bridge was partially open (people/media/organizations/business and/or otherwise)?

Culture/Tourism

- Did the bridge closure have an impact on culture/tourism (in the city/region)?
- If so, what was/were the effect(s)? How did you know this/these effect(s) (people /media /organizations/business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to culture/tourism?
- Could you explain what happened?
- How did you know that culture/tourism was (not) affected after the bridge was partially open (people/media/organizations/business and/or otherwise)?

Energy

- Did the bridge closure have an impact on energy (in the city/region – e.g. solar energy and wind energy)?
- If so, what was/were the effect(s) (e.g. solar energy and wind energy)? How did you know this/these effect(s) (people /media /organizations/business and/or otherwise)?
- If not, why?
- What did occur when the bridge was partially open with regard to energy?
- Could you explain what happened?
- How did you know that energy was (not) affected after the bridge was partially open (people /media/organizations/business and/or otherwise)?

Other

- Are there other effects of the bridge closure? Please, explain.
- Are there other effects after the bridge was partially open? Please, explain.

Businesses/entrepreneurs

Economic activities/business

- Did you experience impact on your business after the bridge closure?
- If so, what was/were the effect(s) (in terms of turnover/sale, business)?
- If not, why?
- What did occur when the bridge reopened partially with regard to your business?
- Could you explain what happened?
- Why was your business (not) affected after the bridge was partially open?

Transport

- Did you experience impact on transport after the bridge closure?
- If so, what was/were the effect(s) (in terms of alternative routes, time, fuel, cost and freight, safety)? If not, why?
- What did occur when the bridge was partially open with regard to transport?
- Could you explain what happened?
- Why was your business (not) affected after the bridge was partially open?

Services

- Did you experience impact on the services (e.g. collecting garbage) after the bridge closure?
- If so, what was/were the effect(s) (e.g. collecting garbage)? If not, why?
- What did occur when the bridge was partially open with regard to the services?
- Could you explain what happened?

Culture/Tourism

- Did you experience impact on culture/tourism after the bridge closure?
- If so, what was/were the effect(s)? How did you know this/these effect(s) (people/media/organizations/own business and/or otherwise)?

- If not, why?
- What did occur when the bridge was partially open with regard to culture/tourism?
- Could you explain what happened? How did you know this/these effect(s) (people/media/organizations/own business and/or otherwise)?

Other

- Are there other effects of the bridge closure? Please, explain.
- Are there other effects after the bridge was partially open? Please, explain.

Citizens

Personal situation

- What was the impact of the bridge closure on your personal situation (place of residence, family, working hours etc.)?
- If not, why?
- What did occur when the bridge was partially open with regard to your personal situation?
- Could you explain what the impact was on your personal situation when the bridge was partially open?

Economic activities/household income

- Have the bridge closure had an impact on your household income?
- If yes, how did you manage the loss of income? If not, why?
- What did occur when the bridge was partially open with regard to your household income?
- Could you explain what happened with your household income when the bridge was partially open?

Transport

- How did you travel to your work/family before the bridge closure?
- What was the impact of the bridge closure on your travel needs?
- If so, what was/were the effect(s) of the bridge closure (in terms of alternative routes, time, energy and cost, safety) on your travel needs?
- What did occur when the bridge was partially open with regard to your travel needs?
- Could you explain what the impact was on your travel needs when the bridge was partially open?

Education

- Have the bridge closure had impact on education?
- If so, what was/were the effect(s)? If not, why?
- What did occur when the bridge was partially open with regard to education?
- Could you explain what the impact was on education when the bridge was partially open?

Health

- Have the bridge closure had impact on health?

- If so, what was/were the effect(s) (in terms of time, energy, cost, accessibility, health care services)? If not, why?
- What did occur when the bridge was partially open with regard to education?
- Could you explain what happened when the bridge was partially open?

Community (services)

- Did you experience impact on the community and community services (e.g. collecting trash) after the bridge closure?
- If so, what was/were the effect(s) on the community and community services after the bridge closure? If not why?
- What did occur when the bridge was partially open with regard to the community and community services?
- Could you explain what happened within the community and with the community services after the bridge was partially open?

Other

- Are there other effects of the bridge closure? Could you explain the effects?
- Are there other effects after the bridge was partially open? Could you explain the effects?

Annex 2 – Pilot 1: Questionnaires

A questionnaire for citizens living in the surrounding area of the bridge encompasses the following categories.

- Demographic data
  - Gender
  - Age
  - Place of residency
  - Profession
- Information on the closure of the bridge
  - How were you informed that the bridge was closed?
  - Did the local authorities and/or local administration inform the citizens about the bridge being closed? How?
  - Was the above information clear and sufficient for you? If not, please specify why.
  - The municipality organised several meetings for the situation to be discussed. Have you attended any?
  - If you attended any of these meetings, were they useful to you?
  - If not, what was the reason you didn't?
  - What/Who was your main source of information regarding the state of the High Bridge of Servia?
  - What additional information would you like to have had regarding the closure of the bridge?
- Impacts of the bridge being closed
  - How did the bridge closure mainly affect you?
  - What changes did it cause in your daily life?
  - Are you aware of any actions taken to address the situation? If yes, could you please name a few below?
  - Did citizens organise themselves collectively to deal with the new situation?
  - Did you participate in any of the above actions?
  - If yes, could you please name a few of the actions?
  - If not, could you please specify why?
  - In retrospect, what do you think could have also been done and to what ends?
  - In your opinion, to what extent has the closure of the bridge impacted the local economy?
  - Could you give some examples?
  - In your opinion, to what extent has the closure of the bridge impacted the local environment?
  - Could you give some examples?
- Information on the partial opening of the bridge

- How were you informed that the bridge was partially open again?
- Did the local authorities and/or local administration inform the citizens about the bridge reopening? How?
- Was the above information clear and sufficient for you? If not, please specify why.
- What/Who was your main source of information regarding the state of the High Bridge of Servia?
- What additional information would you like to have regarding the partial reopening of the bridge?

- Partial accessibility of the bridge
  - How did the bridge being partially accessible mainly affect your daily life?
  - Has the fact that the bridge is partially accessible balanced to some extent the impact of its closure in everyday life for the local community? Why?
  - What are your main concerns regarding the state of the bridge? Why?

A questionnaire for risk managers and technicians of Greek cities included topics concerning risks, construction, and material.

Nowadays there is a lack of data on the damages that can be caused to infrastructure due to climate change. In many cases, public authorities do not have the expertise to assess the local impacts of climate change and evaluate adaptation options.

The EU Project RISKADAPT (Asset Level Modelling of RISKs in the Face of Climate Induced Extreme Events and ADAPtation) aims to address these knowledge gaps by providing a comprehensive, interoperable, free and user-friendly platform (PRISKADAPT), which will provide the tools and data that public authorities need to make informed decisions.

For the creation of PRISKADAPT, the information obtained from risk managers is very important as input to the risk assessment module.

Therefore, risk managers are kindly requested to answer the following questions on critical infrastructure and buildings and expectations of PRISKADAPT. The answers are only visible to the project team.

On behalf of the SUSTAINABLE CITY Network, thanks for your collaboration.

Watch the video of the RISKADAPT project.

- How do you assess risks concerning critical infrastructure (e.g. bridges) and buildings (e.g. hospitals)? Please, explain your assessment criteria.
- What are your main concerns about critical infrastructure and buildings (e.g. earthquakes)? Are there specific types of climate-induced extreme events that you are most concerned about, such as heavy rains, floods, or extreme temperatures? How do these events impact concrete structures?
- Why do you have these concerns? For example, have you experienced any failures in the past? Are there any projections related to climate change that have led to increased concern?
- May these concerns lead to proper improvements (e.g. regarding concrete as building material and/or its use in everyday work)? Please explain what these improvements are, how they address the concerns you have identified and if there are barriers to implement the improvements (e.g. cost or lack of knowledge).

- To what extent can critical infrastructure and buildings withstand sever weather events? What are critical factors in this regard?
- To what extent can disaster preparedness prevent problems in critical infrastructure and critical buildings? What actions are needed in this regard? Are there specific actions or strategies that you would recommend to improve the disaster preparedness for specific structures?
- How do the actions you propose take into account the framework of sustainability (preventing the depletion of natural resources), the circular economy and the protection of the environment? What is your advice if critical infrastructure or buildings need to be renovated or rebuilt? Would, for example, concrete be one of your options as a building material? What are its advantages or disadvantages? Are there any alternatives?

Please answer the above question assuming that circular economy is based on three principles: (1) driven by design (eliminate waste and pollution), (2) circulate products and materials (at their highest value), and (3) regenerate nature (decouple economic activity from the consumption of finite resources).

PRISKADAPT Platform

The PRISKADAPT platform will be an integrated, interdisciplinary, interoperable, public and free, user-friendly platform that aims to support risk-driven management decision-making on adaptation to complex problems caused by climate change at the infrastructure level, focusing on their structural system.

- What type(s) of risks are important to be included in the platform (PRISKADAPT) that will be developed in RISKADAPT? Why are these risks important?
- What are important features of PRISKADAPT that will support risk-informed decisions regarding adaptation to severe weather events? Think of reproducibility and applicability, sustainability, flexibility, reusability, reliability, maintenance, security, efficiency and user satisfaction.

(e.g. the accuracy and completeness with which users achieve specific goals, resources expended in relation to the accuracy and completeness with which users achieve the goals, the extent to which the product or service meets the needs and expectations of the user)

Are you willing to evaluate a prototype of PRISKADAPT?

- Yes
- No

Contact Information

- Name:
- Surname:
- Email:

I consent that the above information may be used by the RISKADAPT project partners solely for the evaluation of a first version of the PRISKADAPT platform:

- Yes
- No

If you wish to withdraw your consent, please send us an email at info@sustainable-city.gr

I want to be kept informed about the progress of the project and I consent to the use of my personal data to receive emails about the project.

- Yes
- No

Thank you for your time in completing our survey.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Annex 3 – Pilot 1: Focus group topic list

(METHODOLOGY) - When a (precast concrete) structure is submitted to an extreme event (meteorological, accidental, natural etc...), how the performance of a structure is assessed?

(INPUT) - What kind of information (both about the structure and the event) are the most relevant to assess its status?

(CONCRETE) – What are the characteristics of concrete that would best contribute to the resilience of a construction work?

(GENERAL) – Additional questions

- What a makes a structure “robust” (i.e. able to avoid disproportionate collapse due to an initial damage)?
- What a makes a structure “resilient” (i.e. able to adapt to and recover from the effects of changing external conditions)?

Annex 4 – Pilot 2: Agenda for meetings

In the three meetings the focus in the discussion was the user needs and requirements related to icing modelling and structural risks for the energy transmission system. Whereas in the first meeting the topics were introduced, in the second meeting each topic was discussed from various perspectives, and in the third meeting discussion was directed towards suggestions for research.

Annex 5 – Pilot 2: Topic list interview

Haastattelukysymyksiä liittyen jäätämiseen ja sään ääri-ilmiöihin

[Tämä liittyy RISKADAPT-projektin pilottiin n:o 2. Tarkoitus olisi tehdä kysely sidosryhmille heidän tarpeistaan. Sitä käytetään pilotin suunnitteluun ja myös "PRISKADAPT" -alustan suunnittelussa. Kohderyhmiä ovat lähinnä tuulivoiman tuottajat ja ehkä myös sähkö- ja verkkoyhtiöt alueilla, joissa jäätäminen voi olla ongelma. Alla on osittain vielä konekäännettyä tekstiä…]

Taustaa

RISKADAPT (http://riskadapt.eu) on EU-projekti vuosille 2023–2026. Se tuottaa yhteistyössä loppukäyttäjien ja muiden sidosryhmien kanssa alustan, joka tukee sopeutumista ilmastonmuutokseen. Projektissa keskitytään infrastruktuurien haavoittuvuuteen. Esimerkkinä rakennukset, sillat ja sähköverkko. Voimakkaat sääilmiöt – esimerkkeinä tulvat, rankkasateet, myrskytuulet, kuumuus ja kuivuus – vaikuttavat erityisesti kriittiseen infrastruktuurin, kuten rakennuksiin tai voimalinjoihin. Ilmastonmuutoksen vaikutukset infrastruktuurin ovat erityisen merkittäviä niiden pitkän käyttöiän, korkeiden investointikustannusten sekä yhteiskunnan ja talouden toimintaan vaikuttavan roolin vuoksi.

Rakennukset ja infrastruktuuri voivat olla alttiita ilmastonmuutokselle niiden suunnittelun (heikko kestävyys myrskyjä vastaan) tai sijainnin (esim. tulva-alueilla, maanvyöryissä, lumivyöryissä) vuoksi. Ne voivat vahingoittua muuttuvien ilmasto-olosuhteiden tai ääri-ilmiöiden seurauksena: merenpinnan nousu, rankkasateet ja tulvat, erittäin matalat tai korkeat lämpötilat, runsaat lumisateet tai voimakkaat tuulet. Ilmastonmuutoksen seuraukset rakennuksille ja infrastruktuurille vaihtelevat alueittain.

Sään ääri-ilmiöt määritellään joko niiden aiheuttamien vaikutusten mukaan tai tilastollisesti, ilmiön toistuvuuden perusteella. Ilmatieteen laitoksen määritelmän mukaan ilmiö on harvinainen, jos se toistuu keskimäärin kerran 10–30 vuodessa ja poikkeuksellinen, jos sen keskimääräinen toistuvuusaika on yli 30 vuotta.

RISKADAPT-hankkeessa luodaan alusta, joka hyödyntää asiantuntijoiden ja kansalaisten palautetta riskinarviomoduulin syötteenä, ottaen huomioon sekä tekniset että sosiaaliset riskit. Tätä varten keräämme palautetta eri sidosryhmiltä. Seuraavat kysymykset koskevat sään ääri-ilmiöiden vaikutusta infrastruktuureihin. Erityisenä kiinnostuksen kohteena ovat jäätämisen ja voimakkaiden tuulien vaikutukset, mutta myös muut sääilmiöiden vaikutukset. Lisäksi toivomme vastauksia koskien asiantuntijoiden odotuksista RISKADAPT-hankkeen ja sen tuottamien palveluiden suhteen. Vastaukset ovat näkyvissä vain projektiryhmälle, mutta niiden tuloksia käytetään projektin toimintojen kehittämiseen. Kiitos yhteistyöstänne.

Kysymyksiä:

- Minkälaisilla voimakkailla sääilmiöillä katsotte olevan suurin vaikutus toimintaanne?
- Otatteko riskiarvioissa huomioon voimakkaiden sääilmiöiden vaikutuksen toimintaanne? Mitkä sääilmiöt? Entä miten olette varautuneet riskitasojen muutoksiin tulevaisuuden ilmastossa?
- Jäätämisellä tarkoitetaan tässä yhteydessä talviolosuhteissa tapahtuvaa jään kertymistä pinnoille kuten voimajohdoille tai tuulivoimaloiden lapoihin. Seuraavat kysymykset koskevat jäätämistä.
    - Millaisia vaikutuksia jäätämisellä on toimintaanne?
    - Oletteko huolissanne tulevaisuuden ilmaston aiheuttamista muutoksista jäätämisessä?

- Minkälaista tutkimustietoa kaipaisitte muutoksista tulevaisuuden jäätämisolosuhteissa? Mitkä ovat teille relevantteja aikajaksoja (esimerkiksi 2030–2050 tai 2050–2100)?
- Ilmatieteen laitos tuottaa kaupallisia jäätämisennusteita eri toimijoille. Ovatko nämä tuotteet teille tuttuja? Mihin olette näitä ennusteita käyttäneet? Varaudutteko muilla tavoilla jäätämiseen?

- Onko teillä jotain muita kommentteja tai toivomuksia RISKADAPT-projektin suhteen? Erityisesti voimakkaiden sääilmiöiden aiheuttamiin riskeihin infrastruktuurille sekä tulevaisuuden ilmaston aiheuttamiin muutoksiin.

Questions in English

- What kind of severe weather phenomena do you consider having the greatest impact on your operations?
- Do you consider the impact of severe weather phenomena in your risk assessments? Which weather phenomena? How have you prepared for changes in risk levels in future climate?
- In this context, icing refers to the accumulation of ice on surfaces such as power lines or wind turbine blades in winter conditions. The following questions concern icing.
    - What are the effects of icing on your operations?
    - Are you concerned about future climate-induced changes in icing?
    - What kind of research information would you like regarding changes in future icing conditions? What time periods are relevant to you (e.g., 2030-2050 or 2050-2100)?
    - The Finnish Meteorological Institute provides commercial icing forecasts for various stakeholders. Are you familiar with these products? How have you used these forecasts? Do you prepare for icing in other ways?
- Do you have any other comments or wishes regarding the RISKADAPT project? Especially regarding the risks to infrastructure caused by severe weather phenomena and the changes caused by future climate.

Annex 6 – Pilot 3: Meeting agenda (30/03/2023)

Agenda meeting 30 March 2023 (online meeting)

- Welcome and introduction of attendees
- Introduction of RISKADAPT and pilot Hospital Cattinara
- Explanation of role and types of stakeholders (technicians, practitioners, citizens, social services and businesses)
- Explanation of climate change, extreme events and effects on infrastructure and buildings
- Explanation of stakeholders' input that will be used for elaboration of three scenarios: disaster, adaptation and preventation
- Questions
- Wrap up and closing

Annex 7 – Pilot 3: Meeting agenda (17/05/2023)

Agenda meeting 17 May 2023 (physical meeting)

- Welcome and introduction RISKADAPT
- Explanation of goals, climate change and impacts
- Explanation of research (methods and tools)
- Explanation of PRISKADAPT
- Meaning of social research and introduction of questionnaire
- Invitation to fill in the questionnaire (technicians, technicians of the hospital, practitioners of the social and health system, citizens and civil society (enterprises, local institutions, and policy makers)
- Questions
- Wrap up and closing

Annex 8 – Pilot 3: Questionnaire

Introduction

RISKADAPT is an EU project running from 2023-2026 that will provide, in close cooperation with end-users and stakeholders, a platform to support decisions toward adaptation to heavy weather events due to climate change, such as floods, heavy rain and wind, heat, and drought with regard to critical infrastructure and buildings. The impacts of climate change are particularly pertinent to infrastructure and buildings given their long lifespan and their high initial cost, as well as their essential role in the functioning of societies and economies.

Buildings and infrastructure can be vulnerable to climate change because of their design (low resistance to storms) or location (e.g. in flood-prone areas, landslides, avalanches). Indeed they can be damaged or rendered unfit for use by any changing climatic condition or extreme weather event: rising sea level, extreme precipitation and floods, occurrences of extreme low or high temperatures , heavy snowfalls or strong winds. Consequences of climate change for buildings and infrastructure will differ from region to region.

One of the most common ways to define an extreme event is statistically. In the series of weather events that have occurred over a certain period of time, we identify those events that deviate from the average, and the more they deviate, the less frequently they are observed. Usually the most extreme events have a very high return time: this means that the time interval between these events can be many tens of years.

Source: Massimiliano Pittore Transalp Project. For further information https://www.eurac.edu/it/magazine/che-cos-e-un-evento-estremo

For PRISKADAPT, the platform that will be designed and implemented, information from technicians, health care professionals and citizens is important as input to the risk assessment module, including technical and social risks. Therefore, technicians, health care professionals and citizens are kindly requested to answer the following questions on critical infrastructure and buildings. In addition technicians are also requested to answer questions concerning their expectations of PRISKADAPT. The answers are only visible to the project team and questionnaires are anonymous. Thanks for your collaboration.

Structural damage or no functionality can be explained as ‘no delivering of health service possible’

Limited damage or limited functionality can be explained as ‘limited availability of health service and limited accessibility for patient and visitors’.

Information on heavy weather events: https://climate.ec.europa.eu/climate-change/consequences-climate-change_it

Information on sustaining winds: https://www.nhc.noaa.gov/aboutsshws.php

Generalities

Please provide the following basic information:

- Gender: Female, Male, Other
- Age: 18-30, 31-50, 51-65, over 65
- Degree of education (alternatives?) school obligation, higher secondary school, bachelor's degree, master's degree, other
- Job (optional)
- Neighbourhood of residence (in Italian, Rione. Should we need to give some alternatives?)

The Cattinara hospital is the hospital where they usually go to get :

- first aid
- long-term medical care
- ordinary preventive or precautionary health care

We want to divide the questionnaire participants into five categories. Which of the following categories do you think best defines your point of view or role as a representative of an association or institution when answering the questionnaire?

- Technicians: engineers or generalist technicians
- Technicians: engineers or technicians working in the health sector
- Practitioners: health care professionals
- Citizens: civil associations
- Citizens: individuals and householders

Here, the questionnaires are divided into three different types according to categorisation: Technicians, Practitioners and Citizens.

P-RISKADAPT - for all the categories

1. Given the different types of information that the RISKADAPT platform (PRISKADAPT) can provide (see below) rate to which extent, in your opinion, this information is relevant for the wellbeing of local people and for achieving the purpose of the RISKADAPT project (i.e. to better prevent risk from and adapt to climate change).

   Scale: 0= Not Relevant At All; 1 = Of Little Relevance; 2 = Of Average Relevance; 3 = Relevant; 4 = Highly Relevant

   a. Information on most impacting meteorological hazards
      From 0 (not relevant at all) to 4 (highly relevant)

   b. Information the vulnerability of the Cattinara Hospital
      From 0 (not relevant at all) to 4 (highly relevant)

   c. Information on the vulnerability of people (patients, hospital personnel, visitors, residents) and their exposure to the negative social and economic impacts that may be created by likely damages to the structure and to the functionality of the Hospital
      From 0 (not relevant at all) to 4 (highly relevant)

   d. Information on emergency and/or contingency plans and/or alternative health care facilities (in case of disruption of the services provided by the Cattinara hospital)
      From 0 (not relevant at all) to 4 (highly relevant)

   e. Information about prevention plans and measures addressed to reduce the risk before any disruptive event
      From 0 (not relevant at all) to 4 (highly relevant)

Technicians

Prevention/Preparedness/Response/Recovery/Mitigation

2. How do you assess your knowledge about the resilience of the technical aspects of the Cattinara Hospital to heavy weather events?
From 0 (no knowledge) to 4 (very well)

3. In the event of an extreme weather event, what is your greatest concern regarding the likely damages to the structure and functionality of the hospital?

4. In each dimension of local community wellbeing (i.e. health, economy, infrastructure and community services, environment – see below), rate to what extent, in your opinion, the impacts of heavy weather events that may be created by the likely damages and loss of functionality to the Cattinara Hospital are relevant in terms of their negative consequences.

Scale: 0= Not Relevant At All; 1 = Of Little Relevance; 2 = Of Average Relevance; 3 = Relevant; 4 = Highly Relevant

3.1 Impacts on peoples' **health**

- *On hospitalized people*
  From 0 (not relevant at all) to 4 (highly relevant)
- *On hospital personnel*
  From 0 (not relevant at all) to 4 (highly relevant)
- *On visitors*
  From 0 (not relevant at all) to 4 (highly relevant)

3.2 Impacts on the **economy,** in terms of:

- *The economic cost of restoring the structure after damage*
  From 0 (not relevant at all) to 4 (highly relevant)
- *The likely changes in current employment conditions of the hospital personnel*
  (e.g. loss of job, part-time flexibility, mobility of personnel)
  From 0 (not relevant at all) to 4 (highly relevant)
- *The changes and impacts on the hospital supply chain*
  From 0 (not relevant at all) to 4 (highly relevant)

3.3 Impacts on local **infrastructure and community services** in terms of:

- *Impacts on logistics and services (should some patients need to be transferred to other health care facilities, or should the hospital need to be temporarily closed)*
  From 0 (not relevant at all) to 4 (highly relevant)
- *Impacts on access to and availability of other health care facilities close by*
  From 0 (not relevant at all) to 4 (highly relevant)

3.4 Impacts on the local **environment** in terms of

- *Rubble and hazardous waste (from damage to, or restoration of the Hospital)*
  From 0 (not relevant at all) to 4 (highly relevant)
- *Pollution, dust or noise (from damages to, and restoration of the Hospital)*
  From 0 (not relevant at all) to 4 (highly relevant)

5. Please, add any other relevant impact that was not included in the list above and that you think is important to consider.

6. Which interventions should be planned in the short term to ensure no damage or loss of functionality of the building caused by heavy weather events?

7. Which interventions should be planned in the long term to ensure no damage or loss of functionality of the building caused by heavy weather events?

8. Are you aware of any strategy (e.g. prevention plan, emergency plan) to ensure that health services could be continued in case of an extreme weather event and of damages to the structure or the functionality of the Cattinara Hospital? If yes, please specify which one.

Practitioners

Prevention/Preparedness/Response/Recovery/Mitigation

1. Rate to what extent you are aware of the damages that may be created by heavy weather events on the Cattinara Hospital and its services.

Scale: 0= Not Aware At All; 1 = Little Aware; 2 = Of Average; 3 = Very Aware; 4 = Fully Aware
From 0(not aware at all) to 4 (very well aware)

2. Rate to which extent, in your opinion, the relevance of the following impacts that may be created by the likely damages to the Hospital because of a heavy weather event.
- Accessibility for patients :
  From 0 (not relevant at all) to 4 (highly relevant)
- Accessibility for visitors
  From 0 (not relevant at all) to 4 (highly relevant)
- Availability of health services:
  From 0 (not relevant at all) to 4 (highly relevant)

3. Among all health care services provided by the Cattinara hospital (e.g. first aid or other specific health care departments), which one would be the most critical to protect and/or most exposed to, and likely to be affected by the damages caused by heavy weather events?

4. In each dimension - same as Question 3 of Technicians

5. Please, add any other relevant impact that was not included in the list above and that you think is important to consider.

6. Rate to what extent, in your opinion, these people would be impacted by the likely damages to the structure or the functionality of the Cattinara Hospital that heavy weather events might create.

Scale: 0= Not Relevant At All; 1 = Of Little Relevance; 2 = Of Average Relevance; 3 = Relevant; 4 = Highly Relevant

- Hospitalized people
  From 0 (not impacted at all) to 3 (heavily impacted)
- Visitors
  From 0 (not impacted at all) to 3 (heavily impacted)
  Hospital personnel

From 0 (not impacted at all) to 3 (heavily impacted)
- Hospital supply chain personnel
  From 0 (not impacted at all) to 3 (heavily impacted)
- Others (please specify)

7. The inhabitants of which *Rione* of the Trieste Municipality do you think would be most exposed to and/or impacted by the likely damages that heavy weather events might create on the Cattinara Hospital? Briefly explain why.

8. Which interventions should be planned in the short term to ensure no damage or loss of functionality of the building caused by heavy weather events ?

9. Which interventions should be planned in the long term to ensure no damage or loss of functionality of the building caused by heavy weather events?

10. As a healthcare professional, to what extent are you prepared for a loss of functionality that may be due to, for example, a heavy weather event?
From 0 (no prepared at all) to 4 (very well prepared)

11. Rate to which extent, in your opinion, the hospital is prepared for a crisis or disaster due to a heavy weather event?
From 0 (no prepared at all) to 4 (very well prepared)

12. Are you aware of whether there is any strategy (prevention plan, emergency plan) in place to ensure that health services can be continued during a crisis or disaster due to heavy weather events?

13. If yes, what are the strategies of which you are aware?

Citizens

14. How often do you go to Cattinara hospital?
   - 1-3 per year,
   - 3-9 per year,
   - more often

15. How do you go to Cattinara hospital?
   - public transport
   - car
   - otherwise (please, specify)

16. In case of limited access to health services at Cattinara hospital, what would you do to get medical help?
   - Seeking alternative health services. If so, please specify where.
   - Waiting until the situation improves.
   - Seeking medical help at home.
   - Others (please specify)

17. In each dimension - see question 3 of Technicians

18. Rate to what extent, in your opinion, these people would be impacted by the likely damages to the structure or the functionality of the Cattinara Hospital that heavy weather events might create.

Scale: 0= Not Relevant At All; 1 = Of Little Relevance; 2 = Of Average Relevance; 3 = Relevant; 4 = Highly Relevant

- Hospitalized people
  From 0 (not impacted at all) to 3 (heavily impacted)
- Visitors
  From 0 (not impacted at all) to 3 (heavily impacted)
  Hospital personnel
  From 0 (not impacted at all) to 3 (heavily impacted)
- Hospital supply chain personnel
  From 0 (not impacted at all) to 3 (heavily impacted)
- Others (please specify)

19. The inhabitants of which *Rione* of the Trieste City and Province do you think would be most exposed, to and/or impacted by the likely damages that heavy weather events might create on the Cattinara Hospital? Briefly explain why.

20. Which interventions should be planned in the short term to ensure no damage or loss of functionality of the building caused by heavy weather events?

21. Which interventions should be planned in the long term to ensure no damage or loss of functionality of the building caused by heavy weather events?

22. Please, add any other relevant impact that was not included in the list above and that you think is important to consider.

23. Are you aware of whether there is any strategy (prevention plan, emergency plan) in place to ensure that health services can be continued during a crisis or disaster due to heavy weather events?

24. If yes, what are the strategies of which you are aware?

Information

25. In case of limited access to health services at Cattinara hospital, what information would you need?

26. How would you like to be informed?
Email – letter – news clipping in newspaper – by phone – by social media – others

27. By whom?
Your general practitioner – the Cattinara Hospital personnel – the local municipality – the regional health care service – others