Deliverable D6.3

Report 2 of Workshops in Application Case Studies

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Abstract

WP6 includes activities about the application case study coordination, project coordination, reporting and communicating and quality assurance. WP6 sets out the activities and actions that need to take place, and information on implementation specifically in four application case study areas individually and horizontally. Additionally, WP6 includes information on project management that is structured so that technical issues are managed separately from finance and administration. In total, WP6 includes fifteen deliverables. This deliverable D6.3 is the second report of the activities in the four application case studies (Sint Maarten on the Caribbean Islands; Brenner Corridor in the Alps; Istanbul in Türkiye; Bucharest in Romania) between April 2023 and March 2024.

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Document History

Version	Date	Author	Description
V1	11.03.2024	Funda Atun	Prepared the first draft of the deliverable
V1	14.03.2024	Till Wenzel, Philipp Marr	Contributed to Alps Case Study
V1	15.03.2024	Marcell Hurlimann, Philipp Marr, Alice Nikuze	Contributed to section 2.3
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V1	19.03.2024	Serge Monturet, Joris Ranchin	Contributed to Section 2.2
V1	21.03.2024	Cees van Westen, Dinand Alkema	Contributed to Caribbean Case Study
V1	22.03.2024	Seda Kundak, Caglar Goksu, Ahmet Atıl Asici, Kerem Yavuz Arslanlı, Duygu Kalkanlı, Ali Yılmaz, Cihan Mert Sabah, Tionge Munthali, Murat Yün, Kemal Duran, Betul Konukcu, Ece Pak	Contributed to Istanbul Case Study
V1	22.03.2024	Iuliana Armas, Cosmina Albulescu	Contributed to Bucharest Case Study
V1	25.03.2024	Bettina Koelle	Contributed to section 2.4
V1	25.03.2024	Cees van Westen,	Contributed to section 2.5
V2	27.3.2024	Marcel Hürlimann, Pavan Kumar	Reviewed the entire deliverable
V2	28.3.2024	Serge Monturet, Joris Ranchin	Reviewed the entire deliverable
V3	29.03.2024	Funda Atun	Finalised the last version
V3	29.03.2024	Cees van Westen	Submitted

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About PARATUS:

The PARATUS project aims to increase the preparedness of first and second responders in the face of multi-hazard events and to reduce the risks related impacts on various sectors resulting from complex disasters. The outcome is to develop an open-source cloud-based Online Service Platform that offers support in reducing dynamic risk scenarios and systemic vulnerability caused by multi-hazard disasters. To achieve these objectives, the project will perform in-depth assessments of complex interactions between hazards and their resulting impacts on various sectors, analyse the current risk situation and study how alternative future scenarios could change multi-hazard impact chains. Based on these analysis, scenarios of multi-hazard impacts will be co-designed and developed with stakeholders in four application case study areas (including the Caribbean Islands, the Brenner Corridor in the Alps, Istanbul in Türkiye and Bucharest in Romania,).

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List of Acronyms

Acronym	Definition
AIT	Asian Institute of Technology
AISCC	African Island States Climate Council
ACS	Application Case Study
ASFINAG	Autobahn and Schnellstraßen-Finanz-Aktiengesellschaft
BCP	Brenner Corridor Platform
BFW	Federal Research and Training Centre for Forests, Natural Hazards and Landscape
CARICOM	Caribbean Community of States
CCEO	Council of Caribbean Engineering Organisations
CDEMA	Caribbean Disaster Emergency Management Agency
CIMH	Caribbean Institute for Meteorology and Hydrology
DSU	Department for Emergency Situations
ENGAGE	ENGAGE is an EU-funded project, started in July 2020, whose mission is to provide novel knowledge, impactful solutions and emergency response guidelines for exploiting Europe´s societal resilience
EURAC	EURAC Research
GBA	Geological Survey
GDES	Gender, Diversity, Ethics and Security
GDPR	General Data Protection Regulation
GLOMOS	Global Mountain
HCD	Human-Centered Design
IFRC	International Federation of Red Cross and Red Crescent Societies
IGSU	Romanian General Inspectorate for Emergency Situations
IMM	Istanbul Metropolitan Municipality
IOC	Indian Ocean Commission
ITU	Istanbul Technical University
KNMI	Royal Netherlands Meteorological Institute
M	Month
MDLAP	Operative Centre for Emergency Situations
NLRC	Netherlands Red Cross Caribbean
NEMO	National Emergency Management Organisation
ÖBB	Austrian Railway
PARATUS	Increasing Preparedness and Resilience of European Communities by Co-Developing Services Using Dynamic Systemic Risk Assessment
RAN	Resilience Advisors Network
RCCC	Red Cross Red Crescent Climate Centre

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REA	European Research Executive Agency
SIDS	Small Island Development States
TEATT	Ministry of Tourism, Economic Affairs, Transport and Telecommunication
UB	Universitatea din Bucuresti
UN-ECA	UN Economic Committee for Africa
UNDRR	United Nations Office for Disaster Risk Rection
UNU-EHS	Unite Nationa University Institute of Environment and Human Security
UNIVIE	Universitat Wien
UT	University of Twente
UTECH	University of Technology , Jamia
UWI	University of the West Indies
WLV	Torrent and Avalanche Control
WP	Work Package

Executive Summary

WP6 demonstrates the work process of the application case studies and project coordination. WP6 includes 15 deliverables. The work package sets out the activities and actions that need to take place, and information on implementation specifically in four application case study areas individually and horizontally. Additionally, WP6 includes information on project management that is structured so that technical issues are managed separately from finance and administration.

This deliverable D6.3 is the second report of the stakeholder workshops that have been organized in the period from April 2023 to April 2024 in the four application case studies of the EU Horizon Europe PARATUS project (https://www.paratus-project.eu/): Sint Maarten, Caribbean; Brenner, Austria; Istanbul, Türkiye; Bucharest, Romania.

PARATUS considers the Caribbean in a wider context by including cross-border issues. The main hazards are tropical storms (with their associated hazards such as extreme wind and rainfall, leading to windfall, storm surge, flash floods, debris flows and landslides), earthquakes, tsunamis, volcanic eruptions (and associated hazards, such as ash cloud dispersal), pyroclastic flows, lava flows and lahars). The Caribbean case study focuses on the development of a multi-hazard early warning dashboard (KNMI is the lead partner) which will link to exposure and vulnerability modelling. The dashboard will derive an impact-based forecast that can be directed at humanitarian response planning by the Netherlands Red Cross (as key stakeholder) and its Caribbean branches. Another sector that will be considered is the telecommunication sector, since it may be impacted by tropical storms, resulting in an impact on emergency response, and on economic sectors such as tourism. During previous hazardous events in the area this enhanced the impacts tremendously.

The Alpine Application Case Study's focus is on the impact of the interruption of cross-border transportation by different hazards in a mountainous environment, such as extreme wind, floods, rockfall, mudflow, landslides and snow avalanches within the Brenner Corridor reaching from Kufstein (Austria) to Bolzano (Italy). Temperatures in the Alps have warmed almost twice as fast compared to the global average. These

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changes have impacts on known and unknown natural and anthropogenic hazards; cascading as well as compounding events can influence the susceptibility of different anthropogenic structures, such as critical infrastructure and e.g., potentially threaten cross-border transportation which constitutes the main focus of this Application Case Study. The Brenner Corridor marks one of the key transit routes connecting southern and northern Europe. Each year more than 10 million cars and 2 million trucks pass the corridor. It needs to be stressed that the Corridor comprises not only the Brenner highway itself but also municipal roads and railway tracks.

In the case study of Istanbul, we plan to focus on urban dynamics (including demography, social factors, economy, built-up environment, etc.) to reveal systemic vulnerabilities. Istanbul is a mega city with its population of over 15 million inhabitants. Istanbul is highly susceptible to earthquakes, as well as associated hazards such as liquefaction, landslides and tsunami. In addition, hydrometeorological hazards (i.e., extreme temperatures, fires, flooding) are also becoming increasingly problematic. Since the 1999 Kocaeli Earthquake, the population of Istanbul has increased from around 8 million to 15 million. This population growth, combined with the speed of urban expansion and the integration of new migrants (both native and foreign, including refugees from countries such as Syria and Afghanistan), has contributed to an escalating level of disaster risk. Furthermore, the income and welfare gap between wealthier and disadvantaged groups is more pronounced in such big agglomerations, making disadvantaged groups even more vulnerable during times of disaster.

Bucharest Case Study focuses on the cascading impacts of a potential major earthquake. During the 1940 and 1977 earthquakes (with moment-magnitudes Mw of 7.7, respectively 7.4) that occurred in the Vrancea Intermediate-Depth Source, 1564 people were killed in Bucharest, mostly due to the collapse of medium and high-rise buildings. Most damage was in the city center, where many constructions built without considering the seismic design code (prior to 1940), and with poor construction quality, were and still are located. As the 2011 statistics show, Bucharest hosts more than 31430 buildings belonging to the pre-code era. Experts employed by the Bucharest General Municipality individually evaluated 759 vulnerable buildings and considered 357 of them as being in the seismic risk class I (meaning that they could collapse at any event similar to the control period earthquake). The 1977 earthquake also proved that some newer buildings can also be severely affected, due to design and construction errors.

The activities in the application case studies support the overall aim of the PARATUS project that is to co-develop an open and online platform together with stakeholders. Stakeholder engagement is the key to the success of the project. The PARATUS project, therefore, aims to engage with representatives from a wide range of sectors related to Disaster Risk Management to gather insights, knowledge, and expertise, and to ensure that the project results are relevant and of high quality.

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1 Introduction to WP6 and D6.3

WP6 includes activities about the application case study coordination, project coordination, reporting and communicating and quality assurance. WP6 sets out the activities and actions that need to take place, and information on implementation specifically in four application case study areas individually and horizontally. Additionally, WP6 includes information on project management that is structured so that technical issues are managed separately from finance and administration. In total, WP6 includes fifteen deliverables (Table 1.1).

The objectives of D6.3 are:

- To report the result of the activities conducted in the application case study areas between April 2023 and March 2024
- To share the methods conducted in the application case study areas and the lessons learned
- To share the follow-up planning

Table 1.1: PARATUS Deliverables D6.1 – D6.15

#	Name	Due date (month)	Description
D6.1	Strategy and case study protocols	6 (submitted)	Strategy, case study protocols, including template for follow up, overall coordination
D6.2	Report 1 of workshops in application case study area	6 (submitted)	Reports on workshops in application case study areas
D6.3	Report 2 of workshops in application case study area	18 (this report)	Reports on workshops in application case study areas
D6.4	Report 3 of workshops in application case study area	24	Reports on workshops in application case study areas
D6.5	Report 4 of workshops in the application case study area	38	Reports on workshops in application case study areas
D6.6	Project management plan	3 (submitted)	Project management plan
D6.7	Initial project risk management plan	6 (submitted)	Initial project risk management plan
D6.8	Updated project risk management plan	18 (submitted)	Updated project risk management plan
D6.9	Final project risk management plan	36	Final project risk management plan
D6.10	Initial data management plan	6 (submitted)	Initial data management plan including data security aspects
D6.11	Updated data management plan 1	18 (submitted)	Initial data management plan 1 including data security aspects
D6.12	Updated data management plan 2	36	Initial data management plan 2 including data security aspects,
D6.13	Final data management	48	Final data management plan including data security aspects
D6.14	Draft gender, diversity, and ethics (GDE) plan	12 (submitted)	Lead Beneficiary: UT
D6.15	Final gender, diversity and ethics (GDE) plan	36	Lead Beneficiary: UT

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2 Background information

In PARATUS project we have four application case study areas that are selected to implement the methods developed in PARATUS, together with the local or regional communities and authorities. The case study areas are selected considering combinations of the following aspects:

- Natural and anthropogenic hazard interactions: extreme weather events and associated events, geophysical hazards, slow-onset trends, anthropogenic threats.
- Assets and vulnerabilities in different sectors: social aspects, human health, cultural heritage, environment and biodiversity, public financial management and key economic sectors.
- The scale of analysis: international, cross-border to local applications. Three of them are located in the periphery of the EU, which generally does not receive equal attention with respect to international research efforts but have high levels of vulnerabilities and significant proportions of disadvantaged groups.

As the overall aim of the PARATUS project is to co-develop an open and online platform together with stakeholders, stakeholder engagement is the key to the success of the project. The PARATUS project, therefore, aims to engage with representatives from a wide range of sectors related to Disaster Risk Management to gather insights, knowledge, and expertise, and to ensure that the project results are relevant and of high quality. In PARATUS we will build a network of stakeholders.

The Impact Chain Approach was adopted as a guiding tool to gather structured information from the stakeholders during the Application Case Studies Workshops.

2.1 Impact Chains and Forensic Analysis[1]

The Impact Chain Approach, described in D1.1 and D6.2, has been shared in workshops and meetings at the project level and consequently adopted in the four application case studies during participatory processes. This resulted in a total of 15 Impact Chains being developed before M10. These are presented in D1.1. In the following months the existing Impact Chains developed by the different interdisciplinary partners have been reviewed by EURAC Research. Although the Impact Chains have been developed following shared guidelines, major differences have been encountered, mainly in relation to two aspects: consistency and completeness. In particular, the Impact Chains present a slightly inconsistency in elements and connections, going beyond the proposed categories provided in the guidelines. Moreover, some factors have been attributed to the wrong type of element. Regarding completeness, the review has underlined that some elements, especially vulnerability factors, are missing as well as a few fields on the online platform Kumu[2] where the Impact Chains were developed (*e.g.* source, description etc.).

One of the main goals of WP1 and WP4 is developing an Impact Chain tool. This tool will allow to collect and order the PARATUS Impact Chains in a systematic manner, allowing to consult them in an interactive way. In this context, updating and improving the existing Impact Chain proves to be particularly important.

[1] For more information, please visit deliverable 1.1 (M10) and deliverable 1.2 (M20).
[2] https://kumu.io/

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To better examine past events and to consequently improve the Impact Chains in the aforementioned direction, a Forensic Analysis approach was developed. Forensic Analysis, in the context of analysing past disasters, consists in investigating pre-event conditions, collecting evidence and facts from multiple sources. In other words, disaster forensic approaches aim to identify the causes of disasters to improve current disaster risk management.

The **PARATUS Forensic Analysis Framework** consists in a combination of existing forensic approaches: (i) Forensic Investigations of Disasters (FORIN, (ii) the Post-Event Review Capability (PERC), and (iii) Detecting Disaster Root Causes (DDRC) Framework and Tool, requested by the German Committee for Disaster Reduction (DKKV). For more information, please visit Deliverable 6.1 Strategy and Case study Protocols.

An overview of the main aspects covered by the forensic analysis can be found in Figure 2.1.1. These include "Pre-disaster conditions", existing before the occurrence of the event and providing an insight on the reasons why the event occurred. Moreover, the framework encompasses "Hazard and impact analysis" to gain an in-depth overview of what happened during and shortly after the event. Additionally, the analysis includes recovery measures as well as long-term measures to build resilience in light of future events.

The Forensic Analysis Approach is being applied not only to the Learning Case Studies (LCSs) which are directly linked to the Application Case Studies but also to a broader set of other LCSs. In both cases, the study of the specific historical event is supporting the improvement or the development of Impact Chains.

More information on this framework can be found in Deliverable 1.2.

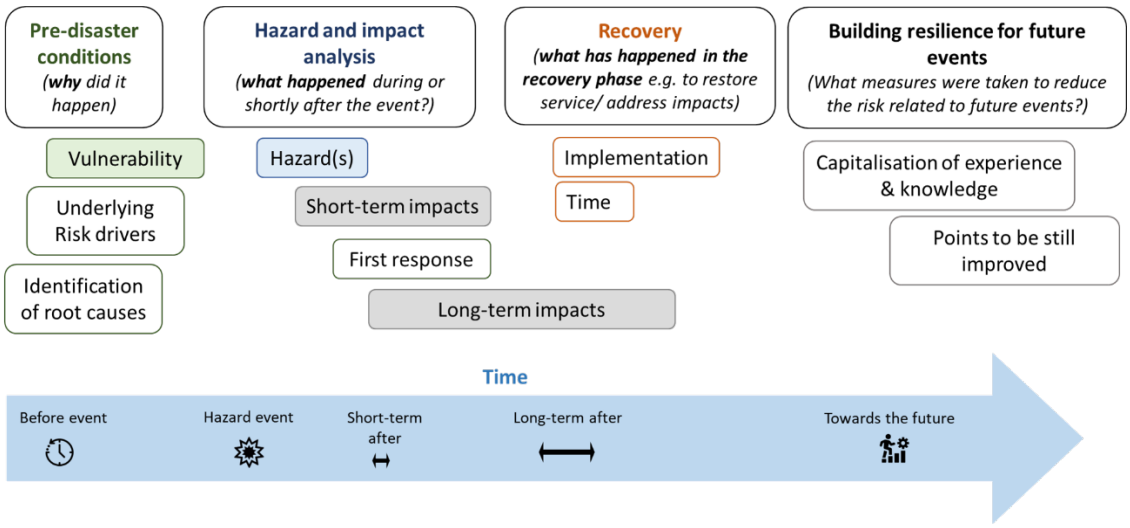

Figure 2.1.1 Main components of the PARATUS Forensic Analysis Framework, ordered in time with respect to the occurrence of the main hazard event. The coloured elements (vulnerability, hazard(s) and impacts) are those which overlap with the Impact Chains approach.

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2.2 Selection of Stakeholders

To implement an orchestrated development process between case study groups and WPs, FI Group conducted individual interviews between October and December 2023 with all leaders of the application case studies and the first four WPs. The objective of these interviews was to gain a detailed understanding of the status in each technical WP in terms of development of the expected results and to foster alignment among them as well as among the Application Case Study leaders. Before conducting the interviews, preparatory work was performed that consisted of matching all the deliverables with the expected tangible results of the project. Also, a questionnaire was developed to streamline the conversations and obtain comparable inputs from each technical/scientific WP leader. During the interviews, the objective was to identify the development phases of each deliverable to understand how they contribute to the project results. The answer to the questionnaires and the outcomes of the interviews will be reported in detail in D5.2 "The PARATUS impact strategy. Final version" in M24.

Following these interviews, a second series of interviews were organised with all application case leaders. They had the same objectives as the WPL interviews but collected on top feedback from the first workshops with stakeholders, with a focus on lessons learned and bottlenecks identified. To foster collaboration with WP leaders, ACS leaders were also asked their expectations towards WP leaders and their potential contribution to the different workshops. The highlights of the interviews are given in Table 2.1

Table 2.1. Highlights of the interviews with application case study leaders.

Application Case Study	Interviewees	Date	Highlights
Istanbul	Seda Kundak	30/10/2023	A large number and variety of stakeholders are active and very interested in this case study area. This requires focussing on very specific areas of the city. Given the political situation in Turkey and the local elections in March 2024, some of the most relevant stakeholders could not attend the workshop, however devoted sessions are planned to receive their input in 2024
Alps	Philipp Marr	23/10/2023	A larger list of Italian stakeholders must be created for a better involvement of the Austrian stakeholders' counterparts on the other side of the Brenner corridor. The wish for more exchanges with other ACS were also expressed. In terms of engagement activities, half-days excursions in the field were judged as very successful in terms of engagement.
Caribbean	Dinand Alkema	18/12/2023	Maintain a good level of communication and engagement with distant stakeholders is a key issue. The next workshop is expected to take place in Barbados, in collaboration with CDEMA[3] that is planning to develop a risk assessment tool that could be an exploitable result of PARATUS. This activity is

[3] The Caribbean Disaster Management Agency, https://www.cdema.org/.

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			related to task T5.4 on exploitation (please refer to the last paragraphs of this section).
Romania	Iuliana Armas	19/01/2024	Focus groups composed of 6 practitioners had been set up, which created much more valuable output than a single, joint workshop. During the workshop, participants felt obliged to attend, did not show much interest for the bigger picture, and displayed different backgrounds and knowledge that hindered communication and the production of tangible results.

During the interview with the ACS leader in Istanbul (see section 3.3), the discussion focused on the workshop that took place in June 2023, that was attended by 90 participants. Thanks to the interviews conducted, stronger links could be created with the Romanian ACS. Both ACS have earthquakes as a main natural hazard under investigation. Consequently, FI Group has worked with ITU on a target stakeholder group classification (please refer to section 3.3 for details) that has led to the planning of a new workshop with Istanbul Municipality in 2024. The plan is to organise focus group meetings with the chamber of industry and trade and AFAD[4], separately, starting with the former. The coordination team (University of Twente) will be involved in the round of meetings and will conduct interviews with stakeholders. The questionnaires remain to be produced and should be aligned with the questionnaires developed for the Bucharest Case Study, to align outcomes between case studies.

Regarding the Alps Case Study, a follow-up meeting took place in February 2024 between FI Group and the ACS leader. The stakeholders that participated to the first workshop were reviewed one by one and it was discussed who they are and what they could bring to the project. It turned out that stakeholders dealing more or less directly with transportation are of high importance to the case study and should be especially engaged. The formats used (and planned to be used) to engage with them were also discussed. The meeting enabled to draft the first version of the stakeholder target group of the Alps Case Study (please refer to section 3.2 for more details). The meeting also highlighted that two interviews had already been conducted with the Tiroler Landeswarnzentrale and the WLV in January 2024, and more will follow (ÖBB, Bundesheer, and an insurance company). A survey is planned to be circulated to stakeholders, ideally during the summer and a workshop is planned for November. In order for the survey to reach out a number of stakeholders, especially in the case study area with a focus on Italian stakeholders, a first meeting with the European Emergency Number Association (EENA) has been planned by FI Group to discuss the objectives of the survey.

In the Caribbean Case Study the choice was made to develop both a regional level approach, which involved stakeholders such as the Caribbean Disaster Emergency Management Agency (CDEMA), and a national approach in several Caribbean countries (Sint Maarten and Saint Vincent and the Grenadines). There was a change in the ACS leader, from KNMI to UT. This change in coordinator, in combination with the long distance and the relative difficulty to get response from stakeholders in the Caribbean via online media, made that the workshops at regional level in Barbados , and at national level in Saint Vincent were organised a bit later than in in the other ACS's, but with very positive outcomes and contacts with stakeholders .

[4] Ministry of Interior Disaster and Emergency Management Presidency (AFAD).

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2.3 Data Collection

During the research, datasets of all the four application case studies will also be stored and shared with project members through dedicated options using UniShare that can be accessed through UniShare account of University of Twente[5]. The access requires logging in. UniShare is a Content Collaboration Platform (CCP) offered and owned by the University of Twente. It enables safe and efficient storing for large volume of data. In this platform there is a folder for each of the four application case studies, all of them with the same structure defined in accordance with the Data Specifications outlined by the INSPIRE Directive[6]. INSPIRE is a European Union initiative that aims to enable the sharing of geospatial information, by establishing a framework for the development of a European spatial data infrastructure.

The UniShare platform has just be created and the partners have started the upload of the different datasets. In particular, the four application case study leaders will deliver information on the current situation (single and multi-hazards, exposure, vulnerability, impacts, risks, damage costs etc.), but this repository is also foreseen to gather datasets on future scenarios. Therefore, information on future climate parameters and future scenarios of exposure as well as of vulnerability will also be uploaded.

A detailed description of the UniShare data platform, its structure and general information can be found in deliverable D6.11 “Updated Data Management Plan”.

2.4 WP3 activities in relation to the case study areas

This objective is addressed by Work Package 3, led by Red Cross Red Crescent Climate Centre, and runs from September 2022 to May 2026. The objective is to assess existing approaches for Disaster Risk Reduction and Climate Resilience, and compile a toolbox of approaches. Adaptation and mitigation options will be explored in a co-creation process with a range of diverse stakeholders in the application case study sites. Two serious games will be developed that will support an engaged and innovative learning process at the application case study sites. In addition, a stress test methodology will be developed for short- and long-term decision making and planning processes for different sectors. The expected results are:

- Methodology and tool for analysing risk mitigation measures, which also addresses SSH aspects.
- Co-developed serious games for the evaluation of optimal adaptation/mitigation measures for risk reduction under “What if?” scenarios to simulate the decision-making process.

The PARATUS team is especially focusing on different sectors and exploring adaptation options specifically linking to compound and cascading risks at different time scales. Documentation of adaptation options explored in the case study areas will also contribute to adaptation options described and the list will contribute to the platform in WP4, with a dedicated section linking to data and examples from across PARATUS to illustrate the systems.

Through workshops in the case study areas a first inventory was made of the problems encountered and the stakeholder roles and requirements. In follow-up workshops and interactions, we will work out specific sets

[5] https://unishare.utwente.nl/
[6] For more information on INSPIRE directive: https://inspire.ec.europa.eu/Themes/Data%20Specifications/2892

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of adaptation and Disaster Resilient Reduction (DRR) options for the stakeholders, depending on the local setting, hazard types, sectors, and legislative framework.

Game development has been progressing well, with our game team providing some trial games to facilitate workshop processes in the case study areas while exploring the development of a more complex simulation game that can be used in the case study areas.

2.5 WP4 activities in relation to the case study areas

A central theme in the PARATUS project is the co-development of the tools with stakeholders. The central stakeholders within the four applications case studies are therefore full project partners. They will be directly involved in the development of the platform. We foresee that the PARATUS Platform will have two major blocks: an information service that provides static information (or regularly updated information) and simulation service, which is a dynamic component where stakeholders can interactively work with the tools in the platform. The PARATUS will further make sure that documentation (*e.g*. software accompanying documentation) is also publicly available via the project website[7] and other trusted repositories.

The deliverable 4.1 was submitted to the European Commission on 31/07/2023 and is waiting for approval by the Research Executive Agency. Therefore, this current version may not represent the final version of the deliverable[8].

Human-Centered Design (HCD) is a design and management framework that develops solutions to problems by involving the human perspective in all steps of the problem-solving process. Utilised in multiple fields, including social sciences and technology, HCD has been noted for its ability to consider human dignity, access, and ability roles when developing solutions.

Human-Centered Design is a practice that can be characterized as a multi-stage problem-solving process where designers focus on the human/user's needs and what is desired. It saves time and money by allowing usability and adaptation within what is feasible and viable.

The process started with desktop research on the characteristics of the stakeholders, data availability and applications, and a stakeholder mapping phase. In the next phase we organized a series of workshops in the various case study areas (See the description in WP6 for that) to present the idea of the PARATUS platform and show small demonstrations of the components that were already developed. The next phase consists of a series of stakeholder interviews, where we discuss with individual stakeholders what type of activities they do, which tools they are currently using and which requirements they have**.** This phase of stakeholder consultation has started in a some of the case study areas (*e.g*. in Saint Vincent in the Caribbean, or in the Alps), and is planned to be carried out in the coming period in the others.

[7] https://www.paratus-project.eu/
[8] The deliverable can be downloaded from: https://zenodo.org/records/8199939

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For some of the tools (e.g. the impact chains wiki, or the scenario definition tool) mock-ups have been generated which will be presented and discussed with stakeholders in order to get their feedback.

Box 1:

Example: User Needs Assessment in Saint Vincent. The following activities were carried out:

- One day: Preparation for the stakeholder workshop and instructions by partner specialised in user-centred design.
- Two hours: Execution of the stakeholder workshop with representatives from various government departments. Explanation on the PARATUS project and planned activities
- Two days: Stakeholder interviews with persons different government departments , carried out by two people from the PARATUS project. In total approximately 8 interviews were carried out.
- Two days: Field visit to the Soufriere volcano and to the NE part of Saint Vincent, which was heavily impacted by the 2021 eruption of Sourfrière volcano and subsequent lahars, and by coastal erosion related to sea level rise.
- Two hours: workshop with stakeholders to work out impact chains for a specific historical disaster.
- Two hours: Workshop with demonstration of tools from the PARATUS platform for stakeholders

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3 Reports on Application case studies

This section includes the reports of the activities during the last twelve months of the project in four application case study areas: Caribbean, Alps, Istanbul and Bucharest.

3.1 Caribbean

3.1.1 Update: What happened from April 2023 to March 2024

The Caribbean case study is different from the other case studies within PARATUS, for several reasons:

- It entails both a regional component that covers the Eastern Caribbean area, and includes several countries, as well as individual island countries.
- The stakeholders on the regional scale are different from those at the national scale.
- The applications and sectors are also different for the regional and the national approaches.

Regional scale activities carried out in the Caribbean

The Caribbean is one of the most disaster-prone regions in the world, being vulnerable to an array of natural and anthropogenic hazards. The Caribbean Disaster Emergency Management Agency (CDEMA) is the specialized regional disaster risk management agency of CARICOM. It serves eighteen (18) participating countries.

In line with its function as a clearing house for disaster related and loss-reduction information, CDEMA established the Caribbean Risk Information System (CRIS) as a multi-faceted digital/virtual platform to host risk management data and information to facilitate analysis, research, greater awareness of risk management in the region; and, to aid in providing material to drive evidence-based decision-making processes. In support of this, the Regional Technical Working Group on Disaster Risk Assessment was established with the following five functions:

- Assess regional capacities for the execution of risk assessments and the development of risk profiles for priority hazards affecting CDEMA Participating States. Risk assessment findings are intended to provide input into the development of risk profiles that will inform evidence-based decision making for Physical and Economic Development Planning.
- Determine agreed methodological approaches to the application of risk assessments for priority hazards within CDEMA Participating States
- Promote the utilization of agreed methodological approaches to the development of risk assessments for priority hazards within CDEMA Participating States
- Validate and promote tools (including training) to support the development and implementation of risk assessments within CDEMA Participating States
- Provide technical support to CDEMA Participating States in the understanding of risk assessment findings and the application of same to the development or revising of risk profiles for priority hazards.

A two-day workshop was organized in Barbados from 27-28 February 2024. The workshop had the following objectives:

- To review the status and future direction of the working group,
- To develop a plan for the risk assessment methodology under PARATUS that will describe the agreed risk assessment approach including the scale, purpose, types of hazards, data availability and future changes for consideration in view of climate change and development scenarios,

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- Exchange knowledge on risk assessment approaches within the Small Island Development States (SIDS) from different regions.

The workshop was attended by the members of the Regional Technical Working Group which consists of representatives from organisations from key specialized technical agencies whose mandate positions them to contribute towards the building of a sustainable regional mechanism for undertaking risk assessments for priority hazards in SIDS of CDEMA

Table 3.1.1 Selected key stakeholders for regional-scale work in the Caribbean (February-April 2024)

	Name of the Stakeholder Organization	(1) Practitioners (first and second responders)	(2) International networks	(3) Policy and decision making	(4) Civil Society	(5) Research and scientific	(6) Financial actors	(7) Critical infrastruct. operators	(8) Technology provider
1	Caribbean Disaster Emergency Management Agency (CDEMA)								
2	Caribbean Institute of Meteorology and Hydrology (CIMH)								
3	Seismic Research Centre, The University of the West Indies								
4	United Nations Office for Disaster Risk Rection (UNDRR)								
5	Caribbean Planners Association								
6	Royal Institute of Chartered Surveyors								
7	Council of Caribbean Engineering Organization (CCEO)								
8	University of the West Indies, Faculty of Science and Technology								
9	University of Technology, Jamaica (UTECH)								
10	IFRC								
11	Coastal Zone Management Unit								

Additionally, the workshop also included other specially invited organisations that are involved in risk assessment. Through the GLOMOS programme and the University of Twente collaboration is sought from international organisations (UNDRR, EU) to extend this workshop to exchange experiences between representatives from highly vulnerable SIDS in the Caribbean and the Indian Ocean (Comoros, Seychelles, Madagascar, Mauritius). For this purpose, we expect representatives from the UNDRR Regional Office in Nairobi, the Indian Ocean Commission (IOC Mauritius) and the UN Economic Committee for Africa (UNECA) for the African Island States (united in the AISCC). (Figure 3.1.1)

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Figure 3.1.1[9]*: Participants of the workshop from EURAC; University of Twente, Faculty of ITC, Centre for Disaster Resilience; University of the West Indies, Faculty of Science and Technology, Jamaica;* Caribbean Disaster Emergency Management Agency *(CDEMA); Coastal Zone Management Unit Barbados; Barbados Red Cross; Ministry of Education of Saint Vincent; Caribbean Planners Association, Barbados; GLOMOS, UNU-EHS; GLOMOS, EURAC; Council of Caribbean Engineering Organization (CCEO), Barbados; National Emergency Management Organization (NEMO); Seismic Research Centre, The University of the West Indies, Trinidad and Tobago; University of Technology, Jamaica (UTECH); BePrepared Int. Germany; Indian Ocean Commission, Comores/Seychelles; Caribbean Institute of Meteorology and Hydrology, CIMH.*

A working group was formed that will work out a report on the proposed methodology for Multi-Hazard Risk Assessment in the Caribbean, taking into account the differences in scale, governance, applications and data availability. The aim is to develop this framework in the coming months before the summer, and to present the final version at the bi-annual Caribbean Disaster Management Conference which will be held in Saint Kitts in the first week of December 2024.

Impact-Based Forecasting

During the workshop, 510Global, the data and digital team of the Netherlands Red Cross gave a presentation on their Impact-Based Forecasting Platform. At the same time as our meeting there was an UNDRR meeting on “Early Warning 4 All” (EW4ALL) with representatives from the CDEMA member countries on the capacity assessment for Early Warning. At this moment there are no operational impact-based forecasting programmes. There are Early Warning initiatives, e.g. CREWS (supported by the World Bank, and the status of that was not very well known by the regional members), WFP was working on something, and there was the DEWETRA (by CIMA foundation). We agreed that there should be a separate meeting between CDEMA, UNDRR, 510Global, UT-ITC, CIMH, and other relevant partners in this.

UT is initiating a large project in 12 island parts around Africa, which are grouped in the African Island States Climate Council (AISCC) with funding from the Green Climate Fund (GCF) and coordinated by the UN-

[9] *Note: Participants gave their consents for their photos to be used in the PARATUS project documents.*

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Economic Commission for Africa (UN-ECA). GLOMOS (a collaboration between EURAC and UNU-EHS) is involved in disaster management initiatives in the Indian Ocean (Indian Ocean Commission, IOC) under UNDRR and funded by the EU. The aim of this workshop was to bring representatives from these different regions together (UNDRR, UN-ECA, IOC, EU) to exchange experience and to learn from each other.

The exchange of information between SIDS from the Caribbean and the Indian Ocean, and Africa region on Disaster Management was initiated in this workshop. The PARATUS partners EURAC/UNU-EHS and UT-ITC-CDR are involved in projects in these regions in the coming period, and the aim is to learn from the set-up in the Caribbean and vice-versa. The aim is to see if a special session can be organized on the 4th International Conference on Small Island Developing States, which will be held in Antigua, in May 2024.

On 29 February 2024 PARATUS members visited the Caribbean Disaster Emergency Management Agency (CDEMA), in Bridgetown. We discussed the support of the Disaster Management Working group, as resulting from the earlier workshop. We also discussed the collaboration between SIDS from different regions. CDEMA supported the idea of organising a special session on interregional collaboration and knowledge exchange between SIDS from different regions during the SIDS conference in May.

Figure 3.1.3: Visit to Caribbean Disaster Emergency Management Agency *(CDEMA). Participants are from University of Twente, UWI-Seismic; Indian Ocean Committee; EURAC; UNU-EHS; and members of CDEMA.*

National scale : Saint Vincent and the Grenadines

A team from the PARATUS project visited Saint Vincent between 1-11 March 2024. This island suffered from a compounding event in 2021 when the Soufriere volcano erupted during the COVID-19 pandemic and a Dengue outbreak. In order to get acquainted with the situation the team hiked up the Soufriere volcano on 2 March, together with a local guide who came from a village to the North, and had been a teacher until his retirement, and who was very knowledgeable about the volcanic eruptions, in 1902, 1971, 1979 and 2021.

The eruption in 1902 was the most devastating, as it was accompanied by extensive pyroclastic flows that covered the slope around the volcano on both the Leeward (west) and Windward (east) side up to the sea, killing many people that couldn't take refuge in cellars and stone buildings. The eruption from 2021 occurred during the COVID pandemic and during a period with Dengue so the situation in the shelters was particularly concerning. Nevertheless, the authorities had prepared the evaluation of 23.000 people from the Northern part of the island very well. The event caused damages to housing, public infrastructure, and agriculture worth

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up to $154 million, or 18 percent of the national GDP for 2020. The event caused widespread ashfall resulting in massive lahars which lasted for several months, when they were worsened by an early hurricane during the 2021 hurricane season.

Figure 3.1.4 : above: Crater of the 2021 eruption within the crater of an older eruption, which itself sits in a caldera of a previous event. Below: One of the major lahar channels that connect directly to the volcano, and where a lot of sediment removal took place in the past years.

On 6 March the team visited the North-Eastern sider of the island, which is heavily impacted by coastal erosion, leading to many buildings that had to be abandoned and were destroyed, and by lahars from the various rivers coming from the flanks of the volcano. Many buildings have been destroyed by these events or were demolished by the government because they were in too dangerous conditions.

On Monday 4 March 2024 PARATUS organised a stakeholder workshop in the Financial Government Building of Saint Vincent. The aim of the workshop was to present the PARATUS project and get to know the participants.

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Figure 3.1.5: Stakeholder workshop in Saint Vincent. Participants are from EURAC; GLOMOS, UNU-EHS; University of Twente; members of the units of Transport, Education, Health, GIS, Physical Planning of the Government of Saint Vincent and the Grenadines; SVG Red Cross; National Emergency Management Organisation (NEMO), BePrepared Int. Photo Credit: Cees van Westen (UT-ITC). (Note: Participants gave their consents for their photos to be used in the PARATUS project documents)

At the end of the workshop three options were presented for follow-up activities:

- One-hour interviews with individuals on learning more about their work and needs (we would like these with individual persons, as many as possible). We can make a schedule for that, where they can indicate when they are available, on Tuesday.
- Two-hour workshop on developing impact chains. Preferable on Wednesday morning.
- Three-hour workshop on the tools that have been developed and will be developed. On Wednesday afternoon or Thursday morning.

A total of 10 interviews were conducted with individual stakeholders to learn about their work and experience in disaster management in their country. Based on their experience and needs the PARATUS project aims to build solutions that could help with mitigating the impact of natural hazards and additional risks. A list of stakeholder organisations for Saint Vincent is shown in table 3.1.2.

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Table 3.1.2 Selected key stakeholders from Saint Vincent for interviews, workshops, and focus groups (February-April 2024)

	Name of the Stakeholder	(1) Practitioners (first and second responders)	(2) International networks	(3) Policy and decision making	(4) Civil Society	(5) Research and scientific	(6) Financial actors	(7) Critical infrastruct. operators	(8) Technology provider
1	GIS unit, Ministry of Transport , Works, Lands and Surveys, and Physical Planning								
2	SVG Red Cross								
3	Ministry of Education and National Reconciliation								
4	GIS expert from Ministry of Transport, Works, Lands and Surveys, and Physical Planning								
5	GIS expert, Physical planning, Ministry of Transport, Works, Lands and Surveys, and Physical Planning								
6	Ministry of Health, Wellness and the Environment								
7	Environmental Engineer, Ministry of Transport , Works, Lands and Surveys, and Physical Planning								
8	National Emergency Management Organization (NEMO)								
9	BRAGSA, Roads, Buildings & General Services Authority								
10	Ministry of Health, Welness and the Environment. Insect vector control unit								

Below and example is given of one of the stakeholder interviews with a representative of the Red Cross from Saint Vincent (Questions are indicated in bold).

1. ***Could you tell us about your own work and activities within the context of risk and risk management?***
   RC works closely with NEMO; in case of a disaster NEMO calls for a meeting of the response steering committee, RC has a disaster committee; all 26 groups of RC in SVG get activated; RC disaster response teams ("Community Disaster Response Teams CDRT") go out for damage and needs assessments, this data is then provided to NEMO; RC SVG has a warehouse for water, blankets, health kits, RC also educates people at community level; partners are CDEMA, USAID, IFRC; RC is the "force on the ground".
2. ***What are the combinations of hazards that you consider most significant for the island and for the region? (possible add-on question: how do you consider temporal component of these events (cascading / simultaneous)?***
   Volcano hazard erupts every 40 years; hurricanes, storms, flooding; heavy rains cause river to flood communities, storm surge, few earthquakes (less dangerous); there is also an underwater volcano (Kick'em-Jenny) just outside Grenada; this might cause a Tsunami, drought; two main seasons here in SVG, June – Dec is wet season; seasonal forecasts by National Met Office. Grenadines Islands do not have any rivers, these islands do NOT have desalination plans. No technical accidents. Food Security becomes a growing concern.

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3. ***Which hazardous impacts can cause** succeeding **hazards and / or impacts and are of relevance for the island or the region? Can you give any examples?***
   Strom surge, heavy rainfall, hurricane, droughts, earthquakes which are unpredictable, diseases are causing strong impacts such as influenza, Leptospirosis, Dengue, COVID, Sahara dust is increasingly causing respiratory symptoms leading to asthmatic, starting in Feb/March; Saragossa weeds that is penetrating beaches affecting tourism badly.
4. ***Were there unforeseen challenges or limitations affecting your risk-related work during the recent event in 2021.***
   No. Education level was good, Dr Robinson from UWI Seismic was here in SVG; only challenge: when exactly evacuating people; people would not accept a longer lead time, that means, government had to wait until the last minute; people don´t have trust in forecasts from Met Office.
5. ***What are long-term impacts of the 2021 events that still influence the island and / or the region?***
   Some people have lost their livelihoods, cattle, crops are gone, homes were destroyed, some people still in shelter, re-building comes in stages, especially elder people are still affected, some people did not move back into their former areas – this is also causing problems in the new area; funding a key problem in the reintegration.
6. ***What did you learn through the 2021 event and would you be better prepared for its management today?***
   Yes, we are better prepared now. I was formerly the leader of my local Red Cross teams in charge of evacuees; I feel better prepared now, storage of water during response was a problem, as well as with food, or blankets; **a better database is needed**; centralised system would be needed. Some people go to NEMO to get supplies and afterwards to the Red Cross. NEMO has own database, which is not integrate with other response organizations. Still, ways to distribute food and water fast need to be found.
7. ***Which information on past hazards do you use in your work? What type of hazard information is missing?***
   Some information is stored, but there is not a real database on past events.
8. ***Which information on the impact of past disaster events do you use in your work? What type of impact information is missing?***
   We have some information, but not compiled in a systematic database.
9. ***Do you consider vulnerability of physical elements (such as buildings, communication structure etc.) or people-related vulnerabilities in your work? If yes, which ones and which ones are missing?***
   People's vulnerabilities: poor relief: a lot of people are living on government subsidiaries, often under bad conditions, too many people living in the streets; reaching housing and lands capacities, hard to find a space for cemetery. There are some new care-takers for elder people, subsidiary payment is about 150 dollars every 2 weeks! Mental health problems are increasing; Infrastructure: I am on the committee that goes to see communities and buildings together with NEMO, ministry for housing etc, visit schools, churches, community centres, private houses, checking electricity, plumbing, many buildings are not build according to standards.
10. ***What is still needed to improve the overall risk management (prevention, preparedness, warning, response) to respond better to hazardous events and their combinations in the future?***
    Warnings are in place. Excellent job, dissemination is good via television, internet, radio, church bells, elderly people look at signs in nature (water levels, behaviour of animals), bull horns. How can we convince people to act earlier especially in evacuations? recovery went fast, no more signs of the 21 eruption, lot of solidarity between communities; how to change people's mindset for prevention?
11. ***Is there something else you would you like to share anything of relevance for risk management on the island or the region?***
    I wish we could better partner with donors to implement more good projects; this is our main mandate to help people, teach people to be more resilient; more independencies from government payments

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etc; better education and capacity building; I am an electrical engineer, I could teach some boys to prepare them better for their lives; help elderly, unemployed: People should be less dependent on outside donors, and focus more on resilient sustainable ideas.

12. ***Red Cross specific: Your involvement in Anticipatory Action or Forecast-based Financing?***
    Education, schools are opened, activation centre is right here at Red Cross Center in Kingstown. 3-4 cruise ships were available to evacuate people from the island, but nobody left for another island.
13. ***Which kind of Early Alert Protocols do you have here in SVG?***
    NEMO always takes the lead and triggers the response activities; Red Cross will go and get out people, take them to shelters and feed and support them.

On 6 March we organised a workshop on the development of impact chains, and on 7 March a workshop at the NEMO EOC to demonstrate several tools that have been (or are being) developed under the PARATUS project. The workshop was attended by people from NEMO, Red Cross, Health, Physical Planning, and Transport. We also requested the participants for their willingness to participate in one-to-one online feedback sessions with user-centred design experts.

National scale: Sint Maarten

As follow-up of the workshop in Sint Maarten which was reported in the D6.2 a meeting was organized on Sunday 3 March 2024 with Ms. Ashma Berkel of the NGO "Leaders for Change" and her colleague Mr. George Horsford. Ms Berkel was one of the participants in the 2023 stakeholder workshop. After a brief update of what was done after the 2023 workshop we discussed the ideas for follow-up activities. NLRC – 510Global working on Impact Based Forecasting, and KNMI on Climate Scenarios, downscaling and the Climate Dashboard.

With respect to vulnerable communities, Ms. Berkel informed about the project **SENA (Socio-Economic Needs Assessment)** that was conducted between 2019 and 2022 carried out by the National Recovery Program Bureau (NRPB) – in collaboration with the Ministry of Public Health, Social Development and Labor (VSA) and the Department of Statistics (STAT) of the Ministry of Tourism, Economic Affairs, Transport and Telecommunication (TEATT)[10]. The aim of SENA is to collect up-to-date and accurate data to develop policies that can better serve the Sint Maarten community. The SENA's results will be the foundation of data-driven policy development that caters to the country's current needs.

Duplication in *e.g.* surveying, should be avoided – as the so-called vulnerable people suffer from "stakeholder fatigue". Unfortunately, data sharing is an issue within the government, but also between government and NGO's (such as Leaders for Change). Ms. Berkel also warned about the development of unnecessary tools.

In 2023 there were trainings of **Community Emergency Response Teams (CERT)** funded through the EU-project 'Technical Assistance to Sint Maarten for Disaster Response and Preparedness'. It was done by a multi-disciplinary team from SOFRECO company and led by IRMA. As support to the Government of Sint Maarten's plan to enhance disaster preparedness and response. The target groups were volunteers from the Sint Maarten communities to support first responders (fire brigade, police, health) during disasters to increase community resilience. It's based on UK examples, but it has not yet been formally adopted in Sint Maarten.

On Monday 4 March a PARATUS info lunch was organized in Philipsburg. This info lunch was joined by members of General Health Care (AZG), Sint Maarten Government, Sint Eustatius Fire Department, Netherlands Red Cross, Regional First Aid and Pre-hospital Care Caribbean, University of Twente, and

[10] https://nrpbsxm.org/eistp-sena/

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Netherlands Red Cross/510Global (online). After a short debrief of what happened in PARATUS after the 2023 workshop, we discussed the current situation and who to invite for follow-up activities.

When it came to Impact Based Forecasting, it was mentioned that they have protocols in place already at the to take preparatory actions 96h, 72h and 48h before a hurricane is foreseen to make landfall. These include e.g. airlifting hospital patients and people requiring intensive care from the island of Statia to Sint Maarten – or other islands if deemed necessary. They rely on the weather forecast of the KNMI plus the added second opinion of the met station at Juliana Airport of Sint Maarten (SXM). This does not include anticipatory action such a strengthening buildings. It was also mentioned that most people on the islands actually prefer to receive their hurricane (and weather) forecasts from the Weatherman Plus channel on YouTube because it is easier to comprehend and less technical that the KNMI forecast[11].

For preparedness improvements at Statia, Andre Bennett is the person to contact. For Sint Maarten, it would be the fire department. One of the first things to investigate are topographic data: It is very hard to find addresses in Sint Maarten. Street names and house numbers are not indicated and therefore hard to find. This also hampers (volunteered) support, anticipatory and response actions. A good map would be very useful. A central geo-data base would also be vital, with quick data access and continuous updating.

Responsibilities regarding health issues are also scattered and sometimes unclear. For instance, the Red Cross is responsible for the health situation in shelters; but the diabetes foundation is responsible for diabetics.

Finally, we discussed the “other hazards”; hurricanes are a familiar hazard, including the associated strong winds, floods and to a lesser degree, landslides. But the preparedness to hazards such as volcanic eruptions, earthquakes, tsunamis needs to be improved. Most organizations wouldn’t know what to do.

On **Tuesday 6 March** a follow-up meeting was held with the fire department of Sint Maarten. Together with them we looked at the geo-data portal that provides the fire department with the spatial information they need for their operational activities (e.g. location of water points). It was acknowledged that further training and support would be necessary to improve the system. There is a geo-data portal, under ministry of VROMI[12] that drafted a spatial development strategy 2030 (August 2022).

3.1.2 Improved impact Chain for the 2021 eruption on Saint Vincent

Based on the discussion held in Saint Vincent several impact chains were developed. First an impact chain was developed for the 2021 eruption, as well as for the other historical events (1979, 1971-1972, 1902-1903, 1812). The impact chain for the 2021 eruption is presented here.

In 2021, Saint Vincent faced a compounding hazards event. Aside from COVID-19 which was still rampant, La Soufriere volcano erupted for the first time in the 20s century. This eruption was a unique one in La Soufriere history because it was started as an effusive eruption, then became an eruptive one in the last three months of the event. In addition, in July 2021, a hurricane hit Saint Vincent named Elsa. This not directly coincided with the eruption, but the impact of the eruption was multiplied by the impact of the hurricane.

Volcanic eruption consists of compounding hazards by nature, as well as hurricanes. As shown in the impact chain, in the 2021 eruption there are a number of volcanic hazards that are the main cause of impacts that affected Saint Vincent. For the hurricane, excessive rainfall and high wind resulted in some impacts to the island. Here we will discuss further the impacts for each hazard.

[11] https://www.youtube.com/channel/UCek5H-g5yR0NbI5EHShi9Ug
[12] ArcGIS online: https://gis-vromi-sxm.opendata.arcgis.com/search

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One of the most dangerous phenomena which caused the death of many people in the eruption of 1902 was the occurrence of Pyroclastic Density Currents (PDCs) which are fast-moving and dangerous avalanches of hot ash, gas, and debris.

It was investigated that the tephra fallout reached maximum deposit thickness of 27 cm in around the southeastern Summit Crater rim, and minimum of 4 cm in around the Dry Wallibou. valley. The total tephra fallout volume was estimated from isopach maps based on the field data drew and quantified by five experts.

Lahars is a term that describes flows which involve a mixture of loosely consolidated volcanic debris and water occurring on and around volcanoes. During the 2021 eruption, there are approximately 25 lahar events that occurred. These lahars occurred frequently especially after rainfall events. It is noted that 20 mm daily rainfall on a river catchment is sufficient to result in a lahar. Philips et al (2023) modeled rainfall-triggered lahars on Saint Vincent using simplified catchment hydrology approach with runoff ratios typical for the Caribbean[13]. This approach showed good agreement with the observations.

Hurricane Elsa passed across the Windward Islands and the southern Leeward Islands part of the Caribbean Islands, moving towards some states in the United States such as Florida, Georgia and the Carolinas, Mid-Atlantic and easter New England, and reached the Atlantic province of Canada as an extratropical cyclone, then was promptly absorbed by a larger system. The rainfall amounts were around 3-11 inches with the highest wind speed around 85 mph (140 km/h).

Over the Caribbean, including Saint Vincent, the rainfall amount is lower (at least 3-6 inches) than the average due to Elsa's fast forward motion[14]. However, the maximum sustained winds obtained were 75 mph (120 km/h) with the minimum central pressure was 995 mb. This means that Elsa, which was formed as tropical storm intensified into hurricane at this point. It can be seen from the surface analysis map from NOAA showing that in Saint Vincent area, Elsa transformed into hurricane[15].

In a similar manner impact chains were made for the last historical tropical storms and hurricanes. After obtaining impact chains for some samples of tropical storms / hurricanes that have happened in Saint Vincent, we then developed impact chains for each tropical storm and hurricane event in general. Since the difference between storm and hurricanes is the wind speed, there is not much difference in the impact chain other than the warnings. Although, the intensity and severity of the impact may be different. (Figures 3.1.6 and 3.1.7)

[13] https://www.lyellcollection.org/doi/full/10.1144/SP539-2022-313
[14] https://www.nhc.noaa.gov/data/tcr/AL052021_Elsa.pdf
[15] https://www.ccrif.org/sites/default/files/publications/eventreports/20210714_CCRIF_FinalEventBriefing_TC-Elsa_BRB-LCA-VCT-GRD_Final.pdf

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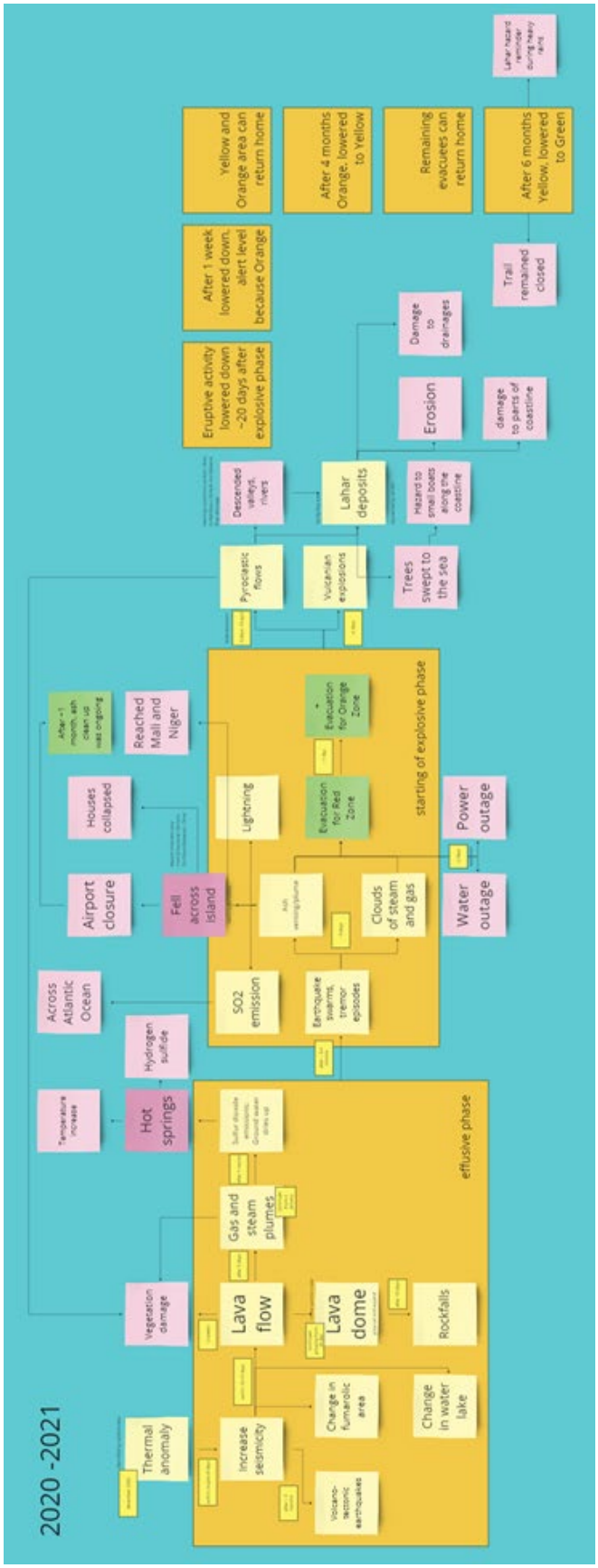

Figure 3.1.6: Impact chain for the eruption of 2021 that occurred during COVID

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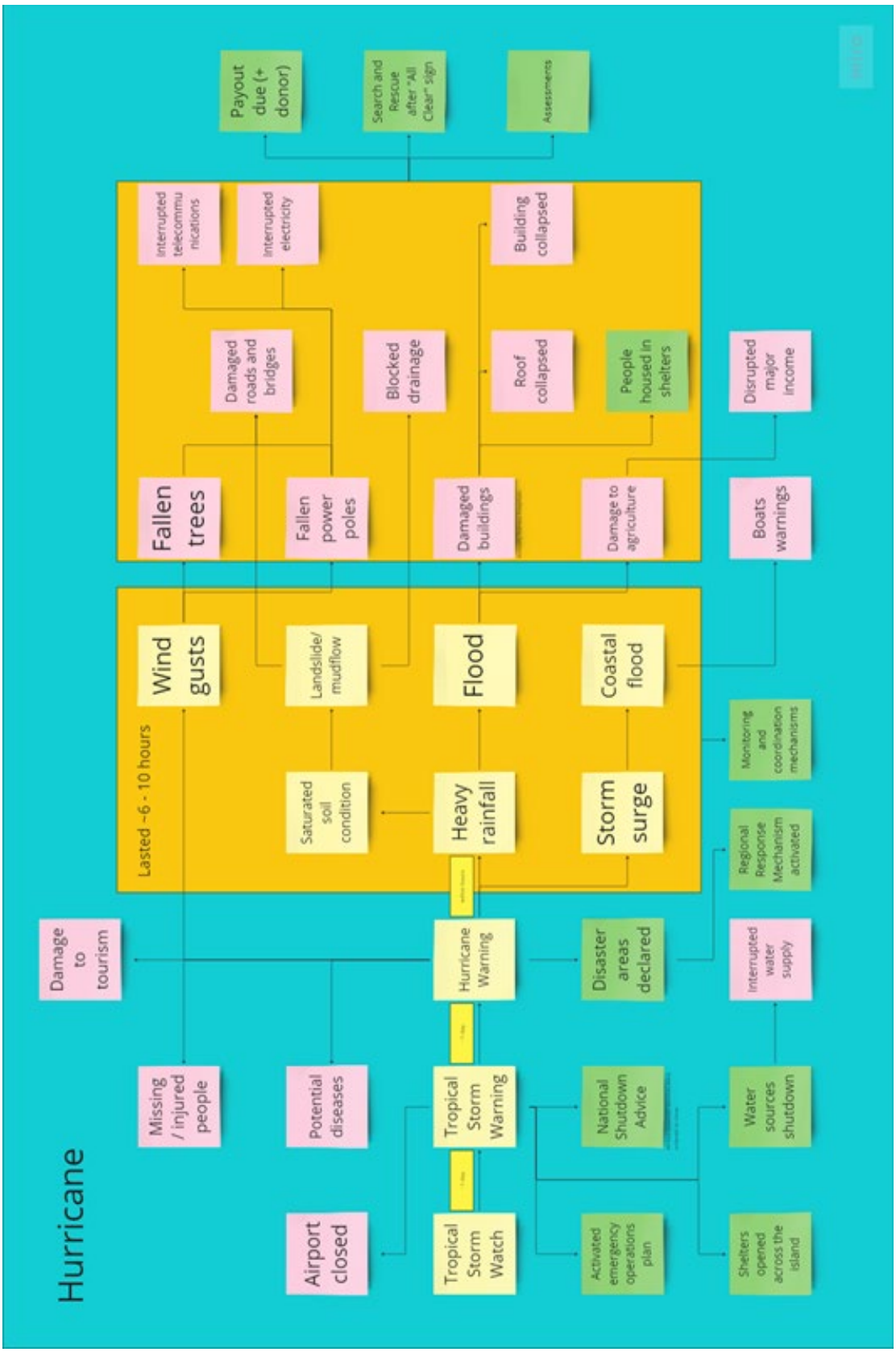

Figure 3.1.7: Generic impact chain for a Hurricane

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3.1.3 Follow-up planning

The follow-up planning consists of several phased. First it is important to collaborate at a regional level with CDEMA and other stakeholder to Initiate the activities of the Working Group for development of the framework document on MHRA, and to communicate on their website.

The following step is to organize a meeting with regional organisations such as CDEMA, 510Global, UNDRR , CIMH to discuss about Impact Based Forecasting in the Caribbean

In order to stimulate the exchange of experience on disaster risk reduction in SIDS from different regions, it is important to further work with CDEMA, GLOMOS, UNDRR and UN-ECA and request to organise a session in the 4th Conference on SIDS in Antigua in 2024.

At the national scale the following steps need to be taken in Saint Vincent:

- Inform the participants on the outcomes of the workshop;
- Inform the participants on the shared information on the Google Drive
- Organize a short course on PARATUS tools
- Organize one-to-one meetings with stakeholders on feedback on software development with 510Global and Youth Innovation Lab.

3.1.4 Conclusion

In the past half year, the activities within the PARATUS project in the Caribbean region have come in an accelerated phase. Good developments have been made both at the regional and the national scale. At the regional scale PARATUS links with ongoing activities that focus on the development of a framework for multi-hazard risk assessment in the Caribbean, and on the exploration of the development of an impact-based forecasting dashboard for the Caribbean. A working group has been formed for the former activity and regular meeting will be held to develop this framework document over the coming half year. The plans for Impact-Based forecasting require careful planning with UNDRR and other stakeholders in the region and ongoing activities such as Early Warning for All (EW4ALL).

At National level steps have been made towards closer stakeholder interaction and supporting stakeholders with tools, and even more required, data on multi-hazards and risk. The capacity of stakeholders in the Small Island Developing States is limited, and most would not develop their own data, but rather work with existing datasets. The positive experience that many stakeholders had with the products generated by UT and AIT in the World Bank funded CHARIM project[16] has proven to be very conductive to reestablishing contacts with stakeholders.

[16] https://www.cdema.org/virtuallibrary/index.php/charim-hbook/country-data/countrydocs-svg/maps-svg

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3.2 Brenner corridor, Alps, Austria

3.2.1 Update: What happened from April 2023 to March 2024

Following the first stakeholder workshop of the application case study Alps in March 2023, a first draft of the minutes was circulated between the participated stakeholders to ask for their feedback. Following this feedback, the minutes, including the slides of the different presentations have been send out to all relevant stakeholders which have been identified at the initial stakeholder mapping. The minutes have also been part of Deliverable 6.2. During the timeframe following the completion of Deliverable 6.2, additional stakeholder interviews and meetings were initiated. As highlighted in Deliverable 6.2, the integration of the Italian participants to the application case study alps was a challenge during the initial stakeholder workshop in March 2023, which was initially prioritized for enhanced cross-border co-development. Subsequently, a dedicated meeting, specifically designed for the needs of the Italian stakeholders took place in Bolzano in May 2023, given that one of the primary challenges and objectives for this application site involves the cross-border integration of stakeholder input.

Chapter 3.2.4 of Deliverable 6.2 outlined the subsequent steps, addressing data availability, usefulness, and identifying missing data. The second planned step involved stakeholder engagement, exemplified by the successful workshop in Bolzano. Although impact chains were further developed, feedback from stakeholders is still pending (details provided in individual interviews in the further sub-sections). In November 2023, another meeting or small workshop with representatives from the Disaster Warning Centre, road authorities, torrent and avalanche control, and the geological survey was organized. Stakeholders who were not present at the initial meeting were addressed, and initial impact chains were presented and discussed. Individual meetings and partly interviews were arranged and conducted with representatives from the Railway, Avalanche Warning Centre, Torrent and Avalanche Control, and a private engineering office specializing in natural hazards. These meetings aimed to specify current situations and discuss future challenges. Additional stakeholders who were absent in the described workshops and meetings were identified and contacted to participate in the upcoming planned workshop in November 2024.

Upon reflection, maintaining stakeholder involvement proved challenging after the conclusion of the first stakeholder workshop in March 2023. The second workshop in Bolzano did not result in further engagement from stakeholders on the Italian side, beyond their initial presentation of PARATUS and contributions during the workshop. We are further perusing to reach a better connection with the Italian stakeholders by constantly reaching out in various ways and inviting them to the workshops.

In the application case study alps, the next large stakeholder workshop is planned in November 2024. The case study lead team found it worthwhile to take time for individual stakeholder meetings and interviews to further discuss the impact chains and to increase the availability of data as data collection is challenging due to confidentiality.

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Table 3.2.1 Selected key stakeholders connected to the transport sector

	Target Stakeholder Group for application case study Alps								
Name of the Stakeholder	(1) Practitioners (first and second responders)	(2) International networks, organisations and mechanisms	(3) Policy and decision makers (incl. Authorities)	(4) Civil Society	(5) Research and scientific community	(6) Financial actors (e.g. insurance companies)	(7) Critical infrastructure operators	(8) Technology provider (industry, SME)	Comments
Tiroler Landeswarnzentral									And the italian counterpart
Tiroler Landsregierung									split it into relevant parts
Tiroler Landesforstdirektion									Administration of Land Tirol
Bezirks Hauptmannschaft Innsbruck									under the lead of Innsbruck admin
Tiroler Landesstrassendirektion									Association
Tiroler Verkehrsrechtsabteilung									umbrella of Landsregierung
Tiroler Wirtschaftkammer									
Tiroler Versicherung									
Transitforum Austria Tirol									
GeoSphere Austria					Geological survey				former ZAMG & GBA
Österreichisches Bundesheer									
Österreichische Polizei									
ÖBB									Austrian federal railways
Brenner Corridor Platform									
WLV			BMLF (ministry of interior)						Did not attend the workshop
ASFINAG									Highways (maintenance) A13 · italian STH Did not attend the workshop
Autostrada (Italy)									Did not attend the workshop
ÖAMTC	Second responder								Lobby on transportation Did not attend the workshop
WIFO									Research organisation on economics Did not attend the workshop
Key									
Stakeholder in green relate to the transportation sector									

3.2.2 Interview preparation and methodological approach

The primary objective concerning the interviews was to enhance stakeholder involvement on a more individualized level. While larger workshops facilitate general discussions and information dissemination, engaging with stakeholders individually offers a more nuanced comprehension of their perspectives and concerns. This personalized approach establishes a deeper connection, allowing stakeholders to express their unique insights, experiences, and needs openly and precisely.

Individual stakeholder engagement is crucial in the diverse landscape of the application case study alps, where various challenges converge. The natural complexity of the region is compounded by political and local conflicts, adding layers of intricacy to discussions within a broader framework. Media reports and stakeholder feedback underscore the challenges arising from limited space in valleys, serving diverse purposes such as transportation, air quality, forest protection, natural spaces, tourism, and communities, leading inevitably to

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conflicts. Addressing these conflicts requires a tailored approach that acknowledges the nuanced concerns of individual stakeholders.

Moreover, personal contact facilitates adaptable communication strategies tailored to the preferences and priorities of individual stakeholders. This flexibility ensures a dynamic and responsive dialogue, allowing the project team to adjust strategies based on real-time feedback and evolving stakeholder needs. In essence, prioritizing individual stakeholder engagement and cultivating personal connections not only enriches the quality of input but also establishes a more collaborative and mutually beneficial relationship between project teams and stakeholders, fostering harmony in the sustainable development of the application case study alps.

To enhance stakeholder involvement, a targeted approach was adopted by reaching out to key stakeholders for individual meetings. However, the response rate was limited, resulting in two completed interviews. Preceding these engagements, a set of questions was developed, aligning with the goal of employing an open semi-structured interview approach. In a semi-structured interview, the interviewer possesses a predetermined set of questions yet retains the flexibility to explore additional topics and delve deeper into responses in a conversational manner. This methodology facilitates a comprehensive exploration of participants' experiences, opinions, and perspectives, incorporating standardized elements.

Table 3.2.2 illustrates the questions including the topics hazards, impacts, anticipated future changes, and potential mitigation and adaptation measures. This compilation aims to provide a thorough overview applicable to interviews spanning various stakeholders, from first responders and insurance companies to civil society actors. The intention is to enable the generation of comparative interview results. The structured set of questions ensures a baseline structure while allowing the interviewer the flexibility to deviate from the script and explore specific topics based on the participants' responses. Most questions are intentionally open-ended, encouraging detailed and reflective responses rather than simple yes/no answers. This approach contributes to the richness of the data gathered during the interviews.

Table 3.2.2: Interview Questions

Hazards	Tell me about the key hazards you currently face? Are there any events that have remained in particular memorable? (high impact, long lasting, especially challenging) Are there any examples from small events cascading to larger effects? (e.g. to systemic risks) Tell me about past events significantly impacting the area? What was your strategy to handle these hazards? Are there any criteria or risk scenarios used for infrastructure building (e.g. tunnels, roads, rest places…)
	Are there cross-border cooperation's and strategies?
	Is there a change in hazard susceptibility? If yes, do you quantify this?
	How are hazards mapped? Which methods used? Have these methods changed?
	Who is working together? How are **responsibilities** shared, communicated and how is the interaction of practitioners with citizens? (risk pathway)
Impacts	Are you considering direct and indirect impacts to critical infrastructure?

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	What consequences local and cross-regional are evaluated?
	What are preventative or reactive measures? When and who decides these?
	Were measures of **improvement already implemented** with respect to past events? Relocation of activities and people / changed building codes / increased resilience?
Future changes	Which hazards do you think will be a major challenge in the future? Are there certain hotspot areas?
	Are future changes considered? Are there any plans for improvement scenarios?
	What are the changes that are considered? Do you work with scenarios? Are there adjustment strategies to future changes? If yes what yearly return periods are considered? Are there already visible short-term changes?
	What is **currently missing** and where do you see a need for changes?
	What suggestions do you have for improvements? (building codes etc.)
Mitigation & Adaptation	What should we consider when building e.g. a platform to assess multi-hazard risk?
	What timeframe / boundary would be relevant to consider?
	How best to include other practitioners?
	Would you be interested in contributing to the effort of this project and platform?
	What is still missing? What should we still consider so that the outcome will be applicable?
	Would flow charts or guidelines help to consider impacts of multiple hazards and concrete steps?

3.2.3. Key Results from interviews

To maintain anonymity, the interview results are presented below, featuring qualitative responses addressing four distinct question packages. The responses are organised based on common themes and topics rather than chronological order. During the meetings, a general semi-structured approach with open discussions was employed, contrasting a rigid questionnaire format. This methodology aids in identifying patterns and trends across interviews, facilitating the drawing of conclusions and making recommendations that transcend sectors while pinpointing shared discussions on hazards, impacts, and future developments.

The interviews, originally conducted in German, have been translated into English. In the final step, a summary of the main findings will be provided, offering clear recommendations based on key information provided by stakeholders. It is essential to note that the interviews reflect personal opinions and do not necessarily represent the overall opinions of the organization.

3.2.3.1 Interview Partners

- The **WLV (Wildbach- und Lawinenverbaung)** is the torrent and avalanche control for Austria, working on area-related basis in defined torrent catchment areas, responsible for safeguarding communities endangered by hazardous processes. The WLV distinguishes between active and

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passive protection against natural hazards. Active measures include the planning and implementation of typical torrent protection measures (against mudflows, bed-load eruptions), next to avalanche and rockfall protection projects as well as landslide remediation. Passive protection against natural hazards is primarily understood to mean hazard zone planning. Hazard zone plans are available throughout Austria in all municipalities with torrent catchment areas. In addition to planning hazard zones and measures and their implementation, the core competencies of the WLV are consulting and expert activities as well as the handling of subsidies.

- The **Avalanche Warning Service (Lawinenwarndienst) of the Province of Tyrol** is part of the Crisis and Hazard Management Department (Landeswarnzentrale), informing the public about the current snow and avalanche situation in the Tyrolean mountains since about 50 years. The avalanche warning service collects, evaluates and interprets a wide range of information on snow cover and weather. All information and interpretations ultimately flow into the central warning product of the avalanche warning service, the avalanche report.

3.2.3.2 Interview 1: Overview of the Interview WLV

In general, the PARATUS project received positive feedback, with the interview partner expressing the willingness to contribute data, particularly regarding the protection of buildings and the hazard zone plans by the WLV. Notably, there was a keen interest in utilizing tools such as fastflood.org, previously unfamiliar to the participant. However, there was a more cautious interest in Riskchanges.org.

During the interview, WLV's mapping and visualisation tools for hazard zones were presented. Consequently, responses to questions outlined in Table 3.2.2 were not provided in chronological order. Feedback on impact chains was offered, with an invitation to further refine these chains for more detailed comments. However, scepticism arose regarding the perceived usefulness of impact chains, and doubts were expressed about their efficacy in their daily business.

The WLV has a longstanding history of not only preparing active mitigation measures but also working preventatively for over 50 years. This involves identifying hazard zones and implementing mitigation measures to support and protect communities. However, responsibilities are decentralized, as the WLV does not oversee aspects like roads, which fall under the jurisdiction of road authorities. While future scenarios have been contemplated, they have not been implemented.

Two key requests were communicated to the PARATUS consortium: (1) to emphasize communication and (2) to examine changes in risk culture. An illustrative example was provided, highlighting that after implementing mitigation measures, such as a dam to protect against debris flows, less attention is paid to self-reliant protection measures, such as adjusting entrances or relocating essential rooms away from the mountain side. This challenge is particularly relevant for low-probability/high-impact events that surpass or evade retention structures.

Looking ahead, discussions centred around the expectation that most parameters for landslides, grounded in gravitational factors, will remain stable. Nevertheless, the anticipation is that changes in precipitation patterns may lead to more frequent and larger triggered events.

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3.2.3.3 Interview 2: Overview of the Interview Lawinenwarndienst

Given that this meeting marked the second encounter with the PARATUS project, there was no need for an extensive introduction to its goals. The atmosphere was notably pleasant, facilitated by close connections to the University of Vienna. Due to the specific background of the participants, the discussion primarily focused on avalanche processes, mitigation, and communication, leading to the oversight of a few questions.

A pivotal shift in perspective was acknowledged, particularly in the aftermath of the 1999 events in Galtür. Despite the abundance of information on avalanches today, the primary challenge lies in effectively structuring and processing this wealth of data. Tools introduced since 2011, incorporating input from ski tourers, contribute to this process. Platforms like Snaps.live enable the public to provide parameters for snow cover models. The principal risk factor remains rain on snow, coupled with a significant temperature difference between summer and winter, while wet snow poses a persistent challenge. Weak layers, increased gliding snow due to warmer conditions, and a moist snowpack contribute to the complexity of avalanche processes.

The potential use of scenarios to predict gliding snow avalanches was highlighted, despite the specificity of this task. Influencing the sliding process or creating scenarios for predicting release times presents challenges, given the absence of fracture mechanisms found in snow-cut avalanches. Concerns also arise regarding the mix of snow and debris, particularly in flat terrain, as observed frequently in Norway with slush avalanches. Changes in the snowpack itself are documented in data from avalanche report stations.

Scenarios prove valuable in predicting critical risks posed by short-term precipitation, with platforms like hydro online (wiski.tirol.gv.at) and land infobox.tirol.gv.at (snowplus_1.html) providing essential data. When addressing how the PARATUS consortium could contribute, the current main challenges identified were risk communication and data organization.

3.2.4 Follow up planning

Expanding stakeholder involvement entails conducting interviews with additional key stakeholders from the application case study alps. While individual interviews have been exclusively carried out within the northern region of the Tirolean side thus far, the aim is to extend this effort to the Italian side with the assistance of DeepBlue and EURAC.

To ensure a more structured approach and address the limitations experienced during the previous dynamic meeting, it is recommended to adopt a clearer pathway, adhering to the predefined questions, and minimizing open-ended discussions.

Incorporating the learning case study from Lower Austria was initially planned, with a scheduled meeting involving stakeholders from the area. However, this meeting was cancelled due to limited feedback and participation. Despite this development the UNIVIE team is heavily working on the finalization of the learning case studies “Landslide Observatories Lower Austria” as well as the “Vaia event”, which affected the Northeastern part of the Alps 2018. Future steps involve establishing and cultivating ongoing contact with the disaster warning centre of Tirol, which will be pursued in subsequent phases of the project.

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3.2.5 Conclusion

In summary, the stakeholder engagement process for the application case study Alps involved an initial workshop in March 2023 and subsequent activities such as additional smaller workshops and individual interviews. Challenges were faced in integrating Italian participants, leading to a dedicated meeting in Bolzano. Additional stakeholder interviews and meetings followed, with a focus on data availability and usefulness. The second large stakeholder workshop is planned for November 2024.

Individual stakeholder engagement was prioritized through interviews to enhance involvement on a personalized level. Challenges arising from the diverse landscape, political conflicts, and limited space in valleys were addressed through a tailored approach. The semi-structured interview method aimed to explore hazards, impacts, anticipated changes, and mitigation measures. Two interviews were conducted with a focus on the Tirolean side, with plans to extend to the Italian side.

3.3 Istanbul, Turkey

3.3.1 Update: What happened from April 2023 to March 2024

As indicated in the D6.2 (Chapter 3.3.3), the stakeholder workshop was postponed to June 1st, 2023 because of the Kahramanmaraş earthquakes which occurred in February 2023. It is worthy to summarise the aftermath of these earthquakes to better present the motivation and perspective of stakeholders during the activities which were held between April 2023 and April 2024.

Until 2023, the most devastating earthquake disasters in Türkiye were 1939 Erzincan earthquake with a Mw 7.8 and 1999 Kocaeli earthquake with a Mw 7.4. The death toll exceeded 30.000 in the Erzincan earthquake and 17.400 in the Kocaeli earthquake. There is limited data and reports on 1939 Erzincan because of another devastating earthquake in the province in 1992 with a Mw 6.8 which caused the loss of 653 lives and the destruction of more than 8.000 buildings, including city archives. Therefore, in the PARATUS learning case studies (seismic events), we decided to work on 1999 Kocaeli earthquake and 2011 Van earthquake with a Mw 7.2 as the most recent and devastating earthquakes. After the Kahramanmaraş earthquakes, due to the size, impact and comparable features with the 1999 Kocaeli earthquake, instead of 2011 Van earthquake, we have continued with the impact chain and forensic analysis of the Kahramanmaraş earthquakes.

On February 6, 2023, at 04:17 (local time), an earthquake occurred with a Mw 7.7 in Pazarcık/Kahramanmaraş which was followed by a Mw 6.8 aftershock 11 minutes later. About 9 hours afterward, another earthquake occurred with a Mw 7.6 in Elbistan/Kahramanmaraş. On February 20, 2023, two aftershocks with Mw 6.4 (at 20:04 local time) and Mw 5.8 (at 20:07 local time) occurred in Samandağ/Hatay (Figure 3.3.1). These seismic activities affected 11 provinces where around 16 million people live. According to the official statements dated back March 2023, death toll reached 50.783, number of injuries was over 100.000, around 2,7 million people lost their residents (AFAD, 2023). According to the preliminary official reports, in 11 provinces, over 35.000 buildings were collapsed, 179.786 buildings were heavily damaged and 17.491 buildings were labelled as to be demolished immediately (SPO, 2023).

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In the first hours after the earthquake, according to the Türkiye Disaster Response Plan, AFAD declared a Level-4 emergency which refers to the capacity of first and second group of supporting provinces, national capacity and international capacity. Because of the high level of destruction in 11 provinces in the region of, metropolitan municipalities were matched with most affected areas. The response capacity of Istanbul Metropolitan Municipality was diverted to Hatay province. Around 5.000 personnel of IMM were employed for search and rescue activities, evacuation by Osmangazi Ferry, supporting the fire extinguishing at the Iskenderun Port, health services, sanitary services, catering services, repair of water and natural gas infrastructure systems, installation of mobile services and cleaning services. In addition, 9.000 tents and 200 temporary shelters were installed in Hatay. IMM organised donations and with the contribution of district municipalities of Istanbul, around 700 lorries were dispatched to the earthquake affected region (Yavuz Dipşar, 2023; Milliyet, 2023). Meanwhile in Istanbul, the inhabitants who witnessed the devastation due to the Kahramanmaraş earthquakes, applied to IMM to have their buildings inspected. In a very short period, the number of requests exceeded 114.000.

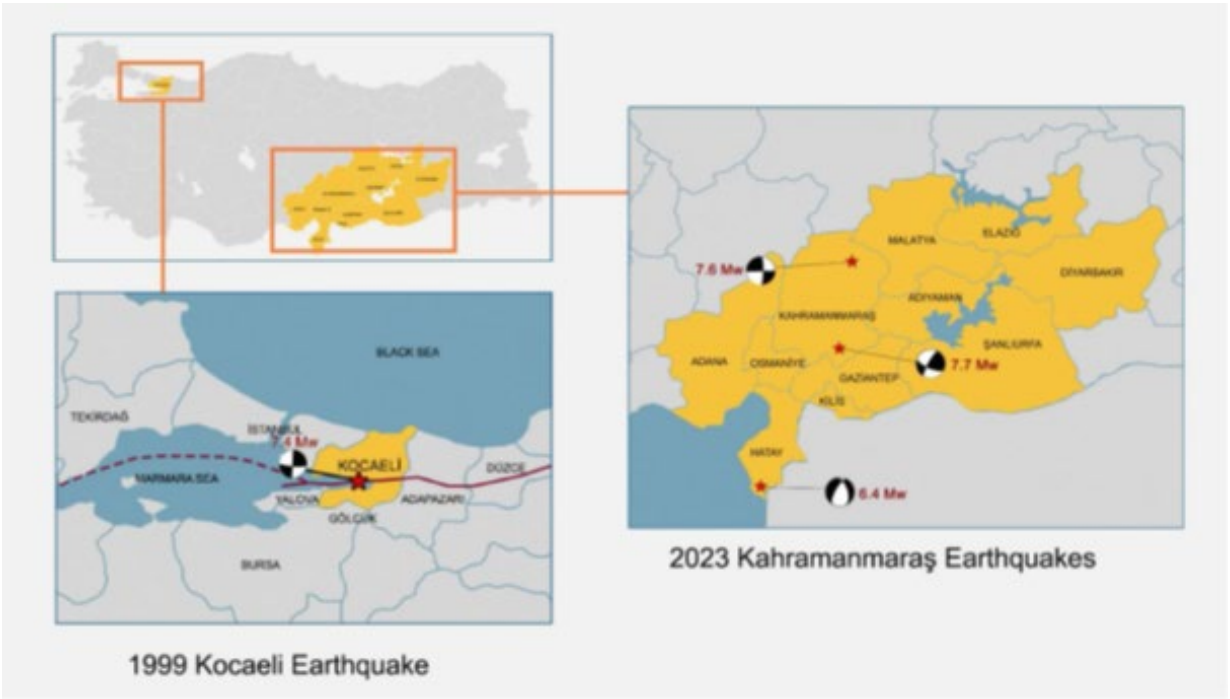

Figure 3.3.1. Geographical settings of 1999 Kocaeli Earthquake and 2023 Kahramanmaraş Earthquakes (Göksu et al., 2023)

The faculties and students of Istanbul Technical University, during the same period, focused on both field studies and desk studies to facilitate the response and recovery processes. In the days following the earthquakes, several teams of civil engineers visited the affected area for building inspection of public facilities and residential buildings. Meanwhile, students formed volunteer groups for search and rescue activities through relevant student clubs of the university. Later on, teams of geological and geomatics engineers conducted field surveys and worked on satellite images. Teams of environmental engineers

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concentrated on debris management and mitigation of environmental degradation. Members of the departments of urban planning and architecture had desk studies and meetings with governmental institutions to produce alternatives for temporary shelter and permanent housing in the affected areas.

About half a year after the earthquakes, the amplifications of the earthquake impacts have been more evident than before. Based on the lessons learned from these earthquakes, to enhance risk assessment and risk mitigation tools with new technologies from an innovative perspective Risk Istanbul (RiskIST) Living Lab. and Marmara Active Fault Hazard and Risk Research Centre were established under Istanbul technical University. Furthermore, during this period, new contacts with Istanbul-based NGO's, Istanbul Chamber of Commerce and Istanbul Chamber of Industry have increased the diversity of stakeholders for the workshop planned for June 2024.

Stakeholder activities

As presented in Del1.1 (chapter 4.1), 87 participants attended the stakeholder workshop on June 1st, 2023. About half of the participants were employees of the IMM and IMM subsidiaries. The other participants were from other universities, NGO's, telecommunication companies, chambers and district municipalities. At the beginning of the workshop, the participants were asked about their disaster experience and their role, to know them better. 58 out of 87 participants talked about their experience and disaster management cases they were responsible for. Most of them stated that they had been involved in various phases of management (mitigation, preparedness, response and rehabilitation). 39 out of 58 described their duty as both in the field and desk based which covers data production, policy development, communication, organization and management. Among the participants, 5 of them were involved in 1999 Kocaeli earthquake, 11 of them in 2023 Kahramanmaraş earthquakes and 15 of them were active in the field in both earthquakes.

Six focus group tables were formed in the workshop. During the first session, the participants were asked to evaluate the potential impact chains resulting from a significant earthquake occurring near to Istanbul. Each table was free to design their point of view according to the following questions:

- What are the natural hazards that an earthquake can trigger?
- What are the impacts of earthquake and triggered disasters?
- What are the elements, systems, sectors and functions that will be exposed to the effects of the disaster?
- Do they have effects on each other? If yes, what are they?
- What are the vulnerabilities of the elements, systems, sectors and functions that will be exposed to disaster?

In 90 minutes, each table developed a poster presenting their answers. The triggered natural hazards are cited such as tsunami, landslides and inundation. Secondary hazards are given as dam breaks, fires at industrial facilities, leakage of chemicals. The cascading effects were defined as impacts on critical services, lifelines and security. Discussion on security issues was crucial because in the first meeting which had been held on December of 2022, prior to Kahramanmaraş earthquakes, an officer from Istanbul Fire Brigade had a very strong emphasis on how security is vital aftermath of disasters. Beside the problems which might occur in the three main economic sectors, participants noted logistic issues in both response and rehabilitation

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phases. In terms of defining systemic risks and discussing their impacts, participants made important points in line with their past professional experiences and the experiences of the Kahramanmaraş earthquakes that occurred a few months prior to the meeting. Consequently, humanitarian issues, supply of basic needs of disaster victims, sheltering and communication were common keywords in each table. This session was successful by the means of hearing the experience of professionals within the comparison of the last earthquakes impacts to the previous disasters and their evaluation and discussion in dealing with such devastating events.

In the second half of the workshop, a scenario-based approach was conducted to reveal major impacts caused by an earthquake with a magnitude greater than Mw 7.0. In each scenario the size of the earthquakes were the same but temporal aspects differed from each other to delineate urban functioning and people's mobility. The focus and outcomes of each scenario spotlighted specific critical zones or sectors, providing valuable insights for further investigation in subsequent phases of the case study analysis. The diagrams generated during the stakeholder meeting have been refined and digitally rendered for enhanced visualization (Figure 3.3.2).

Figure 3.3.2. Scenario-based approach for Istanbul (see Del.1.1, Chapter 4)

After the evaluation of stakeholders' contributions in the workshop, a focus group meeting was organized with IMM Directorate of Earthquake and Ground Research on July 26th, 2023. The highlights of the scenario-based approach have been discussed and two-level research design has been agreed on. The first level would present urban growth dynamics and systemic risks at provincial scale. Accordingly, referring to the scenario-based approach, some specific areas which are likely critical in urban functioning during emergencies, would be analysed in detail. Meanwhile, in the frame of WP2 and WP4, data collection and risk evaluation processes have been started. The hazard data was obtained by the Directorate of Earthquake and Ground Research. After establishing contacts with IMM Directorate of Smart Cities, we have discussed the details of various indices which they had produced and shared in an open platform. The database represents land use, social

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and demographic variables, as well as indices on accessibility, liveability, security and diversity (Figure 3.3.3 and 3.3.4).

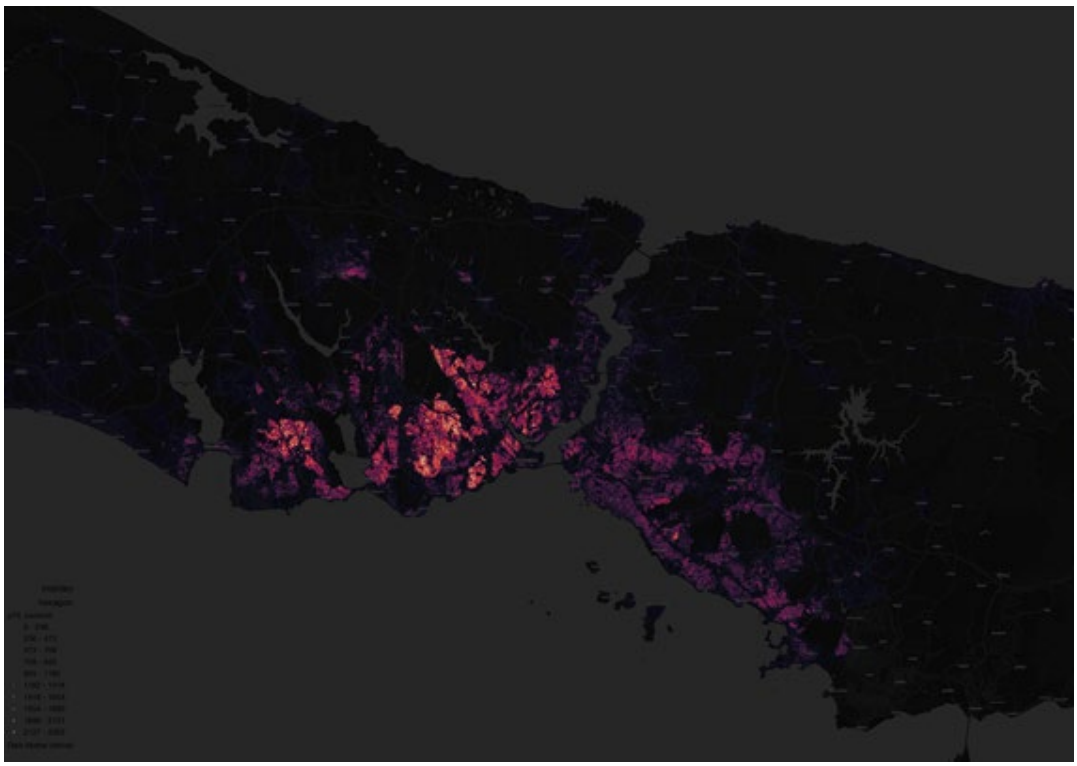

Figure 3.3.3. Population density

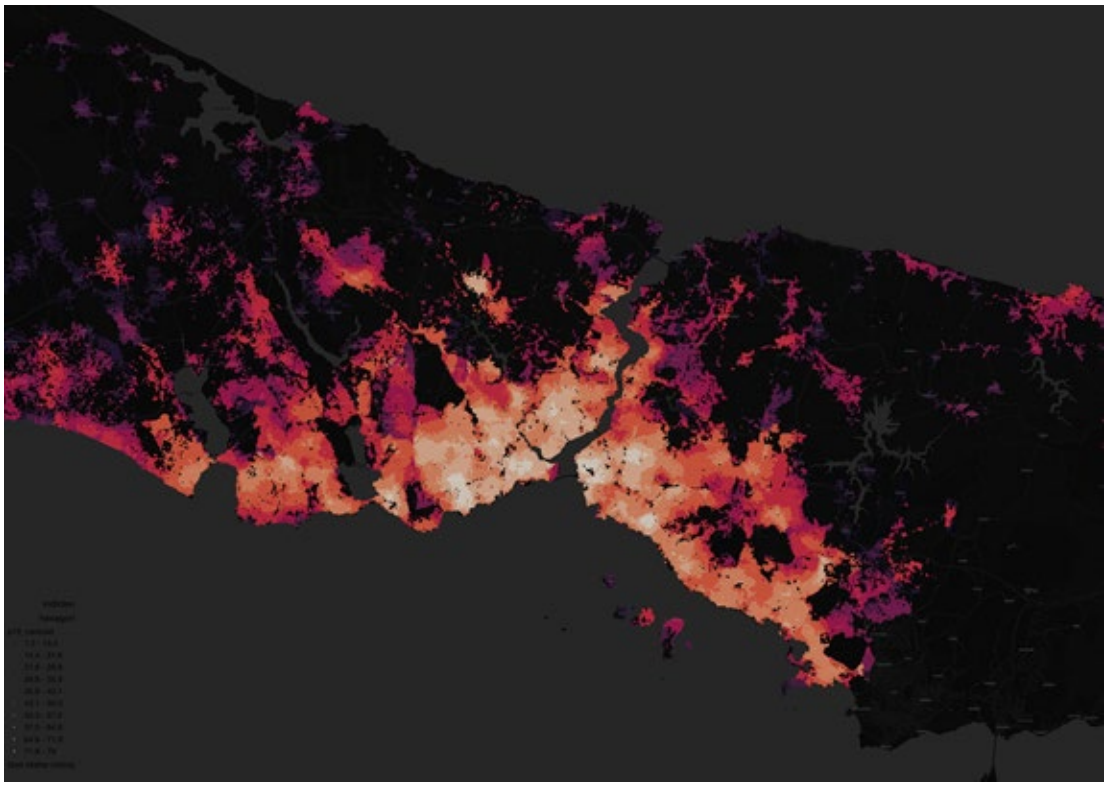

Figure 3.3.4. Quality of Life Index

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Following the successful focus group meeting with IMM Directorate of Earthquake and Ground Research, on January 11th 2024, the research team organized another meeting to discuss the potential risks and bottlenecks associated with industrial facilities during emergencies. The meeting was attended by representatives from various industrial sectors, including manufacturing, energy, and logistics. The main objectives of the meeting were to identify critical industrial facilities within the study area, assess the vulnerability of these facilities to various hazards, discuss potential cascading effects and systemic risks arising from industrial disruptions, and identify probable bottlenecks in the supply chain and emergency response.

During the meeting, participants shared their experiences and concerns regarding the resilience of industrial facilities during past disasters. They highlighted the need for comprehensive risk assessments and contingency plans tailored to the specific needs of each industrial sector. The research team presented the two-level research design agreed upon in the previous focus group meeting, emphasizing the importance of analysing critical areas in detail. Participants provided valuable insights into the interdependencies between industrial facilities and urban infrastructure, such as transportation networks, power grids, and water supply systems.

Several probable bottlenecks were identified, including limited redundancy in the supply chain, leading to potential shortages of raw materials and finished goods; inadequate backup power systems, which could result in prolonged downtime during power outages; insufficient storage capacity for hazardous materials, increasing the risk of secondary disasters; and limited access to industrial facilities due to damaged transportation infrastructure.

The focus group participants agreed to collaborate with the research team in providing relevant data and expertise to support the risk evaluation process. This includes sharing information on the location and characteristics of critical industrial facilities, as well as their vulnerability to various hazards (Figure 3.3.5). Moving forward, the research team will integrate the findings from the focus group meeting into the ongoing work packages (WP2 and WP4). This will involve incorporating industrial facility data into the risk evaluation process and developing targeted strategies to mitigate the identified bottlenecks and systemic risks. The insights gained from the focus group meeting will contribute to the development of a comprehensive scenario-based approach that considers the complex interactions between urban growth dynamics, industrial activities, and disaster risk management.

The follow-up meeting with the Chamber of Industry and Chamber of Commerce will focus on developing practical tools and collaborative initiatives to enhance natural hazard mitigation and resilience for businesses and the wider community. The meeting will begin with a recap of the previous focus group meetings, highlighting the key findings and outcomes, followed by a presentation of the identified bottlenecks and systemic risks from the industrial facilities focus group. The potential impacts of these issues on businesses and the economy will be discussed, emphasizing the need for proactive measures to mitigate these risks. The importance of cooperation between the Chamber of Industry, Chamber of Commerce, and other stakeholders will be emphasized, encouraging participants to identify shared goals and priorities and fostering a sense of collective responsibility in addressing natural hazard mitigation and resilience.

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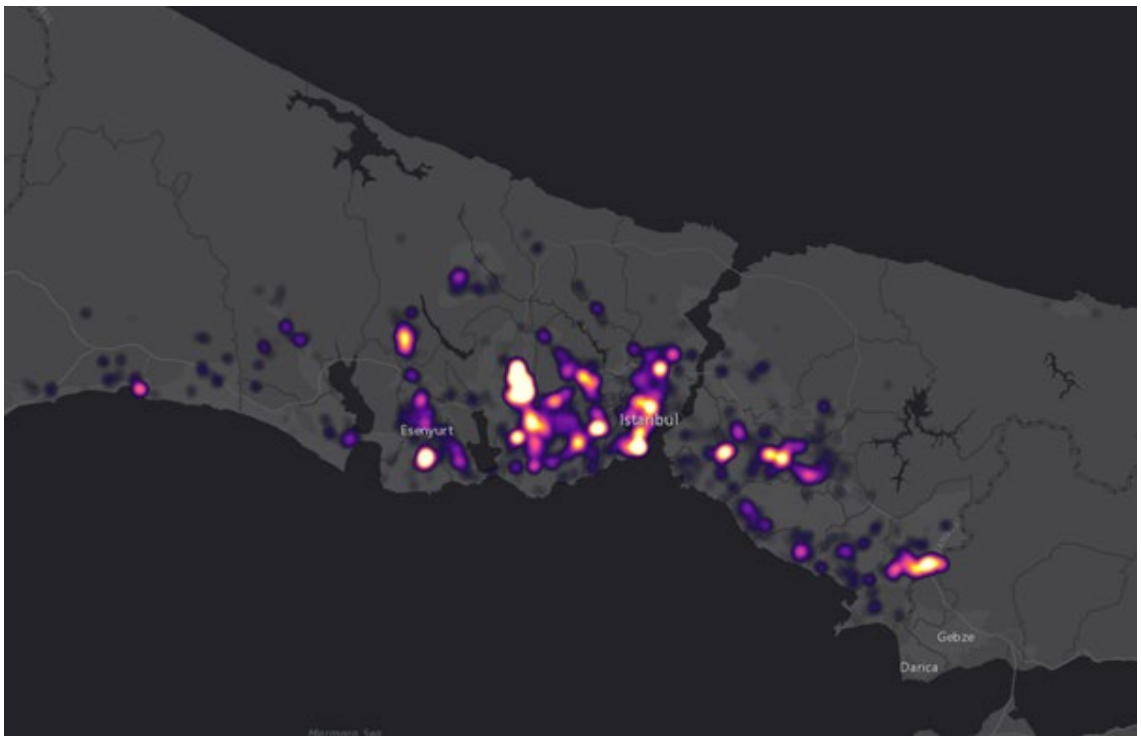

Figure 3.3.5. Concentration (heat map) of industrial facilities

Several mitigation and resilience tools will be proposed, including such as a Business Continuity Planning (BCP) Framework, Supply Chain Resilience Assessment, Infrastructure Resilience Checklist, and Hazard-Specific Mitigation Guidelines. The development of these tools will involve collaboration with experts to create industry-specific recommendations, as well as the identification of potential pilot projects and the sharing of case studies and best practices from other regions or industries. Capacity building and awareness will be prioritized through workshops, seminars, and collaboration with educational institutions to develop training programs and public awareness campaigns. The meeting will conclude with a clear outline of the next steps and action plan, assigning responsibilities and timelines for tool development and implementation, establishing working groups for specific initiatives, and agreeing on a schedule for future meetings and progress updates. Throughout the meeting, participants will have the opportunity to share their thoughts, concerns, and suggestions, ensuring that all stakeholders feel heard and engaged in the process. The meeting will conclude with a summary of key decisions and action items, reinforcing the commitment of all attendees to work together towards enhancing natural hazard mitigation and resilience for businesses and the wider community.

Improved Impact Chains

In the scope of WP1, it is aimed to utilize information from already existing learning case studies and combining this information with disaster history in application case studies. To achieve this objective, we employ impact chain and forensic analysis methodologies. Impact Chain provides a structured framework outlining the complex cause-and-effect relationships underlying risks within a specific context. It categorizes factors into hazard, vulnerability, or exposure components, emphasising community involvement and

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integration of local knowledge and past experiences. We have applied the impact chain approach to review the 1999 Kocaeli and 2023 Kahramanmaraş earthquakes, utilising a comprehensive dataset including the loss data, detailed information on damaged structures, scientific findings, and operational reports. This analysis is facilitated by a software platform for visualization and a structured database for data management (Figure 3.3.6 and 3.3.7). On the other hand, forensic analysis is structured around hazard and impact analysis, pre-disaster conditions, recovery efforts, and resilience building for future events. This approach provides qualitative and quantitative insights, linking past experiences with future risk mitigation strategies. Hazard and impact analysis explore the spatial and temporal dimensions of seismic events, assessing short-term and long-term impacts. Pre-disaster condition analysis investigates the underlying factors contributing to disasters, encompassing physical, environmental, socio-cultural, economic, and institutional dimensions. Recovery efforts examines the measures taken post-disaster to restore services and rebuild communities. Finally, building resilience focuses on the measures to reduce future risks and enhance preparedness across various dimensions. This forensic perspective offers valuable insights for informing future disaster risk reduction strategies and fostering resilient communities. Ongoing forensic analysis of the 2023 Kahramanmaraş earthquakes continues to contribute to this effort.

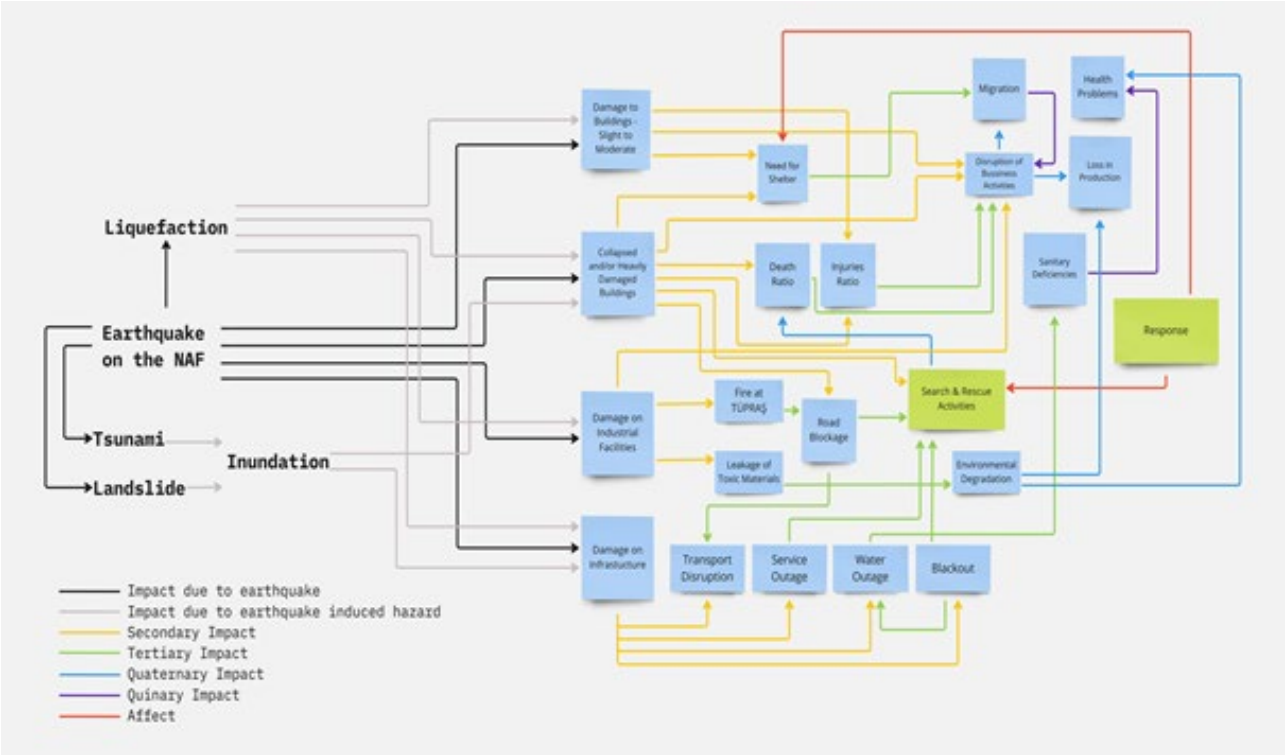

Figure 3.3.6. Impact Chain Analysis of 1999 Kocaeli Earthquake (Göksu et al., 2023)

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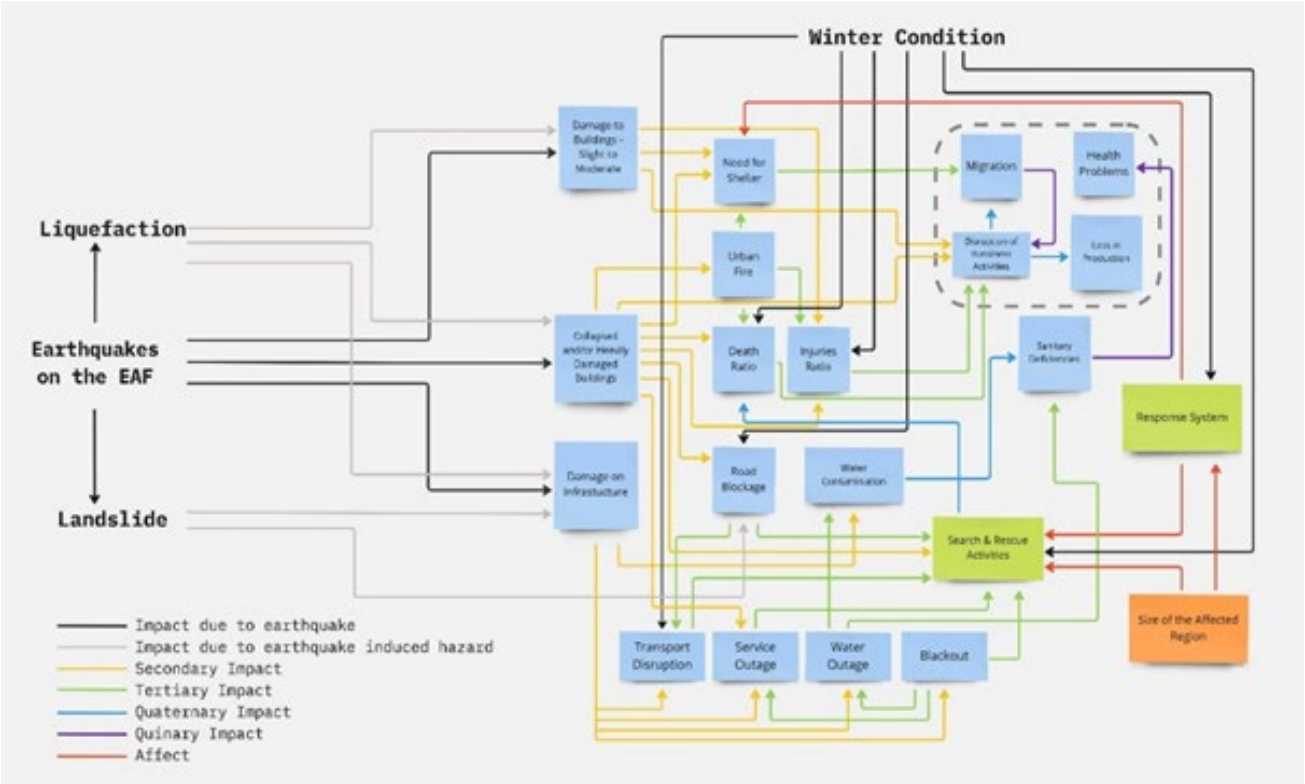

Figure 3.3.7. Impact Chain of 2023 Kahramanmaraş Earthquakes (Göksu et al., 2023)

Learning case study planning

The other two learning case studies which would be analyzed by ITU to produce impact chains are heatwaves and wildfires of July-August 2021. Turkey has been warming since the intensification of industrialization, with 2020 marking the third hottest year recorded since the 1970s (MGM, 2021). The annual average temperature measured for 2020, 13.5°C, was 1.4°C above the 1981-2010 normal (MGM, 2021). The 2020 heatwave saw numerous temperature records broken across the country, with some stations recording temperatures exceeding 40°C (Erlat et al., 2022). Statistical analysis indicates that the severity of the heatwave exceeded 100-year return periods at most stations (Erlat *et al.*, 2022). Moreover, the warming trend is attributed to adiabatic warming and drying influenced by subsidence and weak circulation patterns. Heatwaves are most common in July and August, affecting provinces like Antalya and Mugla with at least two heatwaves annually, lasting between 3-7 days. The heatwave experienced in July-August 2021 preceded the forest fires in southern Turkey. The frequency and severity of heatwaves globally pose significant risks to human health. Particularly vulnerable regions like the Mediterranean and coastal cities such as Istanbul face heightened challenges. The Mediterranean Region and Istanbul's complex climate, influenced by its geographical location and interactions with surrounding regions, present challenges such as temperature and precipitation changes, drought, sea level rise, urban heat island effect, and air quality issues (Yılmaz et al., 2023). Heatwave impact chain involves various interconnected consequences on human health, ecosystems, and economies (IMM, 2018):

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1. Health Impacts: Heatwaves pose the most significant direct health risk due to conditions such as sunburn, heat cramps, heat exhaustion, and heatstroke. They can lead to increased hospitalizations and mortality rates, especially among vulnerable groups like the elderly, children, and individuals with disabilities. Additionally, extreme weather events can cause injuries, exacerbate respiratory illnesses due to air pollution, and facilitate the spread of infectious diseases.
2. Air Quality: Heatwaves exacerbate air pollution, posing risks to individuals with respiratory conditions like asthma and chronic obstructive pulmonary disease (COPD). Increased temperatures and stagnant air circulation worsen air quality, potentially leading to respiratory issues and cardiovascular problems.
3. Ecosystem Services and Biodiversity: Heatwaves threaten ecosystems and biodiversity, affecting flora and fauna in sensitive areas like forests, wetlands, and coastal regions. Changes in temperature and precipitation patterns, coupled with urbanization pressures, increase the vulnerability of natural habitats and species.
4. Infrastructure and Energy Sector: Heatwaves strain energy infrastructure, leading to increased demand for cooling, potential power outages, and damage to transmission and distribution networks. Industries reliant on energy, such as manufacturing and food processing, face operational challenges and higher production costs during heatwaves.
5. Water Resources Management: Heatwaves exacerbate water scarcity issues, affecting reservoirs, groundwater levels, and water supply systems. Increased temperatures and reduced precipitation can lead to drought conditions, impacting agriculture, industry, and urban water supply.
6. Tourism Sector: Heatwaves disrupt outdoor tourism activities and may affect indoor attractions due to increased temperatures and extreme weather events like storms and floods. The tourism industry needs to adapt to climate change to minimize disruptions and ensure visitor safety.
7. Public Awareness and Communication: Effective communication strategies are crucial for raising awareness about heatwaves and encouraging adaptive behaviors. Timely and targeted messages, supported by media coverage during extreme weather events, can promote preparedness and resilience in communities.
8. Healthcare Infrastructure: Healthcare facilities need to enhance their capacity to handle increased patient loads during heatwaves, ensuring adequate staffing and resources for home-based care services. Planning for potential health impacts and implementing preventive measures are essential for minimizing adverse outcomes.

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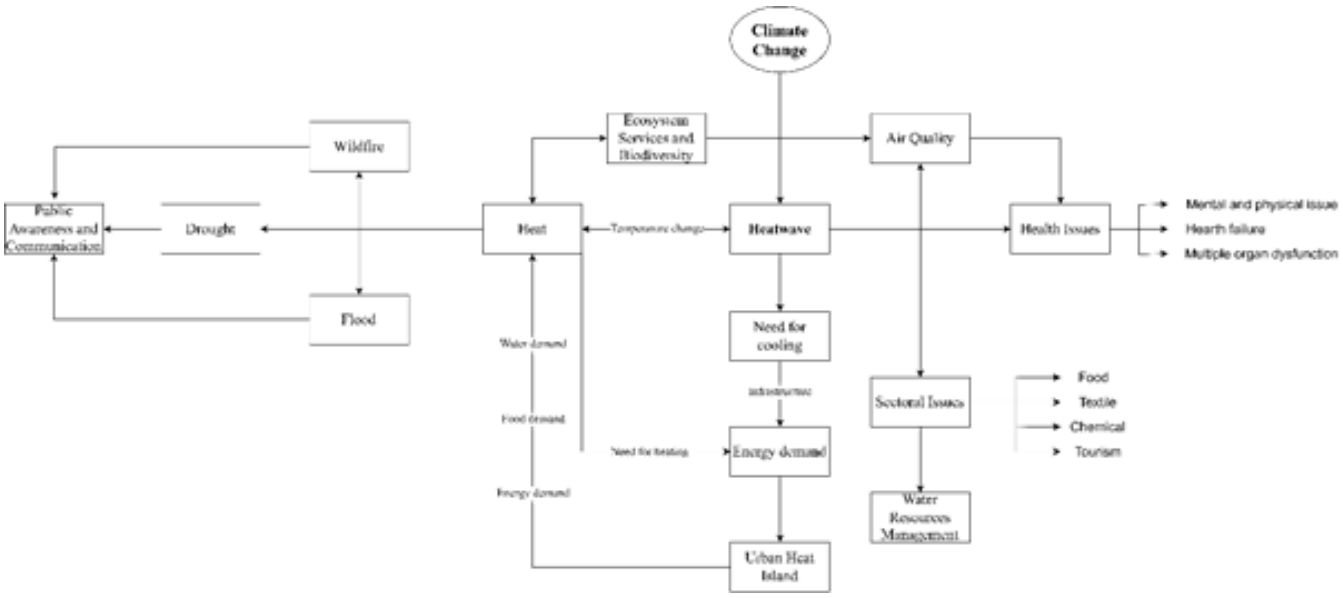

Figure 3.3.8. Draft impact chain diagram for heat wave.

In the summer of 2021, especially in July and August, Turkey experienced the worst wildfire events in its history. These remarkable events started in Yenikoy neighbourhood of Manavgat district in Antalya on the 28th July, 2021 and accumulated to a total of 299 wildfires spreading in 54 provinces in Turkey, before being finally extinguished on the 12th of August, 2021 in the Koycegiz district in Mugla (Turkish red Crescent, 2021). These wildfires lasted for 17 days and have been considered to be one of the events with longest time taken to be controlled.

Based on literature searches, no evidence of *immediate* secondary hazards triggered or amplified by the July-August 2021 wildfires were found in Turkey. However, a study conducted by Bayazit & Koc (2022) which aimed to determine the impact of wildfires on floods and soil erosion in Marmaris district (one of the heavily affected areas by the wildfires) revealed a relationship between the wildfires and floods that occurred on the 04th to 05th December of the same year. According to Ciurean *et al.*(2018), the occurrence of one hazard has potential to increase the likelihood or magnitude of subsequent hazards; due to changes in the environmental conditions that make the area susceptible to secondary hazards. Wildfire events have been reported to result in land-cover changes such as resulting in bare soils which made areas prone to soil erosion and floods. Based on the findings of Bayazit & Koc (2022), the intensity of the December 2021 floods increased by 12% in Marmaris due to the changed terrain pattern that increased the flow velocity as it enabled the falling precipitation to flow immediately, with little ground seepage.

These wildfires led to a lot of damages and losses in the regions affected. According to the Situation report by Support for Life (2021), by the 1st of August 2021, 7 people lost their lives, which rose to 9 by the time the fire was completely controlled on the 12th of August 2021. Furthermore, almost 170 thousand hectares of forest area and thousands of animals died during this catastrophic event. For instance, AFAD report dated 30th July, 2021 detailed 320 cattle, 3000 small cattle, 22 banana greenhouses, 15 vegetable greenhouses, 360 bee hives, and 1.500 hectares of agricultural areas were damaged in just Manavgat district in 3 days of the fire outbreak. Additionally, the fire also led to damages in buildings and other household items, as some households completely lost their belongings during this time. A study conducted by Eke et al. (2021) found

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that the 2021 wildfires led into decreased air quality both during and post-fire periods, due to the concentration of smoke which resulted into air pollution.

Authorities evacuated neighbourhoods, by land and sea, in affected regions and those near the regions in prone to fires. For instance, 36,000 people were evacuated to safety in Mugla province. Navy vessels were deployed to help ferry away residents from the affected areas to the designated evacuation sites. The fires were intervened with 15 fire extinguishing planes, 62 helicopters, 9 unmanned aerial vehicles, 1 unmanned helicopter, 850 water tankers and water tankers, 450 work machines and 5250 personnel; in which various countries provided personnel and support to tame the fire effectively. Additionally, to prevent fires from heavily affecting the Kemerkoy power plant, precautionary measures were taken before the flames reached the plant; in which fire fighters worked for two days; in which some of the measures taken were: emptying the plant's hydrogen tanks, evacuating workers and removing flammable and explosive substances away from the power-plant.

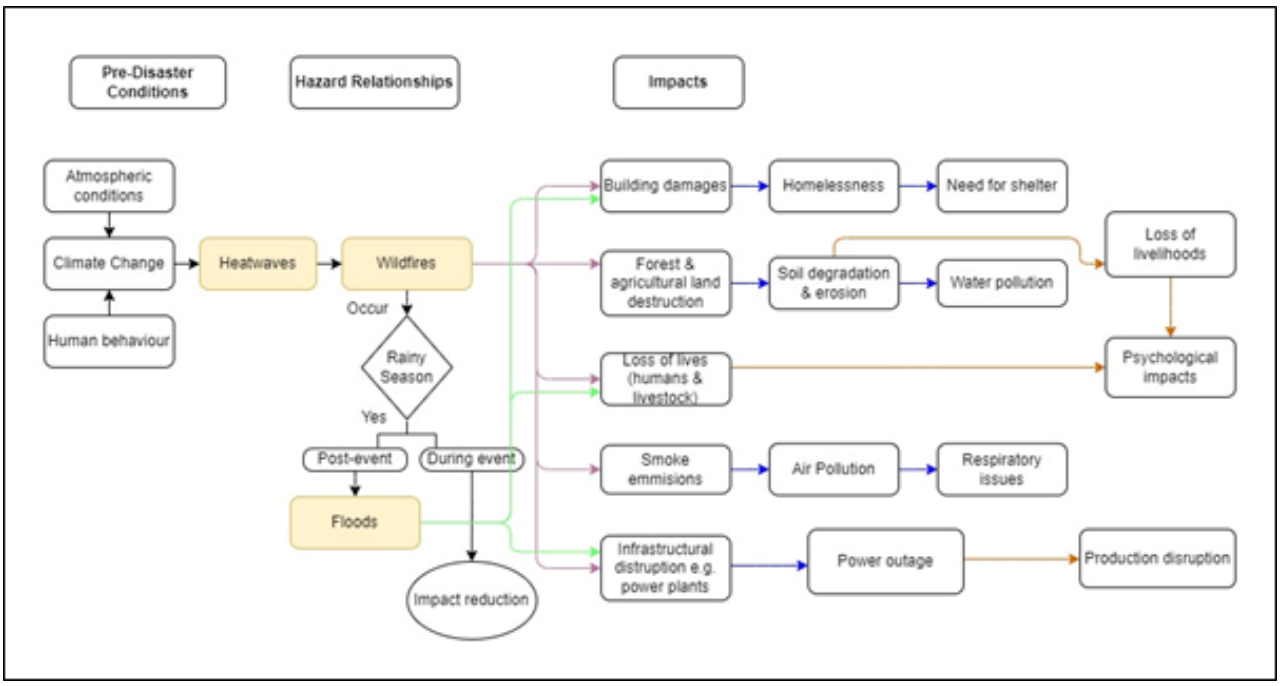

Figure 3.3.9. Draft impact chain diagram for wildfire

3.3.2 Follow up planning

One notable achievement in the Istanbul case study involves the delineation of target stakeholder groups. Given Istanbul's status as a megacity, characterized by its size and diversity, managing the multitude of stakeholders presents a significant challenge. Therefore, a categorization process was undertaken to organize and manage the diverse array of stakeholders effectively (Table 3.3.1). Each sub-group will act as a focus group for future meetings, facilitating sector-based discussions and evaluations tailored to their specific areas of expertise and interest. In the upcoming focus group meetings, a semi-structured questionnaire will be applied to analyze sectoral dependencies, bottlenecks, systemic risks and coping capacities of stakeholders. The outcomes are expected to contribute current and future risk scenarios for Istanbul.

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A stakeholder workshop is planned for September-October 2024. The first part of this workshop will be dedicated to the dissemination of improved impact chains and forensic analysis of learning case studies, the evaluation of scenario-based approach and outcomes of focus group meetings. It is planned to use serious games in the workshop.

Table 3.3.1. Delineation of target stakeholder groups for Istanbul

		Target Stakeholder Group for application case study Istanbul							
	Name of the Stakeholder	(1) Practitioners (first and second responders)	(2) International networks, organisations and mechanisms	(3) Policy and decision makers (incl. Authorities)	(4) Civil Society	(5) Research and scientific community	(6) Financial actors (e.g. insurance companies)	(7) Critical infrastructure operators	(8) Technology provider (Industry, SME)
1	AFAD Istanbul (did not attend the workshop)	High priority. Needs to be contacted in 01/2024		High priority Not possible to have them at the same time as green stakeholder					
2	Police department	High priority. Did not attend the workshop.							
3	Ministry of environment, urbanism and climate change			High priority. Did not attend the workshop.					
4	Ministry of internal affairs			High priority. Did not attend the workshop.					
5	Ministry of transportation and infrastructure			High priority. Did not attend the workshop.					
7	District municipality (core municipality included)			Produces urban development plans.					
6	Istanbul Metropolitan Municipality (huge number of participants)			Emergency organisation. Conflicts with AFAD Istanbul					
8	Municipality Firefighters	High priority							
9	Disater Management Unit Risk assesment and urban regeneration Municipality					Work on earthquake scenarios. Produce risk maps.			
10	Bezmialem Vakif University	Hospital connected. Med Faculty.				Specialises on health			
11	Red crescent								
12	Chamber of engineers								
13	Chamber of planners								
14	Chamber of industry and trade						Needs to be contacted in 01/2024		
15	Turkcell (telecommunication company)								
16	Kutman and partners		International project advisors						
17	Journalists								
18	Military								
19	Association of emergency doctors								

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3.3.3. Conclusion

In the PARATUS Project, Istanbul represents a case for megacities, as well as metropolitan areas, which are facing to natural and human made threats. There are more than 40 megacities in the world, according to the 2023 census. Many of them are either earthquake or flood (extreme weather condition) prone cities. Beside the natural threats, population growth rates, urban expansion speed, composition and integration of new migrants (native and foreign) are considered as emerging risks especially for the cities in developing countries. Furthermore, income and welfare gap between wealthier and disadvantaged population is more visible in such big agglomerations. This gap reflects on quality of life and access to public services. Consequently, disadvantaged population becomes more vulnerable once considered natural and technological hazards.

Most of the megacities are primate cities of their country. Primate cities pioneer country's economy on the one hand, and on the other hand they behave as global representatives within their role in international urban networks. From the perspective of their primacy in their country, we have witnessed that the impacts of certain shocks with which they had been faced, propagated through diverse channels to other cities. Such systemic aspects of adverse events enlarge the field of response and rehabilitation in disaster's aftermath as witnessed in our learning case studies 1999 Kocaeli earthquake and 2023 Kahramanmaraş earthquakes.

To fill the gaps which are briefly described above, in the case study of Istanbul, we focus on urban dynamics (demography, social, economy, built-up environment, etc.) to reveal systemic vulnerabilities. The development of impact chain analysis of learning case studies and involvement of stakeholders to produce probable impacts for an earthquake which would hit Istanbul, have brought further insights to comprehend systemic risks and to define future scenarios.

Based on the findings of impact chain analysis of learning case studies and discussions on scenario-based approach for Istanbul, we plan to evaluate systemic risks at the provincial scale to better understand the progression of systemic vulnerability of the city. This approach would enable us to reveal the interconnectedness of megacity's dynamics. Subsequently, we will narrow our focus to specific sites identified in alignment with the scope of other case studies and determined during the stakeholder workshop. Transitioning between these scales necessitates diverse resolutions of databases encompassing physical, social, economic, and environmental parameters. By establishing connections among relevant indicators across different scales, we aim to identify problem areas and root causes of systemic risks prevalent in Istanbul.

The database for Istanbul has been acquired to assess the current situation. In light of development trends, future scenarios will be formulated under WP2 in the upcoming phase. Additionally, leveraging the impact chain analysis from learning case studies, forensic analysis will be employed. Focus group meetings and stakeholder workshops are scheduled for 2024.

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3.4 Bucharest, Romania

3.4.1 Update: Lessons learned (April 2023 - March 2024)

Following the first stakeholder workshop of the Application Case Study Bucharest in March 2023, several short meetings with the partnership representatives at the Department for Emergency Situations (DSU) were held to weigh the pros and cons of the 2023 experience, the quantity and quality of the results obtained, and to decide on the best methods to proceed with in order to obtain relevant information. The first stakeholders' workshop in Bucharest aimed to bring together practitioners involved in prevention, response, and recovery from major disaster events, with the overarching goals of raising awareness regarding the consequences and implications of a major earthquake striking Bucharest, finding a common language, and developing possible impact chains to feed the PARATUS platform. Upon reflecting on the March 2023 workshop, the shortcomings of the focus groups involving practitioners with heterogeneous groups working on a common problem were quickly identified. In the absence of a shared background, a longer timespan was needed to establish mutual understanding and form common ground. As a consequence, we could not obtain all the targeted information in the mixed focus group sessions during the March 2023 workshop and decided that workshops are best implement in the last stage of the project to disseminate the outcomes, organise pieces of training on the developed tools, and to test if they meet expectations.

The involvement of the General Inspectorate for Emergency Situations (IGSU) was greatly appreciated in granting support in performing qualitative and quantitative research that involved the participation of the personnel responsible for lifesaving and damage reduction during disasters. The most important source of information in 2023 was the focus group hierarchical approach applied with **first responders** (paramedics and firefighters) and the **Unit Commanders**, which brought valuable insights regarding the needs and vulnerabilities in the emergency response system. This bottom-up approach targeted the end members from the **leadership level of DSU and IGSU**, where we interviewed the Head of the National Operation Centre/the Integrated Operational Planning Unit, the Head Inspector of ISU-BIF (Bucharest-Ilfov region), and the DSU Head of Integrated Operational Planning Service at the headquarter of the General Inspectorate for Emergency Situations. At the first and second levels, discussions targeted specific vulnerabilities and needs, and at the leader level, discussions touched upon Impact Chains of recent disasters, expectations, and tools to be made available by the PARATUS Platform.

As the threat of earthquake risks in Bucharest becomes increasingly apparent in the near future (Bala et al., 2023), it is important to understand how adaptive behavioural responses are occurring in relation to risk perception at the city level (Armaș and Avram, 2008, Armaș et al., 2017, Ionescu et al., 2021). Our approach was all the more important because, without exception, at both operational and scientific levels, the major concern resulting from focus groups, workshops, and interviews was the behavioural response of the population in case of a disaster. To achieve this aim, a quantitative survey at the population level was conducted in the fall of 2023 on 500 subjects to test risk perception and disaster risk behaviour against a possible earthquake event in Bucharest. Survey questions were grounded in established socio-psychological theories of behaviour, examining how the inhabitants of Bucharest perceive and adapt to earthquake risk in the endeavour to support policymaking, risk communication strategies, and adaptation efforts in disaster risk

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reduction. Risk perception was emphasized as a significant predictor of the three constructs of the Theory of Planned Behavior (Ajzen, 1985) (correlated with attitude, subjective norm, and perceived behaviour control), and risk perception and intention of preparedness came out as predictors of disaster preparedness behaviour.

Based on the experience gained from these first engagements with stakeholders, for 2024, we decided to work in small groups on specific parts of the Impact Chains with key representatives from the Emergency Department and the Inspectorate for Emergency Situations, as well as with experts in the fields of legislation, finance, and academia - seismology and structural engineers specialised in earthquake hazards (Table 1). These new engagements will facilitate a better understanding of the relationships and dependencies identified in the Impact Chains, as well as the problems related to legislative gaps.

One-to-one stakeholder meetings, a hybrid workshop organised on the 6th of February 2024, and interviews were arranged and conducted in February-April 2024 (Table 3.4.1) with representatives from the National Institute for Earth Physics (INFP), Technical University of Bucharest (UTCB), Romanian Association of Structural Design Engineers (AICPS), Ministry of Internal Affairs - Department of Emergency Situations (DSU), General Inspectorate for Emergency Situations (IGSU), Inspectorate for Emergency Situations Bucharest-Ilfov (ISUBIF), Municipality of Bucharest, aiming to refine the Impact Chains. These meetings started by explaining the assessed hazard-impact-vulnerability nexus captured in the Impact Chains, the links established between these components, and the end goal of Impact Chains in the analytical framework of PARATUS. The next phase focused on the pinpointing of vulnerabilities and threats associated with the current situation and on discussing possible adaptation options and future challenges. Additional stakeholders who were absent in the described workshops and meetings were identified and contacted to participate in the upcoming planned workshop in October 2024 to present our results and receive their feedback.

Table 3.4.1 Selected key stakeholders for interviews, workshops, and focus groups (February-April 2024)

	Name of the Stakeholder	(1) Practitioners (first and second responders)	(2) International networks, organisations and mechanisms	(3) Policy and decision makers (incl. Authorities)	(4) Civil Society *(professions that perform duties to the benefit of the public)*	(5) Research and scientific com	(6) Financial actors *(e.g. insurance companies)*	(7) Critical infrastruct. operators	(8) Technology provider (Industry, SME)
1	DSU								
2	IGSU and ISUBIF								
3	Municipal Administration in charge of retrofitting buildings with seismic risk, General Council of Bucharest Municipality								

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7	Romanian Association of Structural Design Engineers								
6	Association for Intercomunitary Development of the Bucharest Metropolitan Area								
8	Former ER Director at the Central Military Hospital in Bucharest								
9	Instructors of intervention teams								
10	Full lawyers, providing consultancy and representation in all the areas of law, including competences of interpretation and application of the national legal framework								
14	National Institute for Earth Physics - Engineering Seismology department								
15	National Institute for Earth Physics - Applied Geophysics department								
16	Technical University Bucharest								
17	University of Bucharest								
18	Insurance companies (PAID) (to be contacted)								
19	Ministry of Transport (to be contacted)								
20	Ministry of Development, Public Works and Administration (to be contacted)								
21	National Institute for Research and Development in Constructions, Urban Planning and Sustainable Spatial Development URBAN-INCERC								
22	Global Earthquake Model (to be contacted)								
23	Geological prospection companies (to be contacted)								

3.4.2 Methodological approach

To conduct the one-to-one interviews and focus groups (Figure 1), multiple sets of dedicated guidelines (more or less different in question format and requests) were created for all the selected subject backgrounds and expertise, targeting a nuanced comprehension of their professional input. Specific interview guidelines were developed for administration employees, first responders, experts from academia with seismic hazard assessment backgrounds, law experts, experts in emergency medicine, and insurance companies.

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All guidelines put the expert in a disaster scenario of an earthquake exceeding in magnitude the one in 1977, resulting in the collapse of numerous buildings and many people trapped under debris (Figure 3.4.2). Blocked roads determine ineffective intervention, insufficient temporary emergency shelters (with basic amenities), and the reliance on many non-operational services. Each expert was asked to identify the dangers associated with such a destructive seismic event in Bucharest, the primary vulnerabilities from the point of view of their expertise, and potential mitigation avenues for these vulnerabilities. Next, subjects were asked to identify up to five dangers derived from those vulnerabilities and propose optimal mitigation measures to address the respective risks. The last request was to pinpoint the areas most exposed and vulnerable to the mentioned dangers. First responders were also asked about their tools and those they needed to address the identified threats.

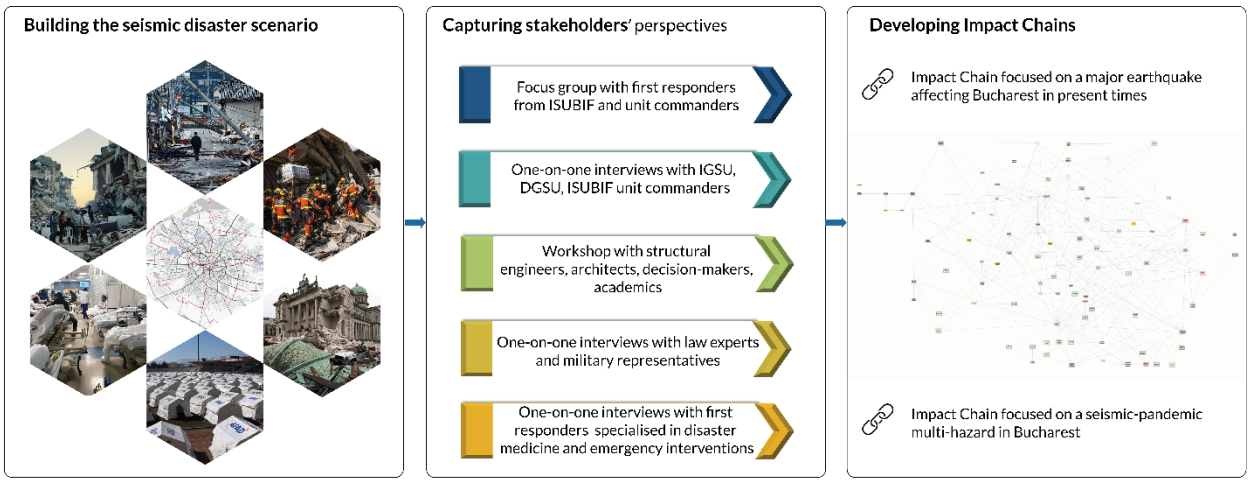

Figure 3.4.2 Methodological workflow specific to Bucharest Case Study

Law experts were asked to identify up to 5 significant deficiencies in the normative acts regulating seismic risk reduction in 2000-present and outline the potential vulnerabilities resulting from these shortcomings. They had to point out the main normative acts from which these deficiencies resulted and were asked what could be done to remove these deficiencies from the normative acts. Next, a discussion was conducted on the progression of legal regulations concerning seismic risk in terms of effectiveness and power to produce positive changes and on what essential legal provisions have been missing from normative acts, resulting in significant implications for seismic risk reduction.

Experts in emergency medicine were put in the multi-hazard scenario wherein a major earthquake event overlaps a pandemic wave, in which case the hospitals in Bucharest and mainly the ICUs are occupied and function at full capacity, the ambulance service is overwhelmed, and the medical personnel is not numerous enough to cope with the seismic-pandemic requirements. They were asked to briefly describe the primary difficulties in providing health care to the earthquake victims and COVID-19 patients, outline the critical concerns regarding the utilisation of physical and human medical resources in managing the earthquake and the pandemic, identify major vulnerabilities of the hospital network within the provided scenario, together with mitigation measures to address these vulnerabilities. Discussions were also oriented to the content of the disaster management plans at the hospital level in Bucharest and to training and implementation protocols specific to these disaster management plans at the hospital level. A critical discussion point focused

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on what restructuring strategies can be implemented within hospitals to address the impacts outlined in the proposed scenario, such as an extension of critical departments (ER, ICU), changes in the functionality of specific departments, streamlining the access of ambulances and supply vehicles, additional outdoor facilities established on the spot, the establishment of rest spaces for medical teams, etc. Integrating polyclinics and family medical practices into emergency management as supplementary medical staff/facilities designated as collection points for victims was also debated. Specific vulnerabilities related to the human resources within the medical system in Bucharest and how hospitals can effectively manage and accommodate a large number of victims in the proposed seismic-pandemic scenario were also important topics. Other questions inquired about a state reserve of medical equipment, materials, and drugs maintained by the Ministry of Health, the protocols in place to support the hospital network in case of disasters, or existing funding instruments/procedures for disaster management within the medical system.

3.4.3 Key results of interviews updating ICs

Question package for first and second responders

The question package designed for the interviews with the first responders (e.g., emergency intervention teams of fire fighters, paramedics, higher-ranking representatives of DSU/IGSU/ISUBIF, etc.) and second responders (*e.g.* military forces) revolved around the scenario of a 7.8 M_W earthquake that would hit Bucharest in present times. Setting the scene by presenting this hazard and its primary impacts (e.g., numerous collapsed buildings and people trapped under debris, blocked roads that render emergency interventions particularly challenging, a shortage of temporary shelters, and the limited functionality of key services), the inquiry aimed to leverage the expertise of emergency intervention teams in identifying the particularities of the seismic disaster. Special attention was dedicated to the vulnerabilities strictly related to the tasks of emergency responders and the adaptation options with the potential to tackle the identified vulnerabilities.

The group of first responders included high-ranking representatives with management functions in the structures in charge of disaster management in Romania: military generals and colonels from the DSU, IGSU and ISUBIF. To gain an even deeper understanding of the efforts required by post-seism interventions, the same set of questions was used to interview two representatives of military forces in reserve (i.e., one captain officer with professional experience in the Security and Protection Service and one military colonel specialised in political-military analysis at international level).

Inputs were narrowed to more specific disaster situations, providing different perspectives on seismic risk management from the tasks specific to the military forces. All interviewed subjects expressed concerns about a major earthquake that would occur at night or during winter, in the last case emphasizing the role of hypothermia in reducing the chances of survival under debris. Within any envisioned scenario, the functionality of roads and lifelines would be impaired, with severe consequences in performing emergency interventions and providing medical care in overwhelmed hospitals. Other significant threats (i.e., cascading hazards) brought into the discussion were the earthquake-triggered breaking of the Ciurel Dam at Morii Lake, the hazards stemming from potential damage to the Institute of Atomic Physics at Măgurele, and earthquake-triggered fires. The captain officer with professional experience in the Security and Protection Service mentioned the worst-case scenario of an earthquake on New Year's Eve. This situation would pose significant

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management challenges due to its spatial, temporal, and objective particularities (e.g., widespread celebration and high alcohol consumption). In this scenario, the participant envisioned excessive panic among the population and increased difficulties in emergency interventions that can result in additional injuries for the population and military rescuers. The vulnerabilities focused on the limited disaster response training, the absence of exercises integral to such training, a lack of individual preparedness, panic among the population (emphasized for causing stampedes), a deficient network of medical units, insufficient intervention equipment, and a lack of disaster management expertise at higher administrative levels (e.g., mayors and deputy mayors).

Regarding potential mitigation measures, the most outlined were retrofitting works, educational programs on earthquakes, the supplementation of hospital beds, medical resources, and intervention equipment, the need for disaster preparedness-related exercises organised by competent structures (IGSU), increased exigency in respecting building design and in using high-quality construction materials, the implementation of fast evacuation procedures and timely provision of first aid, the establishment of field hospitals, and the redistribution of earthquake victims to nearby unaffected hospitals.

The representatives of the military forces emphasized the uncertainty in assigning specific responsibilities to military members based on their skills. Addressing these vulnerabilities involves updating internal protocols tailored to the military forces, implementing a disaster training programme within the regular and ongoing training of military teams (including exercises performed under special spatiotemporal circumstances and theoretical courses) in collaboration with other structures in charge of risk management, and establishing a military department specialized in disaster management. A participant noted that mitigation efforts do not have to depend on modern means but rather on consistency in raising disaster awareness and fostering risk management responsibility within the top levels of military governance.

Question package for critical infrastructure operators, structural engineers, and architects specialised in earthquake hazards from academia

The question package designed for critical infrastructure operators and academia focused on the same seismic scenario and the impacts of the major earthquake on the building stock in Bucharest. Interviews were conducted with the Director of the Professional Association of Civil and Structural Engineers (AICPS), which represents an NGO with about 1,000 members, with academics from the Technical University of Bucharest, and researchers from the National Institute for Earth Physics, as well as technical experts responsible for assessing buildings and determining their risk class, guiding the selection of appropriate intervention solutions (e.g., retrofitting, demolition).

The most prominent earthquake impacts identified by this group of interviewees aligned with those articulated by first responders and the local administration: numerous partially collapsed buildings, panic among people, power outages, and communication disruption. From the perspective granted by their technical expertise, the participants provided valuable details on the physical vulnerabilities that will shape the aftermath of the envisioned seismic disaster. The numerous old buildings with variations in rigidity (having a flexible ground floor and masonry from the first floor upward), tall buildings, or those with glass facades or bay windows were outlined as the most vulnerable. Furthermore, the uncertainty concerning the vulnerability level of buildings that were not technically assessed and the numerous cases where buildings

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lacked technical books were pinpointed as major sources of vulnerability. These were complemented by long-lasting vulnerabilities, such as the outdated post-seism intervention protocols (dating since 2007), the shortage of construction experts, and the cumbersome legal provisions that coordinate retrofitting procedures. On the social side, the limited knowledge and awareness of the population about seismic risk, along with the distortion of information by mass media, were highlighted.

Potential adaptation options for the systemic and social vulnerabilities were targeted: updates of intervention protocols by integrating technology (e.g., IoT, drones), improved plans for relocating the displaced population, and enhanced disaster risk management practices tailored to the recovery phase. Almost all experts mentioned the importance of national educational initiatives regarding earthquakes, which should include disaster preparedness exercises, advocating for a prevention-oriented culture, and the need to reframe the function of the mass media from inciting panic to serving educational purposes.

Question package for policy and decision-makers (including local authorities)

The interviews with local authorities were conducted using a question package similar to the one posed to first and second responders (centred around the same seismic scenario), shifting the focus to the expertise of the local administration and its responsibilities in seismic risk management. The interviewed group included the executive director and one architect of the Municipal Administration for the Retrofitting of Seismic Risk Buildings, affiliated with the General Council of Bucharest, as well as one urban planner working at the Urbanism and Urban Mobility Department of the Bucharest-Ilfov Metropolitan Area Intercommunity Development Association.

An important topic of discussion concerned the progress made in reducing the seismic risk of the buildings in Bucharest and how this progress connects with the modelling of the physical vulnerability. The executive director estimated that there are 10,000 to 20,000 identified vulnerable buildings in the capital city, including 400 buildings that were assigned the first (and most severe) seismic risk class. This represents an essential vulnerability, together with the absence of a retrofitting plan at the city level and the fact that retrofitting was not included in previous regional operational programmes. These vulnerabilities are connected to another vulnerability that often resurfaced during the interview, namely the lack of a coherent legal framework that coordinates seismic risk reduction. The representative of the urbanism department provided a more nuanced perspective, highlighting the translation of these vulnerabilities into a massive displacement of people living in the historical centre (characterised by clusters of vulnerable buildings and also by a high density of administrative buildings) and a prolonged post-seism recovery. He completed the list of noteworthy vulnerabilities by mentioning the fragmented responsibility concerning seismic risk management among different authorities and the existence of emergency management buildings that were assigned seismic risk classes.

Referring to social vulnerability, all the participants interviewed in this group agreed on the low individual preparedness and awareness concerning the threats posed by a major earthquake. They argued that this is partially based on urban legends and limited knowledge regarding the resistance of buildings. The expert in urbanism also detailed on the lack of emergency-related support programmes for people with disabilities.

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Questioned about the adaptation options that would aid in the reduction of the wide range of vulnerabilities and impacts, the higher-ranking representative of the local administration emphasised the necessity of more consistent financial support for retrofitting works. At the beginning of 2024, 147 buildings in Bucharest were in the process of being technically evaluated and then retrofitted. Optimistic perspectives are also set in terms of putting together a proper retrofitting plan at the city level, starting with the identification of additional vulnerable buildings upon implementing the methodology for their visual inspection. The expert in urban planning rounded out the discussion by mentioning the efforts dedicated to constructing a database that would inform evacuation plans and the establishment of gathering points. An adaptation option commonly referenced during the interviews pertained to educational initiatives aiming to inform the population about earthquakes, seismic risk, and vulnerable buildings, including integration within the school curricula.

Question package for law experts

The question package was addressed to law experts with professions that perform duties in the interest of the public (i.e., lawyers and notaries), and it revolved around the presented seismic scenario. This time, the focus of the questions targeted the expertise of the interviewees in identifying the primary deficiencies (acting as proxies of legal vulnerability sources) in the normative acts that have been regulating the reduction of seismic risk in Romania since 2000, and the vulnerabilities that derive from these shortcomings. These topics were explored from the perspective of four full lawyers and a trainee lawyer who provide consulting and representation in all the areas of law, including competences in interpretation and application of the national legal framework, and one notary with analogous skills tailored to notarial functions.

The main shortcomings of the normative acts that govern the reduction of seismic risks in Romania, reported unanimously by the law experts, were the multitude and complexity of the normative acts that modified and completed the Ordinance no. 20/1994. This fundamental legal document comprised 22 normative acts but only 4 republications, which hindered the comprehension and application of its legal provisions in the last 24 years. Besides the intricate structure of the legal framework, other notable shortcomings refer to the failure to issue deadlines or to meet the set deadlines for the methodological norms that coordinate the application of the adopted laws, the delayed regulation of critical aspects (e.g., provisions concerning the acts that constitute offences and their corresponding sanctions, the owners' obligation to allow access to vulnerable buildings), and the use of ambiguous terms to establish the responsibilities of public authorities in reducing seismic risk. All these deficiencies led to major difficulties in understanding, applying, and complying with the legal provisions that aim to reduce seismic risk in Romania.

The cumbersome financing systems for expanses from the state budget set by the legal framework preceding 2020, excessive bureaucracy, and the legal oscillation regarding the funding source for technical evaluations resulted in difficulties in accessing the funds needed for the technical evaluations and retrofitting works of the buildings, which hindered seismic risk reduction in the long run. Other vulnerabilities that slowed down the progress in reducing the seismic risk relate to the focus of the legal framework on buildings with multiple storeys and the absence of legal provisions concerning the management of information on the buildings with seismic risk classes.

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Another primary shortcoming highlighted by two of the legal experts (full lawyer with over 20 years of experience and the interviewed notary) was the premature adoption of the National Strategy for Seismic Risk Reduction (on the 29th of November 2022), followed by the issuance of Government Ordinance no. 6/18.01.2023 and Law 243/20.07.2023 within the next two months. This means that the National Strategy for Seismic Risk Reduction in place does not align with the entire legal framework, as it was established before the issuance of two significant normative acts that followed thereafter.

Within the discourse of the interviews, the participants delineated essential legal provisions that have been missing from normative acts, with significant implications for the reduction of seismic risk. There is a lack of legal stipulations that regulate:

- the provision of consultancy to building owners (regarding the meaning of seismic risk, the consequences arising from not implementing the required actions, and the non-compliance with the measures imposed on them by law,
- the criminal liability for certain acts that should be classified as offences,
- the institutional coordination for the tasks designated to different authorities,
- the centralization of the "authority" and responsibility of state organisms.

Other missing elements refer to the imposition of more severe sanctions for non-adherence to legal regulations and procedural guidelines aimed at avoiding conflicting and hard-to-implement norms.

When considering solutions to address the aforementioned deficiencies of the normative acts, the interviewed law experts reached consensus: the consolidation of all the issued legal provisions into a unified law that regulates seismic risk, accompanied by updated Methodological norms. This unitary legal framework should also remain unchanged or supplemented for a given duration (e.g., 5 years) to establish a foundation for the National Strategy for Seismic Risk Reduction and to produce the desired results in terms of seismic risk reduction.

From a temporal point of view, a portion of the law experts perceived the legal provisions as possessing both positive and negative attributes in terms of effectiveness and power to produce positive changes. While acknowledging the necessity of consistently issuing new legal provisions to amend problematic aspects that were overlooked, the interviewees also highlighted the adverse effects resulting from the very large number of such provisions and their ambiguous content. Given the significant vulnerabilities caused by the convoluted structure of the legal framework governing seismic risk reduction, the positive impact of the new provisions was considerably diminished. Others pinpointed that the discussed normative acts have been influenced by the economic and social agendas of the dominant political parties over the last 24 years, and that political actors prioritised the establishment of legality over efficiency or the safety of citizens.

Question package for first responders specialised disaster medicine or emergency interventions

The question package was directed towards first responders specialised in disaster medicine or emergency interventions, with one respondent with seniority in each of these fields. The inquiry centred on a seismic-pandemic scenario in which a powerful earthquake (7.8 M_w) would occur in Bucharest during a pandemic wave similar to the one in December 2021-March 2022. In this scenario, the seismic impacts presented in the

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other question packages would overlap the pandemic conditions already experienced by the hospitals in Bucharest during the peak of pandemic waves: ICUs functioning at full capacity, overwhelmed ambulance service, and a shortage of medical personnel. Participants were asked to identify the main impacts of the two concurrent hazards (i.e., the earthquake and the COVID-19 pandemic) on the medical system in Bucharest, together with the associated vulnerabilities.

Both interviewees pinpointed the disruption of telecommunications, power outages, blocked roads, and psychological distress as prominent impacts of the multi-hazard under discussion. The disaster medicine expert estimated that approximately 50,000 emergency calls would be made in the first 12 hours of the proposed scenario, part of which would pertain to panic or heart attacks. He also brought to light that such a powerful earthquake would break the Ciurel Dam of Morii Lake and cause the flooding of the nearby Municipal Hospital. On the other hand, the expert in emergency interventions steered the discussion towards the old buildings that host hospitals or their annexes, and on the positioning of hospitals in proximity of highly vulnerable buildings prone to collapse during an earthquake, potentially impeding access to the medical facility. Other aspects that were touched upon during the conversation concern the physical and psychological fatigue experienced by the medical personnel and the potential deepening of the shortage of medical staff due to injuries caused by the seismic event. All these impacts converge to the hub impact of hospitals becoming overwhelmed.

The main vulnerabilities that contribute to these impacts refer to a lack of disaster plans at hospital level, a lack of execution exercises and of a person in charge of the training based on such plans. Furthermore, the first responder specialised in emergency interventions underscored that such disaster plans were not elaborated to account for pandemic conditions; an oversight with significant implications for the management of the proposed seismic-pandemic scenario. The lack of or limited planning concerning various aspects (i.e., planning for outdoor additional support spaces, the reorganisation of hospitals, the supply of medical equipment, materials, or drugs, and the discharging of non-critical patients) was also highlighted as a critical multifaceted vulnerability. Both participants indicated the insufficient capacity of key wards (e.g., ERs, ICUs), the shortage of medical staff and hospital beds, and the low number of doctors with medical specialisations essential in disaster management (e.g., surgeons, traumatologists, epidemiologists) as noteworthy vulnerabilities. These are interconnected with the pivotal vulnerability of the long-lasting underperformance of the Romanian medical system.

In terms of adaptive options, the first responder specialised in disaster medicine emphasised the importance of reorganising hospitals to increase their capacity to cope with the challenges imposed by the multi-hazard. This can be done through both structural (i.e., putting auxiliary spaces to use, supplementing hospital beds, establishing outdoor support spaces and field hospitals) and non-structural measures (i.e., conversions of doctors' specialisations to fit the needs of the disaster situation, adaptation of the shifts of the medical personnel, discharge of 30% of non-critical patients). He suggested that secondary-level medical facilities (i.e., family medical practices or polyclinics) located close to hospitals should be involved in the disaster management coordinated by the hospitals in question. Complementarily, the expert in emergency interventions estimated that the most advanced 19 hospitals in Bucharest have the capacity to provide medical services to just 173 victims, pending a reorganisation process. Additional points raised during the conversation with this participant concerned the deficient communication between medical authorities and

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the public, and the need for enhanced communication protocols to address this issue and promote proactive engagement among citizens. Both experts noted that the legal framework should be modified to include provisions for partnerships between public and private hospitals, and that new financial sources and protocols should be established to mitigate one of the main vulnerabilities of the health care system in Romania, namely the “chronical underfunding”.

3.4.4 Follow-up planning

In 2024, Bucharest Case Study focuses **on a major earthquake as a triggering factor and on different seismic dam-breaking scenarios.**

Two new Impact Chains are planned for 2024, one focusing on **the current situation of a possible seismic event** and **the other on the multi-hazard of the COVID-19 pandemic and a powerful earthquake in Bucharest.** The first Impact Chain will integrate the insights collected upon conducting the smaller workshop in February 2024, as well as the perspectives of the other interviewed stakeholders; aiming for a comprehensive visual and analytical approach to the seismic disaster scenario (Figure 3.4.3).

The second Impact Chains aims to detail the convoluted multi-hazard determined by the convergence of the COVID-19 pandemic and a potential major earthquake on the hospital network in Bucharest, delving into the identification of the impacts and vulnerabilities specific to a major seismic event that would overlap a pandemic wave and also interact with different earthquake-triggered hazards. An important focus will be on the post-earthquake accessibility of the major hospitals in Bucharest, factoring in the collapsed buildings causing road blockages (Toma-Dănilă et al., 2020, 2022).

Zooming in on the most important Clinical Hospital in Bucharest (with the collection of additional data on the pandemic impacts) will enable a more on-point estimation of the potential unfolding of the multi-hazard situation.

A second stakeholders’ workshop is planned for October 2024, where PARATUS's main findings and outputs regarding Impact Chains will be shared and disseminated to relevant stakeholders. After establishing common ground, the workshop's significant focus will be working with first responders, practitioners, and experts on different Impact Chains at the city level, integrating various compounded impacts and exposed elements (hospital networks). During this workshop, a serious game is also planned, and its framework is still to be determined.

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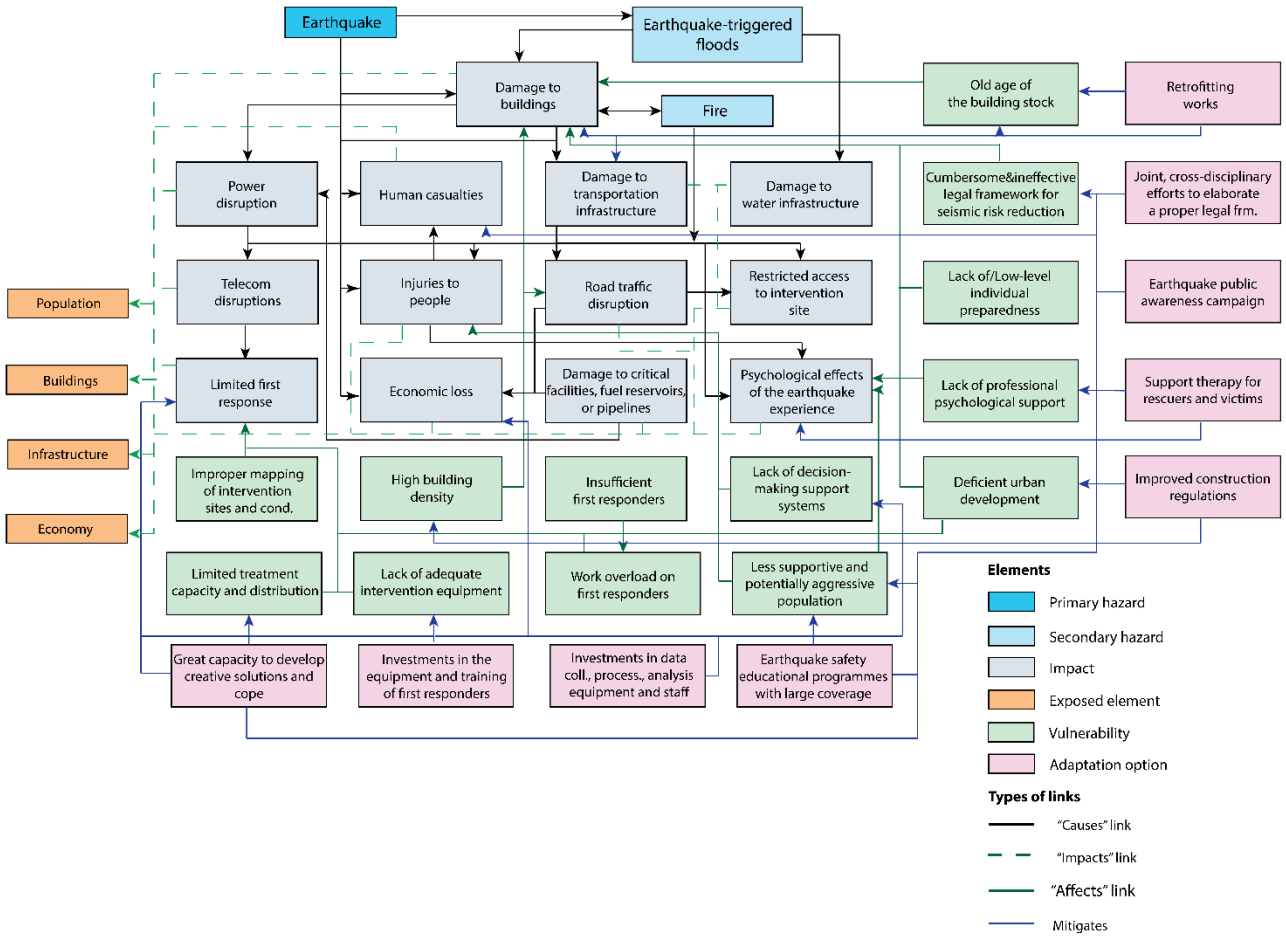

Figure 3.4.3 Details on the elements and connections extracted from the workshop, focus groups, and interviews, and integrated into the Impact Chain focusing on the major earthquake in Bucharest in present times

3.4.5 Conclusion

The stakeholder engagement process for the Application Case Study Bucharest involved a qualitative focus group approach, followed by an initial workshop in March 2023 and extending in 2024 with a small-scale workshop, focus groups, and individual interviews.

The Impact Chain focusing on a major earthquake (7.8 M_W) that would hit Bucharest during present times was further developed integrating the insights collected upon performing interviews with various stakeholders (e.g., first responders, representatives of the local administration, architects, engineers, technical experts, law experts, medical experts in disaster medicine) during February-March 2024. Each of the interviewed professionals highlighted different facets of the envisioned seismic disaster, aiding in the construction of an intricate information puzzle for Impact Chains.

Leveraging the expertise-based perspectives of the stakeholders, Impact Chains on Bucharest were completed with new elements and links. These updates made the chains more robust and increased their capacity to zoom in on the multifaceted challenges associated with the disaster scenarios.

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Interviews conducted with first responders specialised in disaster medicine and emergency intervention training contributed to the refinement of another Impact Chain centred on a seismic-pandemic scenario wherein a major earthquake would affect Bucharest during a pandemic wave. The participants primarily raised concerns about the absence of a disaster plan at hospital level, a lack or limited planning across various aspects (e.g., planning for alternative communication services, medical equipment, materials, and drugs), and the “chronic” underfunding of the medical system in Romania. The reorganisation of hospitals and the issuance of legal provisions that regulate partnerships between public and private hospitals emerged as solutions that can solve many of the discussed issues.

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