Deliverable D6.4

Report 3 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 D6.4 is the third 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 2024 and January 2025.

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Document History

Version	Date	Author	Description
V1	15.12.2024	Funda Atun	Made the concept note
V1	20.12.2024	Serge Monturet, Joris Ranchin,	Provided input for the 2.5
V1	18.01.2025	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	Provided input for the Istanbul Case Study
V1	18.01.2025	Philipp Marr, Till Wenzel, Hannah Andlinger	Provided input for the Alps Case Study
V1	18.01.2025	Iuliana Armaș, Cosmina Albulescu	Provided input for the Bucharest Case Study
V1	18.01.2025	Cees van Westen, Dinand Alkema	Provided input for the Caribbean Case Study
V1	18.01.2025	Silvia Cocuccioni, Federica Romagnoli	Provided input for the 2.1
V1	18.01.2025	Marcel Hürlimann	Provided input for the 2.2
V1	18.01.2025	Bettina Koelle, Michalina Kulakowska	Provided input for the 2.3
V1	18.01.2025	Funda Atun, Pritam Ghosh, Cees van Westen	Provided input for the 2.4
V1	18.01.2025	Sonia Matera, Linda Portoghese	Provided input for the 2.5
V2	18.01.2025	Cees van Westen, Dinand Alkema	Contributed to the Caribbean Case Study
V2	22.01.2025	Funda Atun	Integrated and harmonized all contributions from the various parts and reviewed the deliverable
V2	25.01.2025	All contributors	Edited the deliverable
V2	28.01.2025	Sjirk Meijer	Reviewed the entire deliverable
V2	28.01.2025	Lea Schollerer	Reviewed the entire deliverable
V3	29.01.2025	All contributors	Edited the deliverable
V4	30.01.2025	Funda Atun, Pritam Ghosh	Finalised the deliverable after reviews
V4	31.01.2025	Cees van Westen	Submitted the deliverable

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Disclosure Statement:

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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 risk-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 this 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
CRS	Centre for System Solutions
DLR	German Aerospace Center
DSU	Department for Emergency Situations
EA	European Agency
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
MHEWS	
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
PIRAC	French Red Cross in the Caribbean
RAN	Resilience Advisors Network
RCCC	Red Cross Red Crescent Climate Centre
REA	European Research Executive Agency
SIDS	Small Island Development States
TEATT	Ministry of Tourism, Economic Affairs, Transport and Telecommunication

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UB	Universitatea din Bucuresti
UN-ECA	UN Economic Committee for Africa
UNDRR	United Nations Office for Disaster Risk Rection
UNU-EHS	United Nations University Institute of Environment and Human Security
UNIVIE	Universitat Wien
UPC	Universitat Politecnica de Catalunya
UT	University of Twente
UTECH	University of Technology , Jamia
UWI	University of the West Indies
WLV	Torrent and Avalanche Control
WMO	World Meteorological Organization
WP	Work Package

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Executive Summary

WP6 demonstrates the work process in 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 D6.4 is the third report of the stakeholder workshops that have been organized in the period from April 2024 and January 2025 in the four application case studies of the EU Horizon Europe PARATUS project (https://www.paratus-project.eu/): Caribbean (several countries), Brenner (Austria and Italy), Istanbul (Türkiye) and 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 regional Framework for Multi-Hazard Risk Assessment (with UT-ITC as the main partner), the development of a multi-hazard early warning and impact-based forecasting dashboard (NRC 510 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 a key stakeholder), PIRAC (French Red Cross in the Caribbean), UNDRR, Caribbean regional organisations, and Caribbean National Disaster Management Authorities and Red Cross branches. Apart from the humanitarian sector, also other sectors will be considered, such as tourism, and the telecommunication sector.

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 changes have impacts on known and unknown natural and anthropogenic hazards; cascading as well as compounding events can influence the damage susceptibility of different anthropogenic structures, such as critical infrastructure and, e.g., potentially threatening 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.

Istanbul case study’s focus is on urban dynamics in mega city concepts, i.e. changing demographical patterns, increasing exposure, and associated systemic vulnerabilities. Istanbul is a mega city with a population of over 15 million inhabitants. Istanbul is highly susceptible to earthquakes, as well as associated hazards such as liquefaction, landslides and tsunamis. In addition, hydrometeorological hazards (i.e., extreme temperatures, fires, flooding) are also becoming a risk. 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. Most damage was in the city centre, where many constructions were built without considering the seismic design code (prior to 1940) and with poor construction quality. As the 2011

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statistics show, Bucharest hosts more than 31430 buildings belonging to the pre-code era. Bucharest case study engages various stakeholders (e.g., first responders, representatives of the local administration, architects, engineers, technical experts, law experts, and medical experts in disaster medicine) to co-develop impact chains focusing on a major earthquake (7.8 M_W) that would hit Bucharest during present times.

The activities in the application case studies support the overall aim of the PARATUS project, which 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 D6.4

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 D6.4 are:

- To report the result of the activities conducted in the application case study areas between April 2024 and January 2025.
- 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 the application case study area	6 (submitted)	Reports on workshops in application case study areas
D6.3	Report 2 of workshops in the application case study area	18 (submitted)	Reports on workshops in application case study areas
D6.4	Report 3 of workshops in the application case study area	28* (this report)	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
*In the amendment, we restructured the submission deadline for some of the deliverables, and D6.4 is one of them. Previous submission deadline was M24 and after the amendment it became M28.			

2 Background information

In the 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, and 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 and 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 has 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.

The overall structure of the second workshop series was again designed to support the upcoming deliverables in various WPs. The focus of the second workshops in the case study areas was to update the stakeholders about what happened since the first workshop, co-develop scenarios in WP2, co-design stress testing in WP3, co-design and provide feedback for the serious games in WP3, co-design and provide feedback for Disaster Risk Stakeholder Hub in WP4.

Following the introduction and update, stress testing and serious games were designed to engage stakeholders in exploring complex decision-making scenarios while testing the feasibility and adaptability of serious games with a varied group of actors. By immersing participants in simulations tailored to their regional and thematic contexts, the workshops provided a space for discussions and shared insights into addressing critical challenges of stakeholders and the project. Finally, a presentation of the Disaster Risk Stakeholder (DRS) Hub was given, and participants were asked to complete a survey to collect their thoughts about the DRS Hub in their native language and on the spot. This ensured a maximum number of replies and allowed the possibility for further explanation of the questions asked therein.

2.1 WP1 activities in relation to case study areas: Impact Chains and Forensic Analysis

During the first two years, in the case study areas, we focused highly on the Impact Chain Approach, described in D1.1 and D6.2. In the first we co-developed impact chains in workshops and meetings with case study partners and stakeholders in the four application case study areas. In the second year we developed impact chains for learning case studies, where information was retrieved from desk-based research and then discussed among project partners. Until now, we have co-developed a total of 21 Impact Chains, 13 of them relate to application case studies, while 8 of them relate to learning case studies.

During the period between April 2024 and January 2025, we focused on the standardization of Impact Chains and the integration of IC approach in the forensic analysis of the learning case studies. Results of the standardization process and the integration with the Forensic analysis are presented in D1.2. During this period, we also integrated the impact chains into the Disaster Risk Stakeholder Hub. The impact chain tool allows the collection of information about past disasters in a systematic manner and allows stakeholders to consult them in an interactive way. In this context, updating and improving the existing Impact Chain proves to be particularly important to ensure consistency in the methodology development and identification of cascade interconnections among risk elements.

2.2 WP2 activities in relation to Case Study Areas

At this stage, WP2 activities are focused on data collection. The first datasets of all four application case studies have already been uploaded and stored in the UniShare platform (https://unishare.utwente.nl/). The UniShare platform has different folders for each of the four application case studies (ACS), all of them with the same structure defined in accordance with the Data Specifications outlined by the INSPIRE Directive. A detailed description of the UniShare data platform, its structure and general information can be found in deliverable D6.11 “Updated Data Management Plan”

In the following table, there is an overview of the present situation of the datasets uploaded to UniShare. Until December 18, 2024, the Brenner Corridor Alps ACS uploaded 8 files and 30 folders with a total amount of 1.25 Gb, Bucharest 287 files and 55 folders with a total of 3.4 Gb, Caribbean (Saint Vincent) 5906 files and 84 folders with a total of 18.3 Gb and Istanbul 172 files and 50 folders with a total of 4.79Gb. In summary, until now, we have gathered a total amount of almost 30 GB and about 6500 datasets. Most of these datasets, 98%, are spatial information (vector and raster maps) and additional data (text and Excel files). The rest are documents with descriptive or scientific information (images and pdf format).

Table 2.1: Summary of the datasets uploaded to UniShare platform until December 18, 2024.

Folder	Subfolder	Alps	Bucharest	Caribbean (St Vincent)	Istanbul
Reference data	Adminitrative_units		x	x	x
	Elevation	x	x	x	
	Geology	x		x	
	Hydrography			x	x
	Landcover			x	
	Orthoimagery				
	Transport_Network		x	x	x
Thematic data	Area Management	x			
	Atmospheric conditions			x	
	Buildings		x	x	x
	Human health				
	Landuse			x	x
	Population		x		x
	Sea regions			x	
	Utility/government services		x		x
Impact data	Economic				
	Environmental				
	Social				x
Risk data	Exposure	x	x	x	x
	Hazard	x	x	x	x
	Vulnerability		x		
	Risk		x	x	

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2.3 WP3 activities in relation to the case study areas

Stress testing and serious games were some of the central activities in this round of workshops.

Stress testing is a useful method for measuring a system's exposure to multiple threats. In stress tests, scenarios are crucial. However, the ones frequently utilised nowadays usually fail to consider endogenous elements. Consequently, adaptation opportunities may be lost, and hazards may be underestimated. Stress testing reveals the vulnerabilities of specific systems (projects, plans, etc.) to different risk scenarios, both climatic and non-climatic. It helps connect risk information with scenario planning and adaptation options by examining a wide range of scenarios, which helps us deal with uncertainty in projections for various stressors (climate, environment, socio-economic, etc.). In the workshops we tested the stress testing methodology together with the stakeholders. For more information, please consult the ''Deliverable 3.2 Guide to Stress Test''.

Regarding the Serious Games, for this round of the workshops, the use of the games had 3 goals: 1) testing the flexibility of the chosen methods to address distinct challenges and stakeholder dynamics; 2) engagement and the content relevance for the participants; 3) sparking the reflection over potential solutions and challenges among the stakeholders. There were 2 tools developed for the workshops to address these goals: a serious game for the Bucharest workshop and the Alps workshops. Each game was tailored to the context and needs of the participants, ensuring relevance involving the case study owners and partners working with the case study to join in the development process. By designing scenarios reflective of local issues—seismic disaster response in Bucharest and cross-border collaboration in the Alps—the games encouraged participants to step into diverse roles, explore new perspectives, and engage deeply with the complexities of decision-making.

In Bucharest, the game centred on the earthquake disaster response in the fictional town of Bucur, with participants assuming roles as first responders or uncooperative residents. Meanwhile, the Alps workshop focused on hazards and regional cooperation in the fictional area of *Saltun Montem*, situated between two imaginary countries, *Magna* and *Altum*. Participants, including logistics professionals, regional authorities, and environmental experts, worked in groups to tackle scenarios that balanced economic, environmental, and social priorities, promoting cross-border collaboration.

The games were informed by stakeholder feedback and insights from previous workshops, addressing challenges like balancing short- and long-term planning, understanding diverse perspectives, and refining representations of authority roles. To minimize survey fatigue (WP4), an observation protocol was used, supported by translations provided by the organizers, enabling a detailed analysis of participant interactions and behaviours. Each simulation also ended with an in-depth discussion - reflection on the learnings from the experience, including the need to understand different perspectives, information flow, communication, and misunderstanding of the needs of certain actors. The test of the Alps simulation with Istanbul partners during the General Assembly further tested the feasibility and adaptability of this approach for the Istanbul case study.

The feedback gathered will guide future iterations, reinforcing the value of Serious Games as a tool for fostering dialogue, innovation, and actionable insights across diverse regions and stakeholder groups.

2.4 WP4 activities in relation to the case study areas

The overall objective of the PARATUS project is the co-development of a web-based simulation and information service for first and second responders and other stakeholders to improve their preparedness. The first design document of the PARATUS platform was submitted in M10. The deliverable 4.1 provides a first impression of the platform and its components. Recently, the PARATUS project started collaborating with other EU-funded projects, and the PARATUS Hub transformed into a Disaster Risk Stakeholder Hub that is hosted by the Crisis Management Innovation Network Europe (CMINE): https://drs-hub.eu. With the support of PARATUS, CMINE has formed a group of European projects in the field of Societal Resilience and

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formed the Societal Resilience-cluster (SRC)[1] which meets regularly to develop joint activities such as webinars, Young Researcher Academies, sessions in international conferences, and the Disaster Risk Stakeholder Hub.

The co-development of the tools with stakeholders is the central theme of the PARATUS project. Therefore, in the application case study workshops, we presented the latest version of the DRS hub to collect feedback and understand the needs of various stakeholders. We also prepared a survey and distributed it to the attendees of the workshop.

Based on the preliminary overview of the responses, this document consists of the stakeholders' interpretations and inferences for each tab of the DRS hub. The different sections of this document represent the different sections of the questionnaire and the stakeholders' perspectives associated with them. In this report, the questionnaires for all three languages (Romanian, German, and Turkish) were translated into English to understand the trends better. All the figures and diagrams in this document are in English. To look at the original figures, the readers can look at the preliminary report. The total number of respondents is 69. All the respondents have answered the questionnaire after agreeing to the consent form.

2.5 WP5 activities in relation to case study areas: Stakeholder selection

Targeted stakeholder group classification was reported in D6.3 entitled "*Report 2 of workshops in Application Case Studies*". The stakeholder classification has led to the planning of second workshops. During the second workshops, to capture stakeholder insights, FI, in collaboration with DBL and Application Case Study leaders, conducted interviews with relevant stakeholders during the workshops in Istanbul and Bucharest (24 and 26 September 2024). It is foreseen that at least one video interview will be published for each case study, conducted in the local language and subtitled in English to ensure wider accessibility and engagement of local communities, authorities, and citizens. These interviews focused on the local activities undertaken by each case study, highlighting existing gaps, challenges, and future aspirations. By recording these accounts, the project aims to enrich the understanding of the objectives, hazards and stakeholders involved, as well as the research objectives and methodology of each PARATUS of the case studies and maximise the project's impact on local communities.

DBL, in collaboration with the application case study leaders, developed case study infographics (i.e. Figure 2.1.), produced in advance of the stakeholder workshops, to be used as dissemination material both to external audiences (promoted through project channels) and in the case study areas. The infographics explain in detail each application case study area. They are available for download from the PARATUS website in the Dissemination Repository section.

In addition, the activities carried out during the second workshops of the Alps and the Bucharest Application Case Studies have been described in two blog posts published on the PARATUS website and, respectively, on the Disaster Risk Stakeholders Hub and the Romanian Department for Emergency Situations' website. Below, the links to the blog posts are provided:

- Continuing the dialogue: A recap of the 2nd PARATUS workshop in the Alps
- Highlights of the Second Stakeholder Workshop in Bucharest

Two videos summarising the work done during the first and second Romanian stakeholders' workshops have been created by UNIBUC and published on the PARATUS YouTube channel, as well as on the project website:

- The first Romanian Stakeholders Workshop
- The Second Romanian Stakeholders Workshop

Another video presenting the second Alps stakeholders' workshop is currently under development by DBL and will be soon disseminated.

[1] https://www.cmine.eu/topics/20936/home

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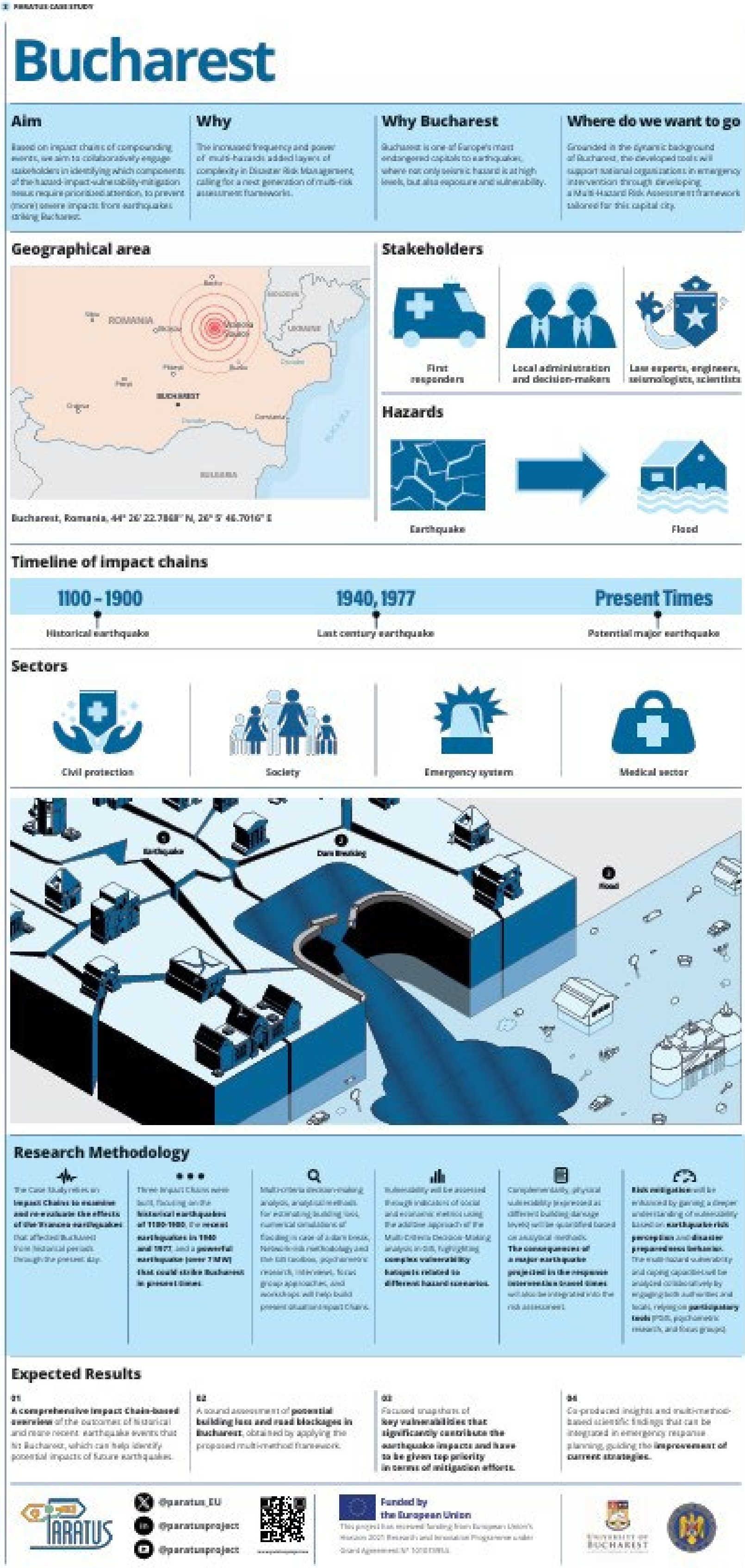

Figure 2.1: Infographics of Bucharest Application Case Study as an Example. (To see all infographics please visit: Dissemination repository - PARATUS)

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3 Reports on Application Case Studies

This section includes the reports of the project activities during the period April 2024 – January 2025 in four application case study areas: the Caribbean Islands, the Brenner Corridor in the Alps, Istanbul in Türkiye and Bucharest in Romania

3.1 Caribbean

3.1.1 Update: What happened from April 2024 to January 2025

In the Caribbean region, we are working on two different scales: Regional and National. In this chapter, we will present the workshops and contacts with stakeholders that were held in 2024. It was decided to accommodate the smaller country sizes by reshaping the workshops in a number of activities, which are reported in this section.

3.1.1.1 Development of the Framework for Multi-Hazard Risk Assessment in the Caribbean

One of the important activities that was carried out within the PARATUS project, in collaboration also with the ESA EO4MULTIHAZARDS project[2], was the development of a regional guideline document. PARATUS' experts support CDEMA by actively being involved in the Regional Technical Working Group on Disaster Risk Assessment.

The Regional Technical Working Group on Disaster Risk Assessment involves experts from:

- Centre for Disaster Resilience, University of Twente;
- Caribbean Disaster Emergency Management Agency
- Coastal Zone Management Unit, Barbados;
- Caribbean Institute of Meteorology and Hydrology;
- University of the West Indies, UWI Seismic Research Centre;
- University of the West Indies, Climate Studies Group, UWI, Mona;
- University of Technology, UTECH, Jamia, Jamaica.

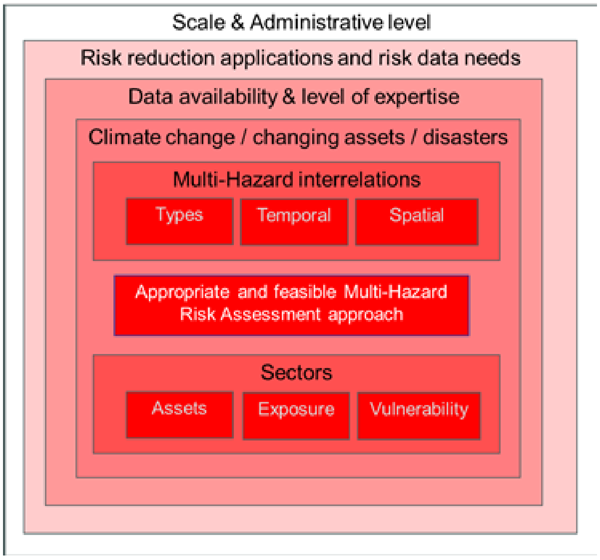

Figure 3.1.1 Illustrating the MHRA framework: the appropriate and feasible method for multi-hazard risk assessment in the Caribbean, given a range of conditions.

The framework for multi-hazard risk assessment in the Caribbean aims to address the lack of understanding of the concept of multi-hazards, how these can be defined and conceptualized, and how the hazard and risk could be assessed, and additionally, to drive the Caribbean towards a systematic generation of risk information at different geographic scales, by enhancing data availability and required resolutions. This MHRA framework provides a general guideline that identifies the various approaches for multi-hazard risk assessment that are suited for different levels of government, different applications, and different situations of data availability. It serves as a basis for the future development of detailed guidelines and capacity building

[2] In the proposal phase of PARATUS project, we indicated our aim to collaborate with other projects to expend PARATUS' project's impact. Currently, we are collaborating with multiple projects in various project tasks, and ESA funded project EO4MULTIHA is one of them.

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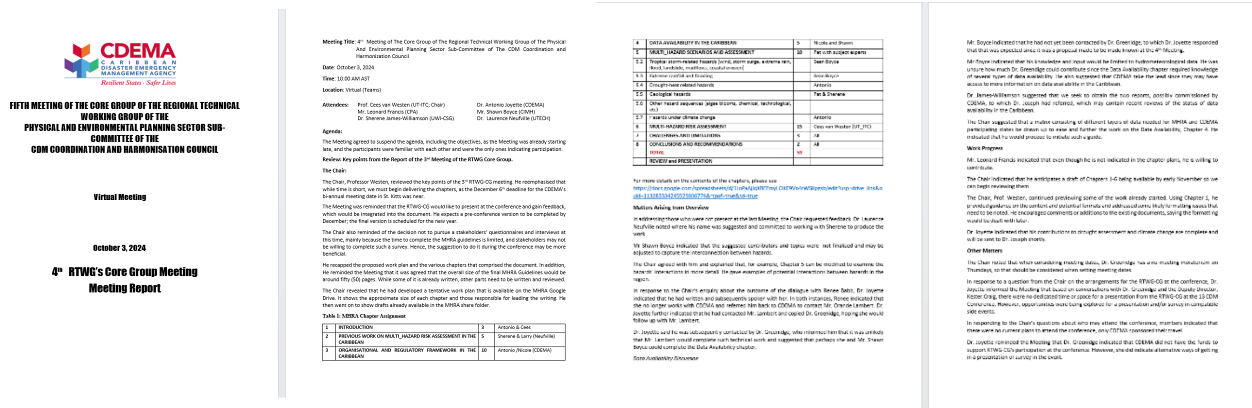
(e.g., at the municipal level). It addresses the management policies and actions to support the cumulative building of knowledge in a sustainable and systematic way, highlighting important inter-institutional aspects of data management and sharing. The framework for MHRA is developed in collaboration with CDEMA and other regional organizations.

3.1.1.2 Meetings of the Working Group

The framework was developed after a series of meetings of the steering group. These meetings were held on average every month for a period of half a year (See Figure 3.1.2 for an example of the minutes of one of these meetings). The international context of MHRA and its relevance to the Caribbean was considered by evaluating international literature on Multi-Hazard Risk Assessment and the relevant approaches that are developed at different levels in other countries, focusing specifically on countries with similar characteristics as the countries in the Caribbean. In the context of Disaster Risk Management (DRM) in the Caribbean, the proposed framework is consistent with the acts and policies on disaster and climate change of the Governments within the Caribbean, and it will serve as a guideline to generate risk information for disaster risk management through the establishment of MHEWS and risk-sensitive development planning including infrastructure planning in various sectors like health, education, transport etc.


CDEMA
CARIBBEAN DISASTER EMERGENCY MANAGEMENT AGENCY
Resilient States - Safer Lives

FIFTH MEETING OF THE CORE GROUP OF THE REGIONAL TECHNICAL WORKING GROUP OF THE PHYSICAL AND ENVIRONMENTAL PLANNING SECTOR SUB-COMMITTEE OF THE CDM COORDINATION AND HARMONISATION COUNCIL

Virtual Meeting

October 3, 2024

4th RTWG's Core Group Meeting
Meeting Report

Figure 3.1.2: Example of the minutes of one of the Working group meetings, on October 3, 2024.

3.1.1.3 Development of the Framework Report

The draft of the Framework Report was completed in December 2024. The report contains 9 Chapters (Figure 3.1.3)

- Chapter 1. Introduction
- Chapter 2. Previous Work on Multi-Hazard Risk Assessment in the Caribbean
- Chapter 3. Organizational and Regulatory Framework In The Caribbean
- Chapter 4. Multi-hazard Risk Assessment Data in the Caribbean
- Chapter 5. Multi-hazard Scenarios and Assessment
- Chapter 6. Multi-hazard Exposure and Vulnerability
- Chapter 8. Recommended Multi-hazard Risk Assessment Approaches
- Chapter 9. Recommendations for Enhancing Multi-Hazard Risk Assessment in the Caribbean

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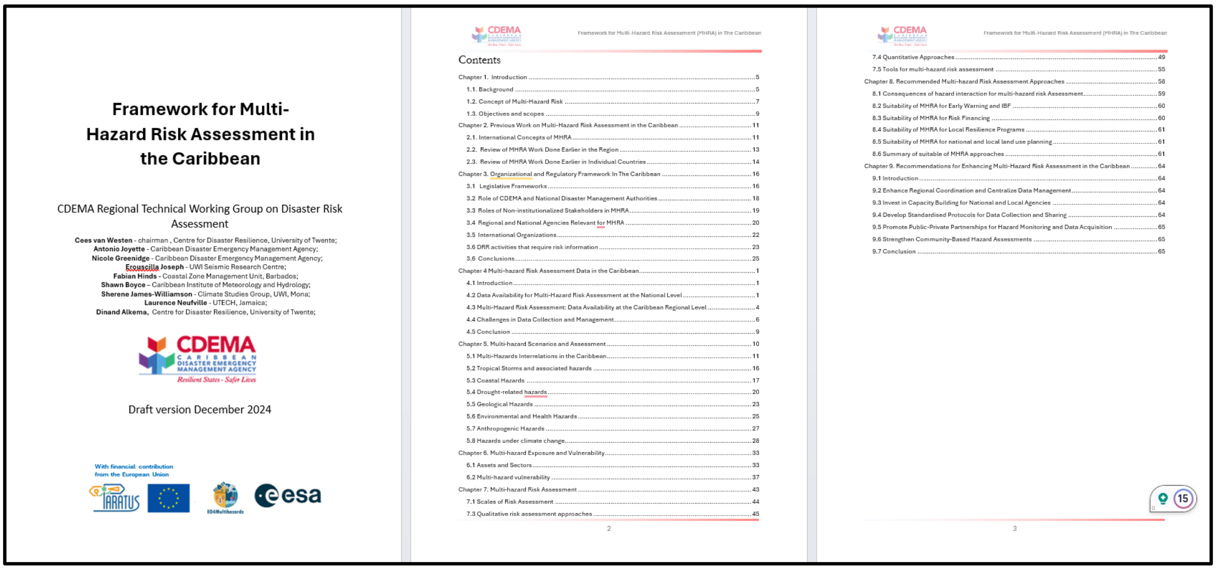

Figure 3.1.3: Front page and table of contents of the MHRA framework document.

3.1.1.4 Workshop during the CDM13 conference

The approach was presented at the Caribbean Disaster Management conference in Saint Kitts and Nevis on 5 December 2024. The conference was organised by CDEMA, and all its member states were present, including St Maarten, which officially became a member in June this year. There were over 450 attendees, including representatives from ESA, the EU, UNDRR, the IFRC, WFP, and donor organisations from the US and Canada. Attending the workshop provided PARATUS project colleagues with an opportunity to present the project in an oral and poster presentation, conduct a survey, disseminate communication materials, and have a direct conversation with the EU communication officer in Barbados.

Figure 3.1.4: Special session organized during the 13th Caribbean Disaster Management Conference.

PARATUS project was represented at 13the Caribbean Disaster Management Conference by Dinand Alkema, PARATUS project Caribbean Case Study Coordinator, on Thursday 5 Dec. at 16:00 and was attended by approximately 30 participants (Figure 3.1.4). The session explored the essential role of high-quality disaster risk information in guiding development investments and prioritizing activities to minimize disaster impacts, especially given limited resources. Moving beyond historical data, which lacks the depth for mid-to-long-term planning, the Caribbean has increasingly adopted quantitative and probabilistic approaches to effectively quantify and manage disaster risk. While these methodologies have a long-standing history in the region, there is a clear opportunity to integrate them more fully into systems that enhance resilience, such as multi-hazard early warning systems, impact-based forecasting, anticipatory action, and financial protection mechanisms.

The session provided an overview of current risk assessment approaches, including examples from the Caribbean's use of risk models in financial instruments, like the Caribbean Catastrophe Risk Insurance Facility (CCRIF), and initiatives like Early Warnings for All (EW4All). The Regional Technical Working Group on Disaster Risk Assessment, operating under the Physical and Environmental Planning Sector Subcommittee, is actively drafting a framework aimed at harmonizing multi-hazard risk assessment approaches, with special consideration for various hazard types, data needs, and application scales. In addition to technical presentations, there was a live demonstration of monitoring and forecasting tools for natural events such as earthquakes, tropical cyclones, and extreme rainfall. The working group plans to submit a draft guideline for feasible disaster risk assessment methods in early 2025. The coordinator of the PARATUS project, Cees van Westen, is the lead author.

Through this session, participants gained insights into the regional progress in disaster risk assessment, including the relevance of historical disaster data for model validation, the application of quantitative and probabilistic approaches, and the impact of collaborative efforts on enhancing social protection resilience. Opportunities to expand risk transfer instruments to other sectors, such as agriculture and social protection, were also discussed, showcasing the potential for informed investments that support community and infrastructure resilience in the face of climate change. PARATUS project was represented with a poster in addition to oral presentation. (Figure 3.1.5)

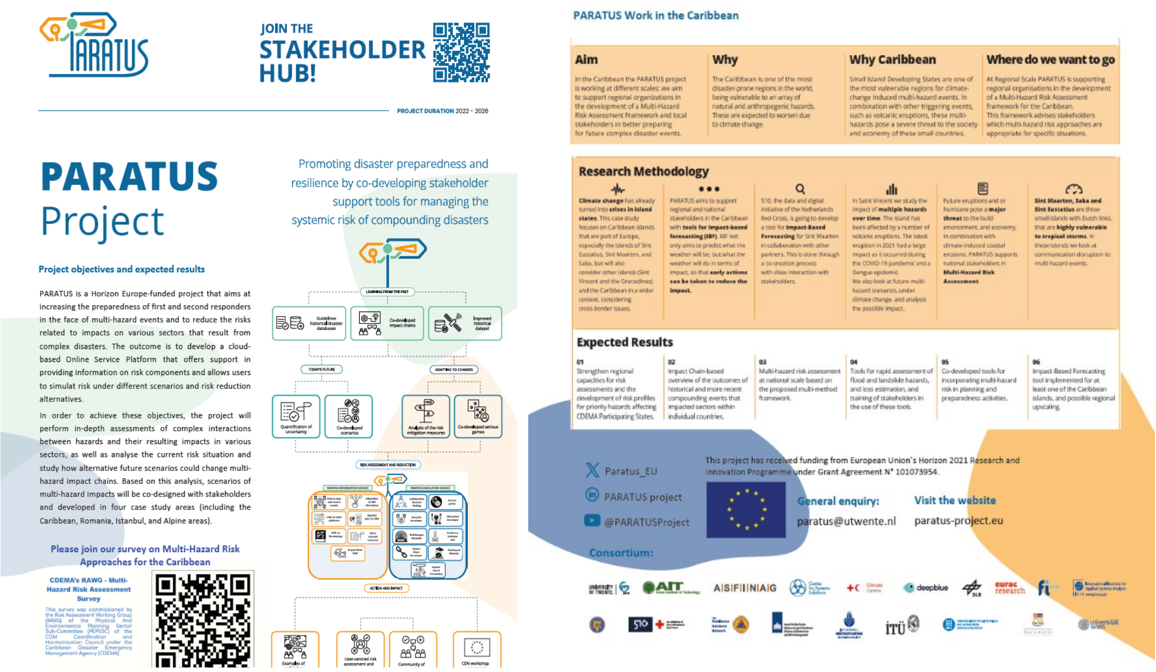

Figure 3.1.5: PARATUS Poster presented at the EU delegation during the 13the CDM Conference.

A questionnaire was developed to survey the opinion of Disaster management Stakeholders from the Caribbean on the application of multi-hazard risk assessment methods. During the 13th CDM Conference in Saint Kitts and Nevis, from 2 – 6 December in St. Kitts Marriott Resort & The Royal Beach Casino, cards were handed out (See Figure 3.1.6) and a poster was placed within the stand of the EU delegation (Figure 3.1.5).

The survey had eleven (11) questions. Stakeholders were asked to respond to the best of their knowledge so we can ascertain the best overview of what is going on at the national level in multi-hazard risk assessment. Unfortunately, the number of replies from the survey were rather low.

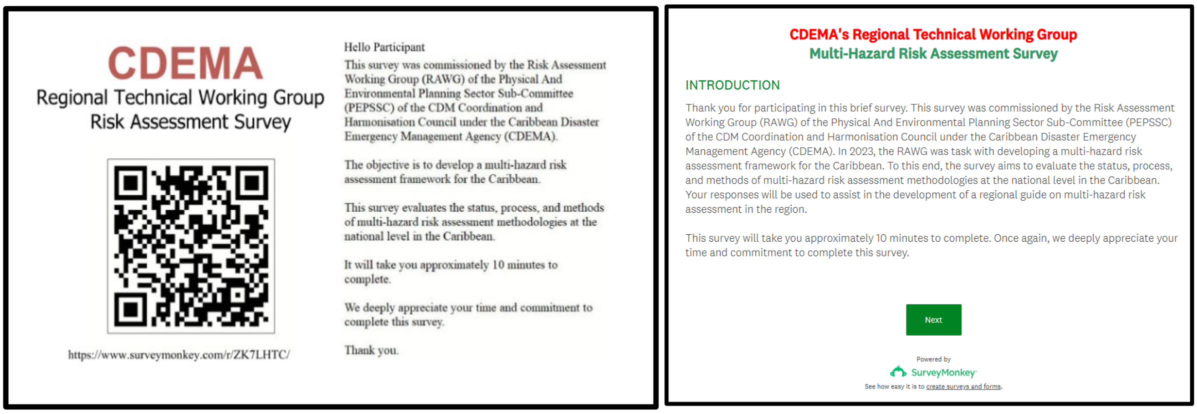

Figure 3.1.6: Left: cards handed out during the conference with a link to the stakeholder questionnaire. Right: First page of the survey.

Additionally, PARATUS colleagues had a meeting with the EU program manager in Barbados. The EU is a major sponsor of CDEMA and they had a large booth at the conference. PARATUS was represented at the conference with a banner and various dissemination and communication materials. The EU program manager was interested in learning more about We explained PARATUS and the Caribbean case study and the work done so far on St Maarten, St Vincent and Dominica and our intentions to scale up to the region as a whole – with a focus on Anticipatory Action.

3.1.1.5 Impact-based Forecasting and Anticipatory Actions

We had a meeting with the representatives of NRC-510 and CDEMA. We explained that within PARATUS NRC-510 is looking into Anticipatory Action in relation to Early Warnings. The challenge for the Caribbean would be to scale it up to a regional level, and this is where CDEMA would come into the picture.

We also had a meeting with **UNDRR** (Project manager, Barbados'Project Management Officer, Barbados) and a representative of NRC-510. Similar to the meeting with CDEMA, we explained PARATUS and the intention of the NRC-510 to develop early action protocols in the Caribbean. UNDRR has a short list of countries that they would like to focus on; these include Surinam, Grenada, Belize, St Kitts and St Vincent. We informed them that the PARATUS Caribbean Case Study Coordinator is planning to go to St Vincent in March 2025 for fieldwork and a workshop/training with government officials. UT, NRC, UNDRR, CDEMA, EU and possibly also WFP agreed to more frequent and continuous collaboration.

3.1.1.6 Development of Climate Scenarios for the Caribbean

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The Royal Netherlands Meteorological Institute (KNMI) provides climate analyses and climate scenarios for the Dutch Caribbean islands of Bonaire, Sint Eustatius and Saba (the BES islands). Also, KNMI advises the Dutch government on climate change and issues warnings to Dutch society about hazardous weather conditions and their impacts. In several workshops, climate scenarios for the BES islands and the Netherlands were presented, offering guidance to policy advisers and other professionals to make informed decisions in the face of a changing climate.

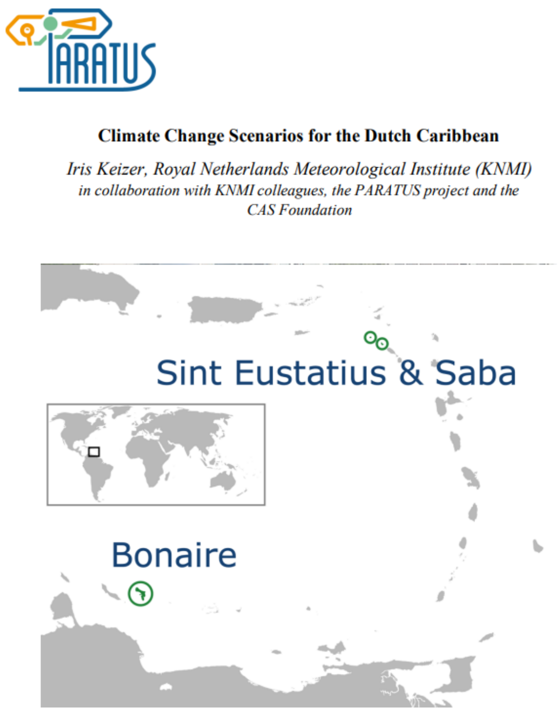

Figure 3.1.7: Blogpost on the development of climate scenarios for the Caribbean.

https://www.knmidc.org/climate/docs/PARATUS%20Blog%20Post_KNMI.pdf

The KNMI climate scenarios translate the insights and research results from the most recent IPCC report to the local situation for the Dutch Caribbean for climate variables that are considered useful for a large group of users. The scenarios were calculated using the latest climate models and developed to provide stakeholders with an idea of how the climate of the BES islands will change between now and the end of this century. The KNMI climate scenarios were developed based on input from stakeholders, policymakers, and experts. They were published in a user report and a scientific report [3], accompanied by several websites containing additional information. The scenarios have been discussed in meetings with stakeholders, end users, and communities. Stakeholders and users include those with an interest in policy-making, impact and risk assessment and disaster management. These meetings were also held to assess additional stakeholder requirements to sustain our efforts in creating user-customized scenarios, ensuring their relevance to a wide range of stakeholders. Some of these meetings were organized in collaboration with climate impact experts from the Climate Adaptation Services Foundation (CAS) and social experts from the research program Islanders at the Helm.[4]

3.1.1.7 Presentation during the Netherlands Caribbean Research Week

PARATUS participated in the NWO Dutch Caribbean Research Week, which was held from 20-27 November as a hybrid event both in the Netherlands and in the Caribbean. It is a free multi-day conference aimed at providing a platform to bring

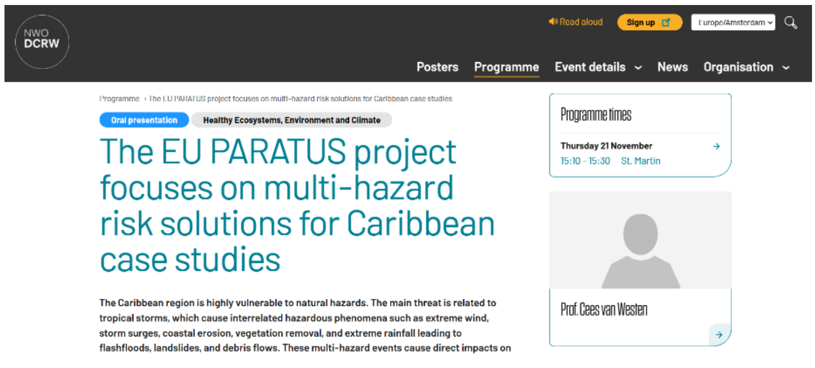

Figure 3.1.8: Announcement of the presentation during the Research Week.

[3] https://cdn.knmi.nl/system/ckeditor/attachment_files/data/000/000/320/original/KNMI23_climate_scenarios_scientific_report_WR23-02.pdf

[4] https://www.knmidc.org/climate/docs/PARATUS%20Blog%20Post_KNMI.pdf

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researchers from the Caribbean science community together.

In the PARATUS project, we have selected Sint Maarten and Saint Vincent as case studies at the national scale, and Dominica as a case study in a sister project (EI4MULTIHAZARDS) funded by ESA.

3.1.1.8 Contacts with Saint Vincent, Saint Maarten and Sint Eustatius

During the third case study reporting period, we had direct contact to discuss the PARATUS project with various stakeholders, i.e. Fire Chief in Sint Maarten, Ministry of the Interior in Sint Maarten, Crisis Manager in Statia, Secretary/Senior Advisor Disaster Management Organization in Curacao, and Ministry of Transport and Works in Saint Vincent.

Saint Vincent and the Grenadines were impacted seriously by Hurricane Beryl. Beryl developed from a tropical wave that left the coast of Africa on June 25 2021. After forming on June 28 in the Main Development Region, it began rapidly intensifying as it moved west through the central tropical Atlantic. On July 1, Beryl made landfall on the island of Carriacou, Grenada, as a high-end Category 4 hurricane, causing total devastation. In Saint Vincent, the Grenadine islands of Union Island, Mayreau Canouan, Mustique and Bequia were severely impacted. We were contacted soon after the hurricane by the Ministry of Transport and Works in Saint Vincent with the request to assist them in the damage assessment after Hurricane Beryl. We contacted several organizations (e.g. UNOSAT) to obtain the latest damage surveys and we communicated these to them, such as:

- COPERNICUS Emergency Mapping Service carried out damage assessment after major events[5].
- UNOSAT carried out an analysis for the Grenadines[6]

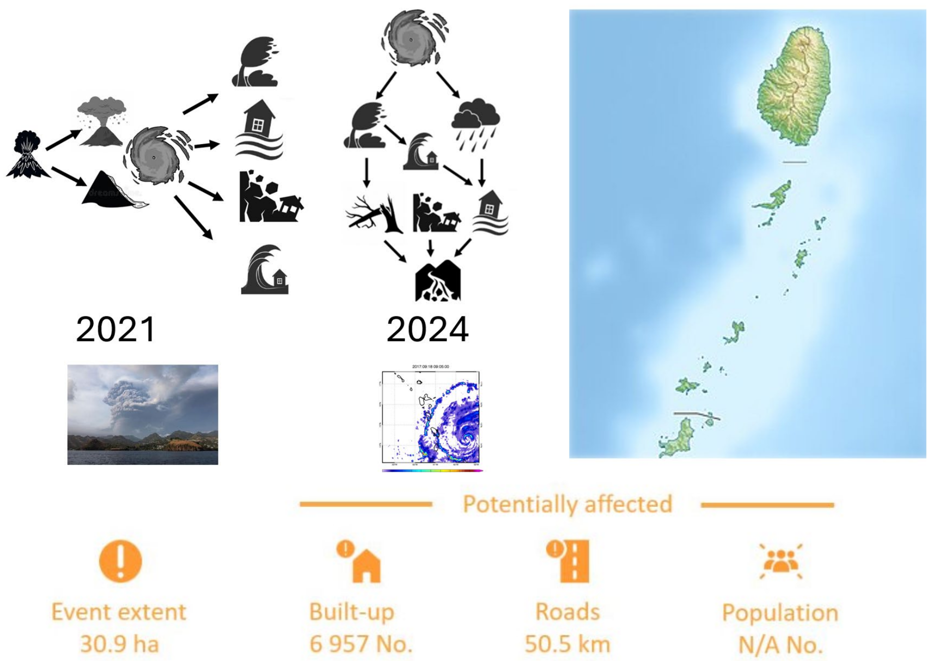

Figure 3.1.9: Graphical representation of the multi-hazard impacts in Saint Vincent and the Grenadines in the past five years. In 2021 the country was impacted during COVID-19 by a volcanic eruption, followed by extreme rainfall, causing a series of compounding events. In 2024 the country was impacted by Hurricane Beryl, which mostly hit the Grenadine islands between Saint Vincent and Grenada. Below: Preliminary damage assessment by UNOSAT.

[5] Check out the storyline on: https://storymaps.arcgis.com/stories/31e195796bf144fea3e6940092e2a022
[6] https://experience.arcgis.com/experience/15d1a500763d42ad94c0f39500f46ac7/page/UNOSAT/?views=Home

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During the CDM13 conference, we had a meeting with the director of NEMO for Saint Vincent and the Grenadines. The director agreed to host student fieldwork in Saint Vincent in early 2025. The director mentioned that St Vincent is at the point of becoming a member of the Disaster Charter but that they still lack the capacity to utilize the information that will come to them. Therefore, it was decided that the PARATUS project would provide them with 1 or 2-day training. Training was indicated before as a potential impact in the proposal document of the PARATUS project. PARATUS partners DLR (Christian Geiß, as their organization is also involved in emergency mapping), AIT (Manzul Hazarika, who carries out work for Sentinel Asia), 510 (Marc van den Homberg), with the EU ERCC (Tim Peirs, Arjen Hijlkema) will provide input in such an online course in spring 2025. We also developed a case study on Multi-Hazard Risk Assessment for Saint Vincent, and used this in a Winter School “From Single Hazards to Multi-Hazards and Systemic Risks: Scientific, Operational, and Communication Perspectives” for the EUMA project (https://civil-protection-knowledge-network.europa.eu/projects/euma). Within this course, an exercise was developed to demonstrate the use of Geographic Information Systems for Multi-Hazard Risk Assessment, with Saint Vincent as a case study. We aim to also use this in a follow-up course in Saint Vincent itself (Figure 3.1.8).

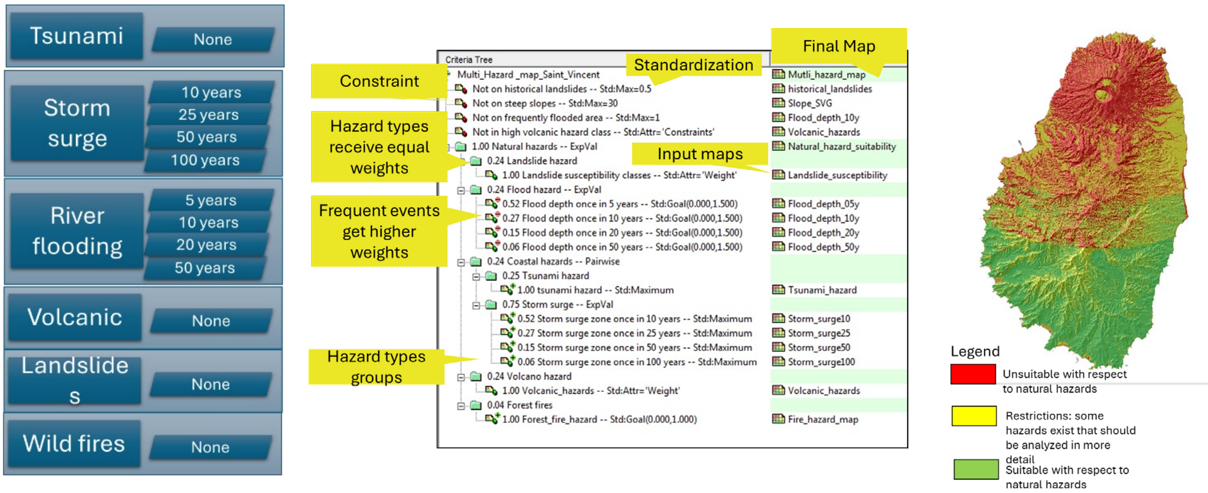

Figure 3.1.10: Summary of the Multi-Hazard Assessment using Spatial Multi-Criteria Evaluation for Saint Vincent.

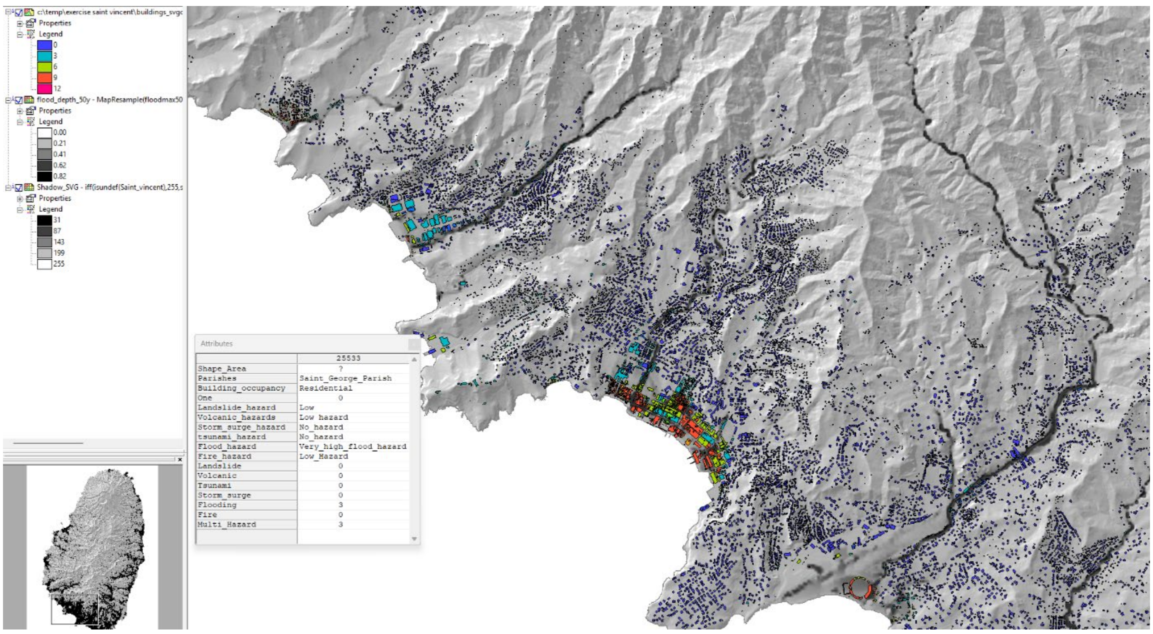

Figure 3.1.11: Example of a multi-hazard exposure analysis for Saint Vincent.

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3.1.2 Follow-up planning

In the coming period, we are planning several activities related to the Caribbean case study, i.e. multi-hazard risk assessment, impact-based forecasting and space weather workshop.

Multi-Hazard Risk Assessment:

At the regional level we will be further working with the Regional Technical Working Group on Risk Assessment, under CDEMA, to complete the Regional Framework on Multi-Hazard Risk Assessment in the Caribbean. The report is currently in the review phase. Several online meetings of the working group will be organised before the Framework will be officially presented in a workshop with online participation, most probably in Barbados.

Linked to this national scale multi-hazard risk assessment activities are underway in several countries. PARATUS will support the national organisations involved, and provide short training. The assessment in Sint Maarten was already completed with the support of 510. In Saint Vincent, we are working together with AIT to develop a case study on multi-hazard risk assessment for Saint Vincent that will be used as one of the demonstration case studies of the newly developed RiskChanges tool. In Dominica, in collaboration with the ESA EO4MULTIHAZARDS project, we are planning to continue the research with several MSc students that will focus on:

- Further development of the Digital Twin for Dominica;
- Analyzing changing exposure levels related to development planning
- Development of a method for building characterization using AI technology
- Analysing the resilience of the transportation network.

In Trinidad and Tobago, we are discussing with the Office of Disaster Preparedness and Management to support them in capacity building for national-scale multi-hazard risk assessment.

Impact-Based Forecasting

In the coming period the activities to come to an Impact-based forecasting platform for the Caribbean will be intensified. Discussions are ongoing with UNDRR, and with PIRAC (French Red Cross in the Caribbean). Also, WMO and regional expert organisations, such as CIMH and CDEMA will be involved. NRC 510 will lead this activity and workshops will be held in the region to concretize this work further.

Space-weather

KNMI is planning to organize a workshop on space-weather impact in the coming period, in which also the Caribbean will have a special emphasis, especially in relation to the vulnerable telecommunication system.

3.1.3 Conclusion

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 regional Framework for Multi-Hazard Risk Assessment (with UT-ITC as the main partner), the development of a multi-hazard early warning and impact-based forecasting dashboard (NRC 510 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 a key stakeholder), PIRAC (French Red Cross in the Caribbean), UNDRR, Caribbean regional organisations, and Caribbean National Disaster Management Authorities and Red Cross branches. Apart from the humanitarian sector, also other sectors will be considered, such as tourism, and the telecommunication sector.

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3.2 Brenner Corridor, Alps, Austria

From April 2024 to January 2025, substantial progress was achieved at the Application Case Study Alps in stakeholder engagement, outreach efforts, forensic analysis of past events, and enhancing data accessibility. In April 2024, the PARATUS Alps team presented their work, including “Geomorphic Hazards and the Imperative of Multi-Hazard Assessment for Road Infrastructure in Mountain Areas,” at the EGU conference. Outreach efforts targeted diverse communities and sectors to raise awareness and gather input, e.g. consulting with emergency responders at the EENA or the Interpraevent conference. Other outreach opportunities included more in-depth discussions about the diverse natural hazards within the Alps study site, in the context of a young geomorphology meeting in May, reaching an early carrier scientists’ community. Furthermore, from April onwards the planning for the stakeholder workshop scheduled for November 2024 began. In June, efforts intensified to prepare for the upcoming workshop, while in August 2024, the focus shifted towards the development of serious games, accompanied by numerous meetings to refine the approach on how to best include practitioners within this social simulation. The project's General Assembly in October 2024 brought clarity to key aspects, setting the stage for the stakeholder workshop in November 2024. During the snow-free period around and after the workshop, data collection on gravitationally induced processes was carried out across the Alpine study site, marking a significant step in receiving some primary data for detailed topographic studies and visits to sites of past hazardous events that have previously not been seen on site. Through close collaboration between the Application Case Studies Alps and Istanbul, Philipp Marr supported a Workshop and participated in a conference of the Union of the Municipalities of Türkiye held in Ankara in December 2024. These efforts reflect the project’s ongoing commitment to advancing multi-hazard assessment and fostering collaboration among stakeholders.

3.2.1 Second Stakeholder Workshop

The second stakeholder workshop took place from the 5th to the 6th of November 2024 in Pfons, Matrei am Brenner, Austria. The workshop was jointly organized by the ENGAGE working group of the Department of Geography and Regional Research of the University of Vienna, together with the partners ASFINAG, EURAC, and BFW. The workshop aimed to co-develop the PARATUS platform by getting feedback and discussing the current outcomes of the Application Case Study Alps. Additionally, we deepen the relations with the stakeholders by giving them space for their active involvement. Overall, 36 Stakeholders participated on the first and 26 on the second day. Of these, about 30 have already attended the first stakeholder workshop. Stakeholder organisations represented at the workshop are listed in Table 3.1.

The workshop was composed of seven main parts: 1) introduction with keynote talks, 2) recap by sharing the outcome of the first two years, 3) scenarios, 4) serious games, 5) co-development of the PARATUS platform, 6) Guidelines, 7) Excursion.

Table 3.2.1: Stakeholder organisations presented at the workshop.

Land Tirol Verkehrs- und Seilbahnrecht, AT
ÖBB - Austrian Railway, AT
Transitforum Austria-Tirol, AT
WIrtschaftskammer Tirol, AT
AsTLR Raumordnung und Statistik, AT
Geosphere Austria, AT
Landesgeologie Tirol, AT
Amt für Geologie und Baustoffprüfung, Proviz Bozen, IT
BMK - Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, AT
WLV – Avalanche and Torrent Control Austria, AT
Forstplanung Landesforstdirektion Tirol, AT
Bezirksforstinpektion Steinach, AT

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Introduction and keynote talks

Followed by welcome addresses from the organizers the first part of the morning session was dedicated to keynote talks. The aim was to highlight different spatial scales within the Brenner Corridor as well as covering different hazards, keeping in mind their temporal characteristics, e.g. being a challenge currently and/or in the future. These keynotes should build the base knowledge for the social simulation, as well as for the group work and discussions throughout the workshop itself.

Raphael Spiekermann from GeoSphere Austria spoke about "Managing risks associated with extreme weather events in a changing climate." The presentation focused on key approaches which include spatial modelling, assessing climate risks, and analysing climate impact chains. Landslide activity models integrate infrastructure repair data and climate risks, ranging from low to high, and account for vulnerabilities under different climate scenarios. The Geosphere RiskLab focuses on minimizing short- and long-term risks through continuous learning from extreme events.

The talk by Gernot Hoch (BFW – Bundesforschungszentrum für Wald) with the title "Climate change and invasive species as challenges for protective forests." dealt with the role of protective forests within a changing climate. Protection forests face increasing threats from climate change and invasive species, exacerbated by abiotic stresses like drought, especially at higher altitudes. Trees are more vulnerable to pests, such as Lecanosticta acicola, affecting larch and pine (Latschenkiefern), leading to higher mortality. Management strategies include diversifying tree species and using remote sensing to identify vulnerable areas. Key questions remain about the protective function of standing dead wood and its potential to become a hazard.

Florian Riccabona (LFD - Landesforstdirektion Tirol) focused specifically on the study area of the Application Case Study with "Protective Forest management along the Wipptal/Brenner traffic corridor." Unique challenges along the Wipp valley, a narrow valley with concentrated infrastructure like highways, railways, and residential areas. Aging protection forests on steep slopes require rejuvenation, but management is difficult due to terrain and legal restrictions. Key species include spruce, fir, larch, pine, and birch, but maintaining stable forests is hindered by damages from grazing, rockfall nets, avalanche protection, and other infrastructure.

The last talk by Max Hanke (ÖBB - Österreichsiche Bundesbahnen) with the title "Railway system: Different requirements, different challenges?" explored the role of natural hazards from the perspective of the Austrian Railway Operator ÖBB. Steep slopes, numerous tunnels, and bridges complicate maintenance, with annual work required to remove loose material from the slopes along the Innsbruck – Bozen line. The railway often cuts directly through hazardous areas, encountering torrents, floods, and debris. Windthrow and wildfires, exacerbated by Föhn winds and dry conditions near Innsbruck, are additional threats. Cooling systems and heat-monitoring technologies help prevent wildfire incidents.

Recap - What happened since the last workshop in the PARATUS project

To share the progress in the project, we organized three talks. First, Flora Höfler (ASFiNAG) talked about ''What happened since the last workshop along the Brenner Corridor?", second, Thomas Glade, the application case study leader presented an update on the PARATUS project, and third, we invited the ISTANBUL application case study leader to share their experience with the stakeholders in the Alps.

Flora Höfler presented that the Wipp Valley faced significant hazards, including windthrow damage, flooding, and debris flows, as well as snowfall paralyzing the Brenner highway A13. A debris flow on the A13 and rockfalls caused further disruption. These cascading events underscore the need for improved communication, collaboration and monitoring.

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Thomas Glade and Philipp Marr presented an update on the PARATUS project to the stakeholders. The objective was to show how the results and inputs during the last stakeholder workshop in early 2023 were utilized and have been achieved until now. In the beginning, a wrap-up of the last stakeholder workshop and the main contents were presented, which comprised past hazardous events in the Brenner Corridor, the concept of impact chains, stakeholder involvement and data availabilities. Following this, it was presented which impact chains were developed on the basis of the stakeholder input of the last workshop and which data we collected and stored since then. Also, a smaller stakeholder workshop in November 2023 was held with single interviews with stakeholders, where the development of impact chains of various events was discussed.

In order to widen the scope and to show other insights into the PARATUS projects, we connected the Alps to the Istanbul Application Case Study. Seda Kundak, Istanbul Application Case Study leader, introduced the participants to the characteristics of Case Study Istanbul and the Marmara Region which was affected by a major earthquake in 1999 and is the smallest but most populous of Türkiye's seven geographical regions. In addition to these parts, the results of the last stakeholder workshop in Istanbul were presented, which was followed by a discussion with the stakeholders at the workshop.

Workshop in Istanbul: Two mobility scenarios were tested to assess Istanbul's preparedness: 1) Earthquake during peak hour with bad weather: Leads to heavy reliance on personal vehicles, 2) Earthquake with favourable weather: Crowds concentrated in the city centre, creating logistical challenges (For more information please see the section on Istanbul Workshop).

Stakeholders were consulted about the impact of the two scenarios on management and logistics in the Istanbul Workshop. Moving forward, workshops at the district level will examine how these dynamics affect the overall system.

Scenarios

The first active involvement of all stakeholders took place within a group work phase. Herein, the participants worked in four different, pre-defined groups in order to develop current and future scenarios regarding different climate scenarios. These four groups were: (1) Traffic and Transport, (2) Tourism and Economy, (3) Security and Civil Protection and (4) Natural Hazards and Environment. The results of the groups concerning the current and future scenarios are the following:

The group Traffic and Transport focused on the preparation of infrastructure at risk. In this context, guidelines established in advance were mentioned as crucial, such as diverting traffic onto alternative routes, for example, rerouting via the Tauern instead of the Brenner. A key priority was also the full utilization of infrastructure, even if this meant closing roads for necessary repairs. To better assess situations, real-time information is essential, with cameras being one tool for this purpose. The question raised whether the increase in incidents was truly due to more hazardous events or if it was simply because more reports were being made. The risks involved not only threatened the infrastructure itself but also the safety of individuals. In the worst-case scenario, structural failures could occur, leading to a long-term disruption of infrastructure. On a smaller scale, the entire infrastructure is mentioned to be highly interconnected – an issue at one point could quickly escalate into a major problem. Policies are therefore named beneficial in this context, but they also limit progress in certain areas. Therefore, it is crucial to prioritize and determine what aspects are most important when making decisions.

The group "Tourism and Economy'' identified the worst-case scenario in which all infrastructure is blocked at once, resulting in significant economic damage. The situation in this scenario involves a large number of stranded people and many indirect impacts on neighbouring valleys. Nevertheless, the sectors of tourism and economy are relatively low when compared on a global scale in the Brenner Corridor.

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In the group ‘’Security and Civil Protection’’, the worst-case scenario involved multiple events occurring simultaneously. A key problem identified is hazard-zone maps since they are mostly based on return periods, which turned out to be inefficient and inaccurate for future scenarios due to climate change. Some valleys furthermore can be cut off, with some being better prepared than others, leading to different scenarios and problems. Also, the emergency chain could be at risk of being interrupted.

In the group ‘’Natural Hazards and Environment’’, it was mentioned to be important to consider factors such as bark beetles, wind, heat, and drought. The protection of forests was recognized as one of the main stabilizing measures. Sliding snow avalanches emerged as a new threat. The magnitudes of factors like wind and rain are changing and, therefore, also important to consider. The greatest identified danger in this group comes from cascading and compounding events, which were considered worst-case scenarios.

The discussion boards of the group meetings are listed in the appendix., i.e. Traffic and Transport: Figure A1; Tourism and Economy: Figure A2; Security and Civil Protection: Figure A3; Hazards and Environment: Figure A4.

Serious Games

As part of the workshop, stakeholders had the opportunity to engage in a Serious Game developed within the PARATUS by Michalina Kulakowska from the Centre for Systems Solutions in Wrocław, Poland. Before its implementation, the game underwent an iterative development process involving collaboration between the developers and the Application Site Alps.

In the beginning, the simulation game and all important components were Introduced to the participants. The area of interest for the simulation, Saltun Montem, was shown by a video. The case study coordinating partners agreed during the development of the simulation to create an imaginary area of interest in order to discuss important issues in a different setting due to the politically sensitive character of the setting at the Brenner corridor. In addition, the coordinators also came up with two made-up countries which neighbour each other: Magna – a big country full of important economic factors and Altum – a smaller country in the South where tourism and industry are the most important economic sectors. After introducing the set-up and the objectives of the game, the participants were divided into four groups (e.g. logistics, authorities), and the roles were chosen randomly (Fig. 3.2.1). The goal was to give the participants the possibility to change their perspectives and try to understand the views of different stakeholders. Throughout the game, the different groups were confronted with different developments along the route between the two imaginary states, such as natural hazards, etc., and they had to decide what to do. The idea was to discuss within the group, develop new ideas for the area, vote for ideas of all groups and reflect on what we did all together in the plenum.

The feedback session yielded valuable insights and suggestions. Alongside positive comments, several suggestions were made to enhance the game. Participants recommended adding a clearer temporal component to distinguish short-term responses from long-term planning, addressing challenges in discussing long-term decisions within immediate disaster contexts. They also suggested highlighting differences in authority responsibilities at regional and local levels and improving cross-border cooperation representation. It was noted that cost considerations are secondary in emergencies, where immediate response takes precedence. Finally, some participants observed a tendency to link the game too closely with the real-world alpine environment, making it challenging to focus exclusively on the game without reverting to familiar real-life patterns.

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Figure 3.2.1: Stakeholders working in groups during the social simulation (Source: Andlinger, 2024).

Co-designing DRS hub

The PARATUS project started by aiming to create an open, online, user-centred platform for systemic risk assessment, and we combined forces with several multi-hazard projects funded by the European Union. Several multi-hazard projects have converged under the DRS (Disaster Risk Stakeholder) Hub platform, instead of being organized within a dedicated PARATUS hub. Current tools for risk assessment are limited and do not adequately support multi-hazard contexts, particularly at the local level. The DRS hub has been co-developed with various stakeholders, the platform addresses evolving risk drivers across physical, socio-economic, and natural environments. The coordinator, Funda Atun, presented the Disaster Risk Stakeholder hub hosted by the CMINE platform.

After showing the DRS hub at the end of the first day, the feedback session continued on the second day as well. The information functions of the DRS Hub were presented as well as the tools developed by the PARATUS project. The applications *www.fastflood.org* and *www.fastslide.org* were presented and feedback and discussion were encouraged. The main focus was on the ability of the tools to work quickly in any application site worldwide, browser based, as a way to support planning but also in case of first emergency response. However, it was also emphasized that the use of these tools requires training, and they do not replace local risk assessment.

Guidelines

The emphasis of the second day was the presentation and discussion of the guidelines, which are the core of D1.4, actionable assessment of hazard interactions in compounding and cascading events. The guidelines are intended to strengthen the uniform and thus comparable handling of multi-hazard interactions and, therefore, serve to implement a better management plan. As a start, the current state of the guidelines was presented during the workshop. For the following discussion purpose, the participants received different cards which they could write on and attach to different categories (hazard type interaction, spatial contexts, temporal contexts). The contributions to the different categories were the following:

Hazard Type Interaction:

- A cyberattack involving misinformation impacts volunteer work and influences people's willingness to help. Scenarios and simulations are helpful to be played through to better understand the situation.

- Natural hazards, both biotic and abiotic, are represented in various types, with particular attention given to cascading and compounding events.

Spatial Context:

- All scales, from global to local are mentioned.

Temporal Context:

- The daily, weekly, seasonal, and annual course of hazards and exposure/vulnerability is observed to be most important, such as traffic volume and late cold snaps.

Topic communication of hazards/risks: ÖBB, ASFiNAG & BMK - different channels and immediacy of threats (e.g. warning of natural hazards vs. warning of traffic jams). Following this interactive feature, a survey was undertaken to get a notion of how guidelines are used by the stakeholders and what their expectations therein are. The survey results are presented in more detail within Deliverable 1.4.

With this lively discussion and a wrap-up of the second day of the stakeholder workshop, as well as a glimpse into the future plans of the Application Case Study, the working part of the workshop ended.

Excursion

Following this, the participants went on a 4-hour excursion to the Italian part of the Brenner corridor to learn about the important hazards and mitigation strategies and to get some insights into the South Tyrolean hazard and risk management.

1st stop: Brenner See – Lueg Bridge (rockfall)

- There was a discussion of rockfall issues on the western slope/rockface, with the ROLA parking space being endangered. Protection measures, such as a dam, were implemented and proven to be effective.
- Afforestation and (natural) reforestation with larch trees were carried out successfully on the eastern slope as countermeasures above the railway line.

2nd stop: Sachsenklemme

- There was a bark beetle infestation on a very steep, rocky slope, with rockfall and debris flow acting as compounding hazards. A discussion of countermeasures and the geological situation took place.
- A bottleneck occurred with the exposure of the state road and motorway, leading to a fruitful discussion of hazard mitigation and exposure/vulnerability.

3rd stop: Pflerschtal/Reisenschuh

- Fluenerhof was affected by flooding (hyper-concentrated flow) from Pflerschbach, causing a blockage at the bridge over the state road.
- Mitigation measures included raising the bridge, implementing object protection for Fluenerhof by raising the ground level and securing the riverbanks with stone walls (‘Zyklopensteine’).

4th stop: Pflerschtal/Bichl

- A stop outside the operations centre of the volunteer fire department Pflersch (Fig. 3.2.2) was made.
- The structure was built as a heavily reinforced building in the debris flow hazard zone from the OL torrent, with the yellow zone indicating a medium hazard level.
- There was an insight into new ways of implementing mitigation measures, aiming to integrate them in a more stylish way into spatial planning aspects.

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Figure 3.2.2: Protection measure in South Tyrol with a double use (Source: Andlinger, 2024).

5th stop: Innerpflersch

- A review was conducted of the measures taken after several debris flow events in Toffringbach.
- Lateral dams were constructed upstream along the torrent, and the confluence with Pflerschbach was reshaped to allow for more debris deposition downstream and a more acute angle of confluence, reducing the risk of blockage by debris and wood.
- All pipes were directed through the bridge in the newly built structures.

3.2.2 Follow up Planning

As the project advances, the following key activities as well as the upcoming deliverables have been identified as priorities for the next phase:

- Stakeholder Engagement
  Continued collaboration with stakeholders will focus on refining and enhancing susceptibility maps for the Brenner Corridor, with particular attention to landslides.
- Multi-Hazard Risk Assessment
  A comprehensive multi-hazard risk assessment will be conducted for the designated Area of Interest. This will involve extensive fieldwork, including laser scanning and hazard mapping, to ensure a detailed understanding of potential risks within the Brenner Corridor close to the Brenner Pass.
- Platform Testing
  The “Disaster Risk Stakeholder Hub” platform will undergo testing with end-users to evaluate its functionality, usability, and effectiveness in supporting disaster risk management activities.
- Scenario Development
  Scenarios addressing critical challenges, such as the impacts of climate change and network disruptions (e.g., consequences of blockages), will be developed. These scenarios will incorporate tools like network analysis to explore potential outcomes and inform decision-making.
- Deliverables
  Especially Deliverable 2.1 focuses on the guidelines for systemic multi-hazard and multi-sectoral risk assessment as the focus for the next phase. Also, the contribution Deliverable 2.2, a Report of scenarios for future changes in terms of hazard, exposure and vulnerability based on drivers and pressures, is in development. Furthermore, collaborative work on Deliverable 3.4 on Serious Games is done.

These steps aim to advance the project’s objectives, enhance collaboration with stakeholders, and improve the tools and methodologies for disaster risk management in the Brenner Corridor.

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3.2.3 Conclusion

The second stakeholder workshop of the Alps Application Case Study from the 5th to 6th of November 2024 took place in Pfons, Matrei am Brenner. The interaction with the stakeholders went very well also, as most participants were already present during the first workshop and, therefore, knew each other and the project. The stakeholders provided very valuable feedback and presented different views, which stimulated discussions. New ideas were developed, and new perspectives could be taken, especially concerning the development of the guidelines for D1.4. The aim of the workshop was to get engaged with the stakeholders again, present the current status of the Application Case Study and the project and get feedback on these issues.

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3.3 Istanbul, Türkiye

The series of workshops within the Istanbul Application Case Study commenced with a kickoff meeting involving representatives from the directorates of the Istanbul Metropolitan Municipality (IMM) in December 2022 followed by the stakeholder meeting in June 2023. The findings highlighted two primary approaches for further investigation: sectoral and local foci. Engagements with the Chamber of Commerce and Industry enriched the understanding of sectoral exposure, emphasizing the vulnerability of business activities in Istanbul and the distribution of hazardous facilities that could trigger Na-Tech (natural-technological) hazards. Additionally, the workshop outcomes underscored the critical role of local dynamics at the district scale, which significantly influences the functionality and responsiveness of the provincial system in disaster scenarios (Figure 3.14).

The workshop scheduled for September 2024 was specifically designed to investigate sub-scale probable failures under stress conditions. Avcılar district, identified as the most severely affected area in Istanbul during the 1999 Kocaeli Earthquake, was selected as the optimal location for this analysis. Building on the earthquake scenarios utilized in the previous workshop (Deliverable 1.1), the scenarios were revised to align with the workshop's objectives. During the session, the Disaster Risk Stakeholders Hub was introduced to participants, and interviews were conducted to gather valuable insights.

Between April 2024 and January 2025, PARATUS-related research activities are twofold: accomplishment of impact chain analysis and forensic analysis of the Kahramanmaraş earthquakes, and presentation of the preliminary outcomes in scientific conferences and meetings. The 2023 Kahramanmaraş earthquakes, with magnitudes of Mw 7.7 and Mw 7.6 on February 6 and Mw 6.4 on February 20, serve as a case study for forensic disaster analysis. These earthquakes devastated 11 provinces in Türkiye, affecting 14 million people, resulting in over 53,000 fatalities, more than 100,000 injuries, and displacing approximately 450,000 residents. Using official records, advanced research, and field observations, the analysis focused on failures in infrastructure, economy, and population resilience. Pre-disaster vulnerabilities, multi-hazard impacts, and response and recovery efforts were assessed, with particular attention to systemic risks and cascading failures that exacerbated the disaster's effects. During the reporting period, PARATUS-Istanbul team attended SRA-Europe Conference held in Athens (Greece) in June with the presentations entitled “Temporal and Spatial Seismic Risk Scenarios of Istanbul” and “Forensic investigations aftermath of Kahramanmaraş earthquake sequence, 6th February 2023”; ASCE Conference held in Antalya (Türkiye) in November with the presentations entitled “Socio-economic Impacts of a Probable Earthquake in Istanbul: A Neighborhood-Level Analysis”, “Na-tech Risk Assessment of a Probable Istanbul Earthquake: A Neighborhood-Level Analysis”, “Post-disaster Migration Pattern in Hatay”, “Examining the Market Prospects for Sustainable Property Development in Disaster Recovery Zones”, “ Effects of Vulnerability and Exposure on Impact Chain of 2023 Kahramanmaraş Earthquakes” and “Co-development of Seismic Stress Testing Scenarios for Avcılar District of Istanbul”; and IDRC Conference held in Ankara (Türkiye) in December with the presentation entitled “Forensic Analysis of Kahramanmaraş Earthquakes”. Furthermore, in the IDRC conference, a special pre-conference workshop was organized by the PARATUS-Istanbul team between December 14-15 with the contribution of Iuliana ARMAŞ and Cosmina ALBULESCU from University of Bucharest (Bucharest case study of PARATUS) and Philipp MARR from University of Vienna (Alps case study of PARATUS).

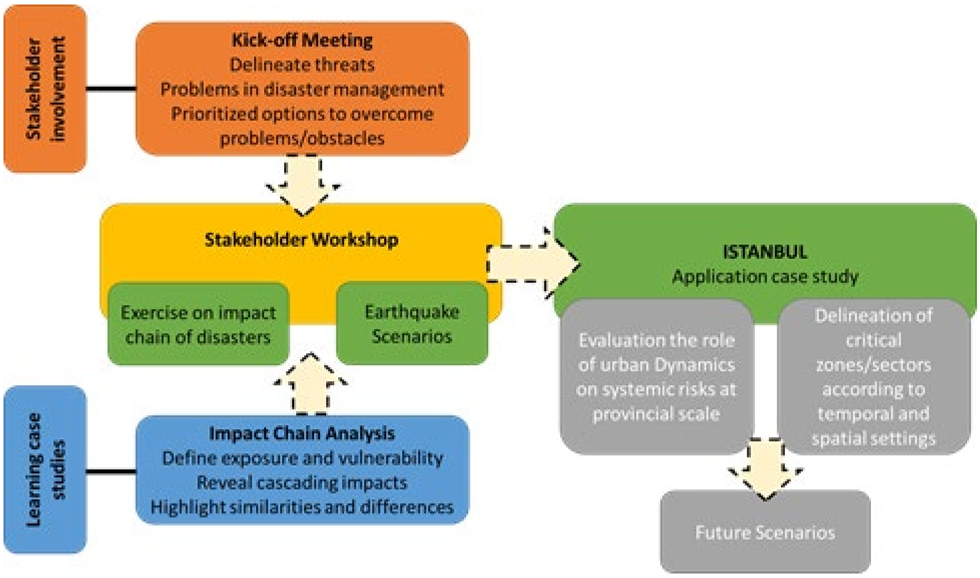

Figure 3.3.1: Flow chart of the contribution of the workshops to the Istanbul Application Case Study.

3.3.1 Update

This section includes the scenarios, problem areas, solution proposals, and post-earthquake process analyses discussed during the PARATUS Project Avcılar Workshop held on September 24, 2024. The workshop focused on a potential major earthquake scenario in Istanbul, with spatial, sectoral, and systemic analyses of the cascading impacts of the disaster specifically in Avcılar district. The primary purpose of the workshop was to introduce the Disaster Risk Stakeholders Hub, prepared within the scope of the project, to participants, and to identify risk areas and their causes at the district level. In addition, different earthquake scenarios were analyzed to assess systemic and sectoral risks, and the effects of potential hazards were discussed. The workshop aimed to develop concrete and feasible proposals to mitigate the predicted risks. Throughout the process, the goal was to strengthen disaster management strategies through the active participation of stakeholders and expert opinions.

The workshop was organized in collaboration with the Istanbul Metropolitan Municipality (İBB) and Istanbul Technical University (İTÜ), with the participation of 87 attendees. Representatives from various universities, local governments, public institutions, and non-governmental organizations located at Avcılar attended the workshop. Furthermore, Aynur KADIHASANOĞLU (Red Cross Red Crescent Climate Centre) and Serge MONTURET (FI Group) attended to facilitate and interview with stakeholders on the different aspects of the PARATUS Project, during the workshop. The purpose of the workshop was to systematically analyze Istanbul's earthquake risks and post-disaster response processes.

3.3.2 Methodological Approach

The workshop program began at 9:00 AM with participant registration and continued with welcome speeches (Figure 3.3.2) (Appendix 2). An introduction to the PARATUS Project and the Disaster Risk Stakeholders Hub was given (Figure 3.3.3). The first session, titled "Mapping Risks in Avcılar," followed by the second session, "Stress Test Scenarios for Avcılar,". The third session covered group presentations (Figure 3.3.4). As a result, the discussions conducted during the later stages of the workshop were enriched and deepened by leveraging the individual experiences and expertise of the participants.

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Figure 3.3.2: Welcome Speeches (Murat YÜN – Istanbul Metropolitan Municipality / Head of Department of Earthquake Risk Management and Urban Improvement; Utku Caner ÇAYKARA – Mayor of Avcılar District; Dr. Rıza Evren KILCI – Vice-Mayor of Avcılar District).

Figure 3.3.3: Presentations (Presentation of PARATUS by Prof. Dr. Seda KUNDAK; DRS Hub by Assoc. Prof. Dr. Kerem Yavuz ARSLANLI; Stress Tests by Assoc. Prof. Dr. Çağlar GÖKSU AKKAYA).

Figure 3.3.4: Group picture.

Focus Group

In the workshop, six discussion groups were organized, and each group was moderated by experts in their respective fields. Career forms were distributed to the participants. Out of 87 participants who attended the workshop, 62 of them filed the career forms in 6 different groups. These forms revealed participants' experiences with past disasters, particularly earthquakes, floods, and inundations (Appendix 3). Before the sessions began, participants filled out the career forms specifying their experiences and roles related to disasters. In this form of design, the types of disasters experienced by the participants were clearly categorized. Earthquakes, floods, fires, floods, landslides, tsunamis, snow, pandemics, fire and terrorism were specified as different types of disasters, and for each type of disaster, the level of experience of the

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participants was examined. In addition, the tasks that the participants preferred to undertake during a disaster were categorized as mitigation, preparedness, response, recovery, research/data generation, policy making, communication, organization and administration/management. In this context, 82% of the total participants had some earthquake-related experience, while around 50% of these people stated that they took part in field operations. In all groups, the majority of the participants stated that they had been on a mission on the 1999 Kocaeli Earthquake and Kahramanmaraş Earthquakes. This provides an important reference point on what kind of background the participants have in disaster management.

Each group had data from a specific type of participants and this data showed the experience levels and the diversity in their tasks. While the majority of participants in Group 1 and Group 2 emphasized their experience with earthquakes, more than half of them preferred to undertake organizational tasks. In Group 3, on the other hand, it was observed that besides various earthquakes, experiences related to the COVID-19 pandemic were more common and recovery tasks were preferred more frequently. In another example, although Group 4 included participants with less disaster experience, this group seemed to have undertaken, especially response and organization tasks. At the same time, Group 5 participants did not have a common experience with a specific type of disaster, and no role stood out in their task preferences compared to other groups. Group 6 participants, on the other hand, had experience in a wider range of disaster types and their task preferences seemed to focus on organization. As a result, the career forms showed the types of disasters and job descriptions experienced by the participants and explained their general tendencies in the field of disaster management.

Mapping Risks and Stress Testing of Scenarios

In the first session, participants were asked to focus on areas in the Avcılar district that could potentially increase earthquake risk and hinder intervention activities. These areas, identified and mapped by participants, along with their risk factors, are detailed in each group.

In the second session, participants worked on a stress test scenario involving extreme weather conditions and earthquakes impacting Avcılar. For each of the six groups, different scenarios were presented, with each scenario changing within the first 72 hours to reflect the evolving conditions (Appendixes 4 and 5). These scenarios were based on different seasons, times of day, and weather conditions (Figure 3.3.5). The focus was on how these scenarios would evolve over the 72-hour period following a 7.0+ magnitude earthquake off Istanbul's coast, followed by multiple aftershocks.

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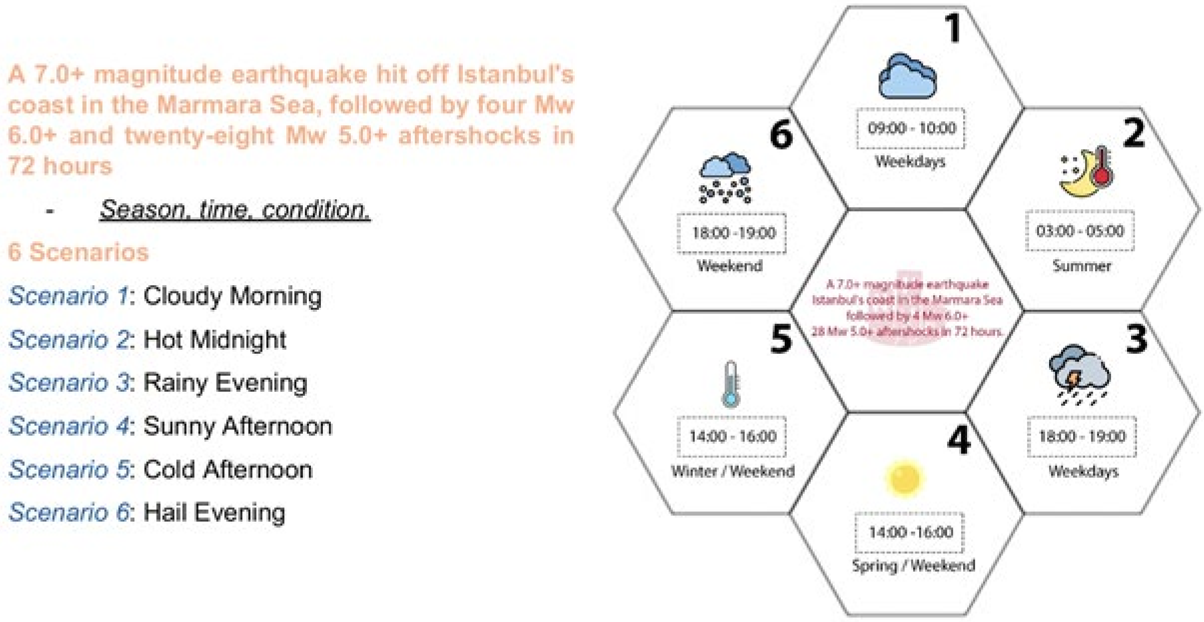

Figure 3.3.5: Season, Time and Condition of Scenarios.

Group 1 scenario, a major earthquake with a magnitude greater than Mw 7.0 has occurred in the Sea of Marmara, off the coast of Istanbul. Within the first 72 hours following the earthquake, four aftershocks above Mw 6.0 and twenty-eight aftershocks above Mw 5.0 were experienced. The earthquake occurred on a weekday morning, around 9:00-10:00 AM, when employees were arriving at their workplaces and students were in class. The weather was partly cloudy with no rain expected.

Group 2 scenario, a major earthquake with a magnitude greater than Mw 7.0 occurred in the Sea of Marmara, off the coast of Istanbul. Within the first 72 hours following the earthquake, four aftershocks above Mw 6.0 and twenty-eight aftershocks above Mw 5.0 were experienced. The earthquake took place between 3:00 and 5:00 AM during the months of July and August when the population was mostly asleep in densely populated residential areas. Temperatures were above seasonal norms, and a new heatwave was expected in the coming days.

Group 3 scenario, a major earthquake with a magnitude greater than Mw 7.0 occurred in the Sea of Marmara, off the coast of Istanbul. Within the first 72 hours following the earthquake, four aftershocks above Mw 6.0 and twenty-eight aftershocks above Mw 5.0 occurred. The earthquake took place on a weekday evening, around 6:00-7:00 PM, during rush hour when the population was at its highest. The weather conditions further exacerbated the situation, with strong rains forecasted to continue, and warnings were issued for flooding and flood risks in some parts of the city.

Group 4 scenario, a Mw 7.0+ earthquake occurred off the coast of Istanbul in the Marmara Sea, followed by four Mw 6.0+ and twenty-eight Mw 5.0+ aftershocks within the first 72 hours. The earthquake took place in the spring, on the weekend, between 14:00 and 16:00. The affected areas with high population density included the coastline, parks, forests, shopping malls, theatres, and cinemas. The weather conditions were sunny, typical of the early days of spring.

Group 5 scenario, a Mw 7.0+ magnitude earthquake occurs during the winter months at midday, followed by an environment characterized by snowfall and cold weather conditions, which severely complicate emergency response efforts and sheltering needs. Within the first few hours, aftershocks ranging from 4.0 to 6.0 in magnitude are expected.

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Group 6 scenario, an earthquake of Mw 7.0 occurred on a Monday in September between 08.00 and 09.00 hours. The roads are busy, summer residents are returning to the city, and there is light rainy weather. Hail is expected in the following hours. On the same day, a few hours later, there was an aftershock of Mw 6.

In the continuation of the workshop, participants were guided through a detailed analysis of the first impact of the earthquake and subsequent events on the Avcılar. Participants would evaluate the impacts in terms of vulnerability, exposure, and the sectors most affected. Figure 3.6 emphasizes the timeline of consequences, breaking it down into immediate, short-term, and long-term phases. The different timeframes (1-2 hours, 24 hours, 72 hours, 15 days, 3 months, and beyond) help participants assess how the impact evolves across various systems, regions, and sectors over time. By considering how these factors interact in both the short-term and long-term, the workshop aims to foster a deeper understanding of disaster response and recovery planning in the context of this specific earthquake scenario. This session would guide discussions on which sectors and regions are most vulnerable in each timeframe and how emergency management can adapt to evolving conditions, helping ensure a more effective and strategic approach to disaster risk management.

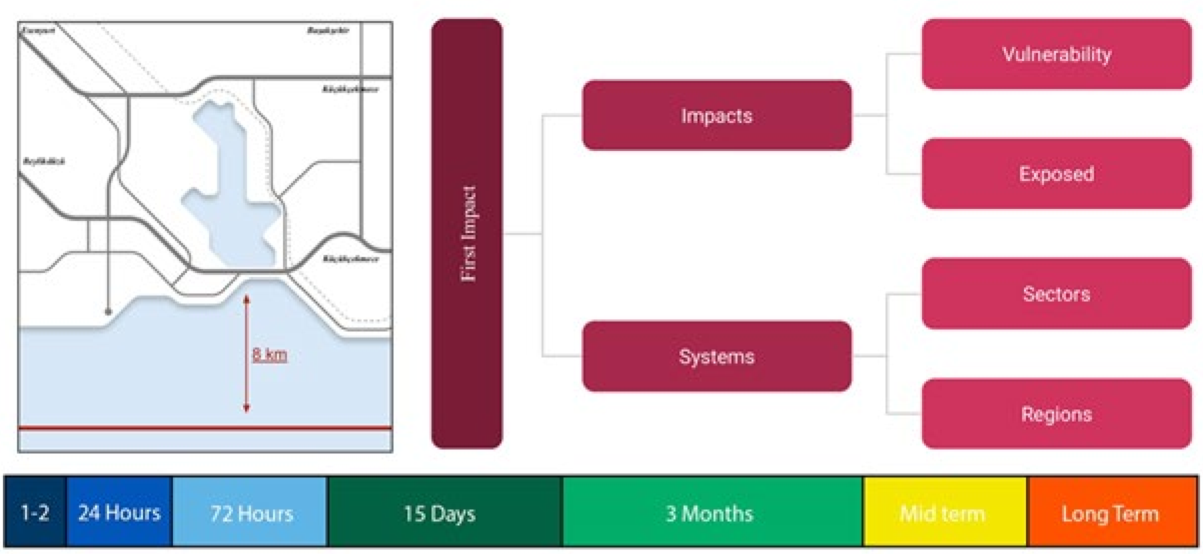

Figure 3.3.6: Stress Tests for Avcılar District.

3.3.3 Key Results

In Group 1, the analysis highlighted the potential for a tsunami in the Sea of Marmara and its significant impact on the district's coastal areas, including challenges to emergency response. Landslides around Küçükçekmece Lake, Gümüşpala, and Ambarlı pose risks to infrastructure, increase casualties, and cause road closures, complicating debris management and emergency accessibility. Flood risks near Küçükçekmece Lake and soil amplification issues south of the E-5 highway could heighten earthquake damage. Legal deficiencies in building inspections and zoning, particularly in Yeşilkent, Firüzköy, and Mustafa Kemal Paşa, further exacerbate vulnerabilities. Fire and explosion risks were noted in Firüzköy and Ambarlı industrial zones. Environmental concerns include potential damage to critical facilities like the İSKİ Treatment Plant and Ambarlı Thermal Power Plant, along with significant structural vulnerabilities in neighbourhoods like Cihangir. Social risks involve migrant populations, campus safety, post-disaster security issues, and accessibility challenges to vital locations like Avcılar State Hospital. Mapped risk areas emphasized limited north-south connectivity, increasing vulnerabilities if key routes are disrupted. Additional concerns include rooftop base station damage, power outages, high casualties, insufficient resources to support vulnerable groups, overwhelmed hospitals, and post-disaster public health challenges. These vulnerabilities collectively underscore significant pressures on emergency and recovery operations (Figure 3.3.7a).

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The scenario of Group 1 is the occurrence of an earthquake on a weekday morning, around 9:00-10:00 AM, when employees were arriving at their workplaces and students were in class (Figure 3.3.7b). **In the immediate aftermath** of the disaster, the district is in shock and chaos. Widespread destruction has forced people to evacuate, while vulnerable groups like the elderly and disabled remain trapped. Roads are blocked, communication is down, and survivors desperately seek news of loved ones. Emergency response is severely hindered by collapsed buildings, injured personnel, and fires caused by industrial explosions. Water contamination has begun due to damage at the treatment plant, and a landslide near Küçükçekmece Lake has worsened the destruction. Children and teachers are frightened, with many schools unprepared for such emergencies. While some wait in safe areas, the overall sense of panic and uncertainty continues to grow. Aftershocks continue to cause building collapses, heightening fear and anxiety. Many families remain separated, adding to the emotional distress. Fires rage in inaccessible areas due to blocked roads and unavailable firefighters, resulting in further loss of life and property. Crowded neighborhoods, some without designated gathering areas, avoid evacuation sites, leading to security concerns. Ambulance services are overwhelmed, and injuries are being treated directly at debris sites. Hospitals are at full capacity, urgently requiring the establishment of field hospitals to manage the crisis.

Medium Term (First 72 Hours): Access to drinking water, food, and hygiene products is increasingly challenging, with growing needs for portable toilets and shelter. Many people remain near their homes, anxiously awaiting news of loved ones trapped under rubble and hoping to recover belongings. Security issues are escalating, particularly for children separated from their families, as tracking their placement in safe areas proves difficult. The lack of cold storage for deceased victims complicates burial processes, while road closures hinder medical care for the injured. Hospitals are overwhelmed by insufficient staff, beds, and equipment, and psychological support is in high demand. Individuals with special medical needs are struggling with disrupted treatment and medication supply. Support is urgently needed for vulnerable groups, including the foreign population in specific neighborhoods. In the first 72 hours, family members and neighbors lead initial rescue efforts, joined gradually by AFAD, local teams, NGOs, and international organizations. Firefighters and search-and-rescue teams from neighboring provinces are beginning to provide critical assistance where access is possible.

Medium Term (First 15 Days): In the aftermath of the earthquake, numerical data and damage assessments are beginning to shape response efforts. Work is underway to restore transportation infrastructure and guide people to temporary shelter areas. Needs analyses are being conducted, while logistics storage areas are established through collaboration among public entities, international organizations, and the private sector. Supply chains are being organized for essential resources such as food, water, shelter, healthcare supplies, and clothing, with psychological support experts also on-site. However, systemic risks are emerging, as Avcılar’s reliance on external food supplies is strained by road closures, raw material shortages, financial constraints, and personnel losses. Disruptions in logistics processes threaten interconnected sectors like energy, water, and healthcare. Additionally, management challenges, including unclear authority and gaps in responsibility, risk compounding the crisis.

Long Term (3 Months and Beyond): As the response progresses, challenges such as limited space, financial constraints, and improper debris management are complicating the establishment of temporary housing areas. These issues disrupt access to food, education, healthcare, security, and sanitation, increasing systemic risks. Inadequate debris removal, including a lack of teams, equipment, and disposal sites, raises environmental and public health concerns, such as soil loss, water contamination, and asbestos exposure. Efforts are underway to resume education and establish temporary housing as autumn rains begin. Unemployment is becoming more apparent, and aid is gradually diminishing. Planning for new jobs and living areas is critical as the district moves toward recovery. Debris removal and reconstruction have started, focusing on earthquake risk mitigation and long-term resilience. Psychological support remains vital, while public and private sector collaboration seeks to restore business continuity and help the community heal. The earthquake's local and global impact is beginning to fade, marking the acceptance phase of recovery.

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Measures to Be Taken and Solution Proposals: Participants analyzed potential risks across short, medium, and long-term scenarios and proposed measures to reduce post-earthquake risks and improve response capacities. Key recommendations include prioritizing urban transformation to minimize physical risks and addressing legal gaps through improved regulations. Clearer authority and responsibility sharing among local governments, along with the involvement of local representatives (muhtars), were highlighted to enhance governance. Infrastructure capacity should be strengthened, gathering areas increased, and tsunami evacuation corridors kept accessible, with public awareness raised for all measures. Public-private partnerships and expanded air transportation, integrated into emergency road networks, are essential for better logistics. Advanced technologies like artificial intelligence and digital twin models are proposed for risk assessments and prioritization. Securing landslide and flood-prone areas, ensuring continuity at critical intersections, and fortifying the administrative network are also crucial steps for long-term resilience.

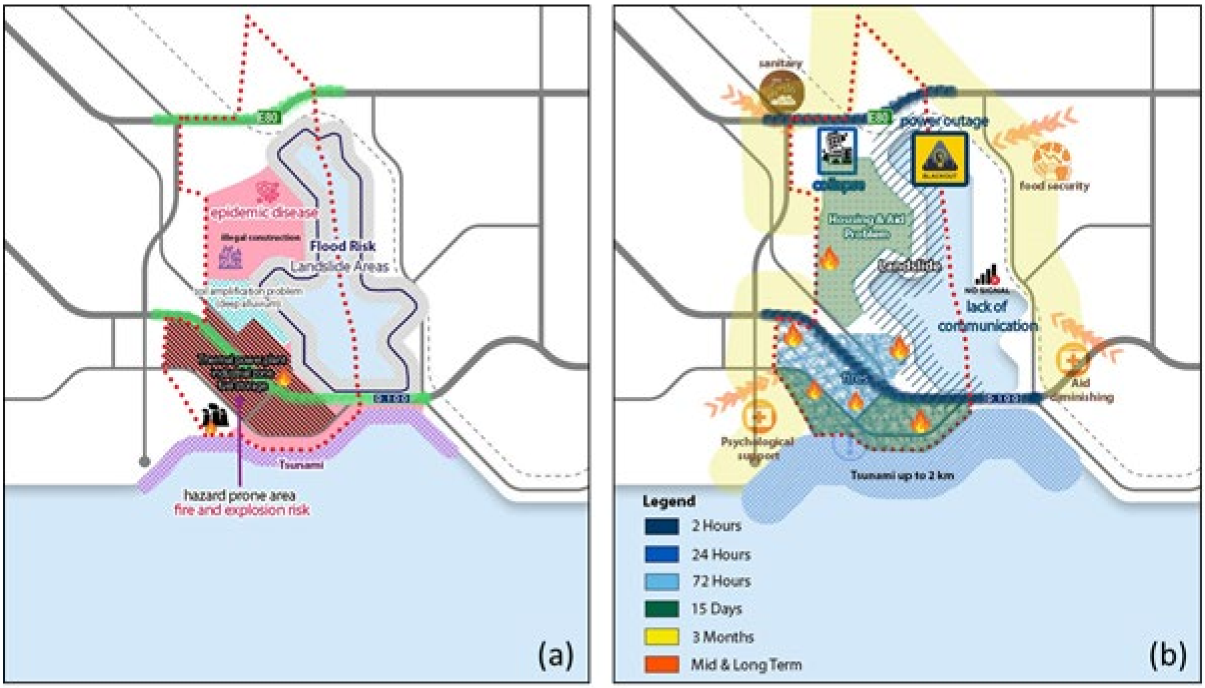

Figure 3.3.7: Risk map (a) and scenario analysis (b) of Group 1.

Group 2 highlighted key risks and vulnerabilities in Avcılar District. Firuzköy and areas around the lake were identified for their ground issues, while Yeşilköy and Tahtakale were noted for informal settlements and marshland vulnerability, respectively. Ambarlı, a landslide zone with high-rise buildings, faced significant damage in the 1999 Kocaeli earthquake and poses explosion and fire risks due to industrial facilities. Major transportation axes, like the E-5 and the highway, experience heavy traffic and are surrounded by old or industrial buildings, increasing risks during emergencies. Esenyurt and Yeşilkent were undergoing partial urban renewal, though comprehensive transformation is lacking. Areas like Mustafa Kemal Paşa (Parseller) and Avcılar Center face high building densities, ageing structures, and limited green spaces, while the University Neighborhood was noted for its strong ground conditions and resilience in past earthquakes. Infrastructure issues, including streetlight failures, prolonged power outages, and traffic congestion, exacerbate vulnerabilities. Social challenges include a significant disabled population, high costs for determining building performance, and insufficient communication about structural assessments. Despite these risks, Avcılar's residents generally have higher education levels compared to neighbouring districts. A single public hospital serves the area. The Avcılar A0 map (Figure 3.3.7a) visualized tsunami, landslide, and soil risks, aiding in identifying critical areas and formulating targeted intervention strategies.

Scenario of Group 2, the earthquake occurs place between 3:00 and 5:00 AM during the months of July and August (Figure 3.8b). In the first 2 hours after the earthquake, buildings along the E-5 line collapsed, and the E-5 road was closed. Explosions occurred at filling facilities in Ambarlı. There were leaks in industrial areas.

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Summer houses around Silivri experienced collapses. Landslides occurred in Ambarlı, Beylikdüzü, Yakuplu, and Denizköşkler. As more than half of Cihangir is built on landfill ground (near Okyanus College), collapses occurred. Adjacent buildings on the side street of Torium Mall collapsed. Emergency assistance had not yet arrived. There was no electricity or communication. Within the first 24 Hours after the earthquake, communication (phones, etc.) was cut off. There was no communication, transportation, or electricity. Traffic congestion occurred. Heavily damaged buildings collapsed during aftershocks. Due to the lack of safe gathering areas, people did not go to designated gathering points; there were tall buildings around these areas, no toilets or water, and security concerns kept people at their homes. Disadvantaged groups (bedridden individuals, people with disabilities, migrants) were in dire situations. There was a lack of equipment in the containers.

Medium Term (First 72 Hours and First 15 Days): In the first 72 hours after the earthquake, attempts were made to reach family and friends. People tried to assist family members and their surroundings (debris). Personal needs started to emerge (food, etc.). Roads were closed. Aid arrived from neighboring provinces. Security issues persisted—thieves from other locations could come, there was organ trafficking, and security guards should be appointed. District officials might be unable to perform their duties; drone training should be provided for use in search and rescue. Looting occurred. Migration began. On the 15th day after the earthquake, the healthcare system collapsed. The weather was hot, bacteria developed. The death toll increased, and burial processes were intense. Missing children/people remained a concern. Drones could be used for security purposes.

Long Term (3 Months and Beyond): Psychological support was needed. The entire country was economically affected. Diseases began to spread. Chaos ensued; similar to Hatay, where there has been no electricity or water at the most affected regions and some residents remained in container shelters for long time. Schools began to reopen. Economic problems surfaced.

Measures to Be Taken and Solution Proposals: Participants analyzed potential risks and challenges following an earthquake and proposed solutions to enhance emergency response and disaster preparedness. Key recommendations included improving emergency communication, establishing helicopter landing zones (e.g., reactivating Atatürk Airport), strengthening critical public buildings, and preparing container housing for relocation. Urban transformation and disaster education for children, including practical demonstrations, were emphasized. Suggestions also included revising disaster gathering areas, ensuring access to building floor plans, and providing facilities for orphaned children. Preparedness measures, such as emergency bags, logistics depots, and reinforced hospitals, were highlighted, along with the need for frequent and thorough building inspections to ensure safety and resilience.

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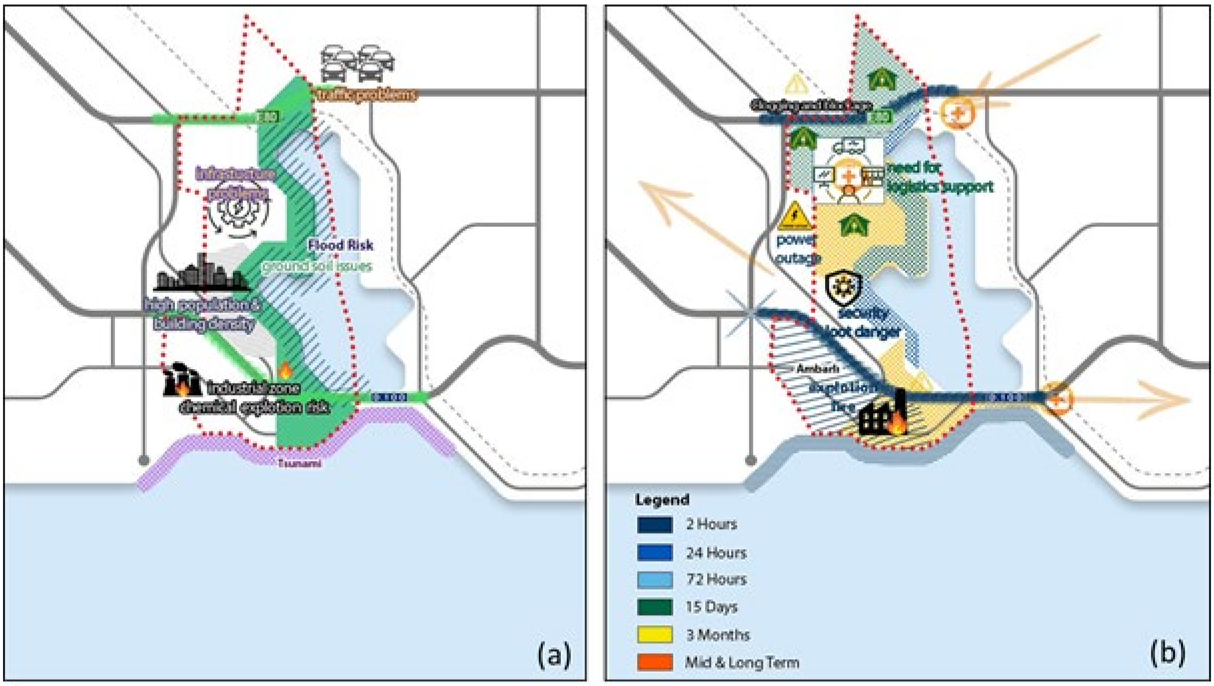

Figure 3.3.8: Risk map (a) and scenario analysis (b) of the Group 2.

Group 3 provided a detailed analysis of Avcılar's risk areas, identifying several significant hazards. Coastal neighborhoods like Deniz Köşkler and areas around Küçükçekmece Lake face tsunami risks from the Sea of Marmara, threatening evacuation efforts. Sloped regions and areas built on landfill grounds, particularly in Ambarlı, Gümüşpala, and Deniz Köşkler, are prone to landslides and structural instability due to loose soil, increasing earthquake-related damage. The Ambarlı Thermal Power Plant poses additional environmental and human risks if damaged. Cihangir was flagged for its vulnerable, ageing buildings, while the University Area, with its large student population and dormitories, was deemed insufficiently equipped for earthquake evacuation and waste management. Industrial zones above the E-5 present fire hazards post-earthquake, complicating rescue operations. Security concerns, including looting and criminal activity, were noted in areas like Haramidere, Tahtakale, and Esenyurt, where disadvantaged groups reside. Flooding around Küçükçekmece Lake further threatens transportation and evacuation routes. The Avcılar A0 map (Figure 3.3.8a) visualized critical hazards such as tsunami zones, landslides, landfill grounds, and loose soils, serving as essential tools for identifying key risk areas and guiding intervention strategies. This detailed mapping enhances stakeholders' understanding of regional vulnerabilities, aiding in effective decision-making and disaster preparedness.

In the scenario of Group 3, the earthquake occurs place on a weekday evening, around 6:00-7:00 PM, during rush hour (Figure 3.3.8b). **In the immediate aftermath** of an earthquake, Avcılar faces several critical risks. Structural vulnerabilities are severe, particularly in neighborhoods south of the E5 highway, where 96 high-risk buildings are expected to sustain significant damage. Coastal industrial areas and power plants are at high risk of fires and explosions due to damage to gas and electricity lines, endangering nearby residents. Coastal regions are also highly vulnerable to landslides and tsunami waves from the Sea of Marmara, compounding the risks in landfill zones. University campuses in Avcılar, serving approximately 50,000 students, lack sufficient dormitory capacity and safety measures, leaving a large student population vulnerable. Additionally, the region's post-earthquake gathering areas are inadequate, especially in the southern neighborhoods where access to safe zones is expected to be difficult. Security concerns are heightened in neighborhoods like Yeşilkent and Tahtakale, where disadvantaged groups reside, with looting incidents likely to escalate if insufficient intervention occurs. Transportation challenges are also significant, as damage to the E5 highway and surrounding roads will hinder evacuation and emergency aid delivery, further isolating at-risk communities.

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Medium Term (First 72 Hours and First 15 Days): In the first 72 hours, basic needs in the area, particularly shelter and food shortages, will become prominent. Difficulties in providing shelter and food will increase feelings of insecurity. Due to the inadequacy of public buildings in terms of resilience, health, and shelter services may be delayed. Damage in industrial areas could pose a risk to human health and the environment due to chemical leaks and fire hazards. Such incidents would hinder the work of rescue teams. Aftershocks could lead to the complete collapse of already damaged buildings. Infrastructure problems, particularly the collapse of communication and transportation networks, would make it even more difficult for response teams to reach the area. From the third day after the earthquake, social conflicts could arise. Frustrations among people may emerge due to delays in aid and lack of security. The idea of delivering aid via sea routes may be considered.

Long Term (3 Months and Beyond): During the three months following the earthquake, debris removal efforts will be prioritized. However, both financial constraints and a shortage of workforce could complicate this process. Inadequate housing will force people to remain in temporary shelters for a long time. Hygiene issues in the shelters could lead to the spread of epidemics and infections. The lack of adequate cleaning and sanitation efforts would exacerbate health problems. In areas where illegal construction is widespread, the reconstruction process will accelerate in the long term. Interruptions in education will need to be resolved, depending on the repair or reconstruction of schools.

Measures to Be Taken and Solution Proposals: Participants identified key risks and proposed solutions to enhance Avcılar's resilience to earthquakes and improve response capacity. Strengthening or rebuilding risky structures was highlighted as essential to reducing casualties and damage. Updating legal regulations and increasing local governments' authority in disaster management were also emphasized to enable quicker, more localized interventions. Awareness campaigns involving local representatives, NGOs, and municipalities were proposed to educate the public on disaster preparedness. Establishing safe evacuation corridors, increasing emergency gathering areas, and deploying AFAD containers in parks were seen as critical for post-earthquake response. Infrastructure upgrades to ensure water, electricity, and transportation continuity were also prioritized. Collaboration with the Istanbul Metropolitan Municipality (IMM), incorporating drone systems, and leveraging technological solutions were recommended for effective disaster management. Strengthening areas prone to landslides and flooding, improving roads and bridges near the E5 Küçükçekmece and Avcılar intersection, and ensuring air access to university areas were deemed crucial for safety and mobility. Finally, enhancing shelter facilities for response teams and building robust organizational networks were identified as vital steps to ensure effective disaster response. These measures collectively aim to minimize risks and accelerate recovery in Avcılar.

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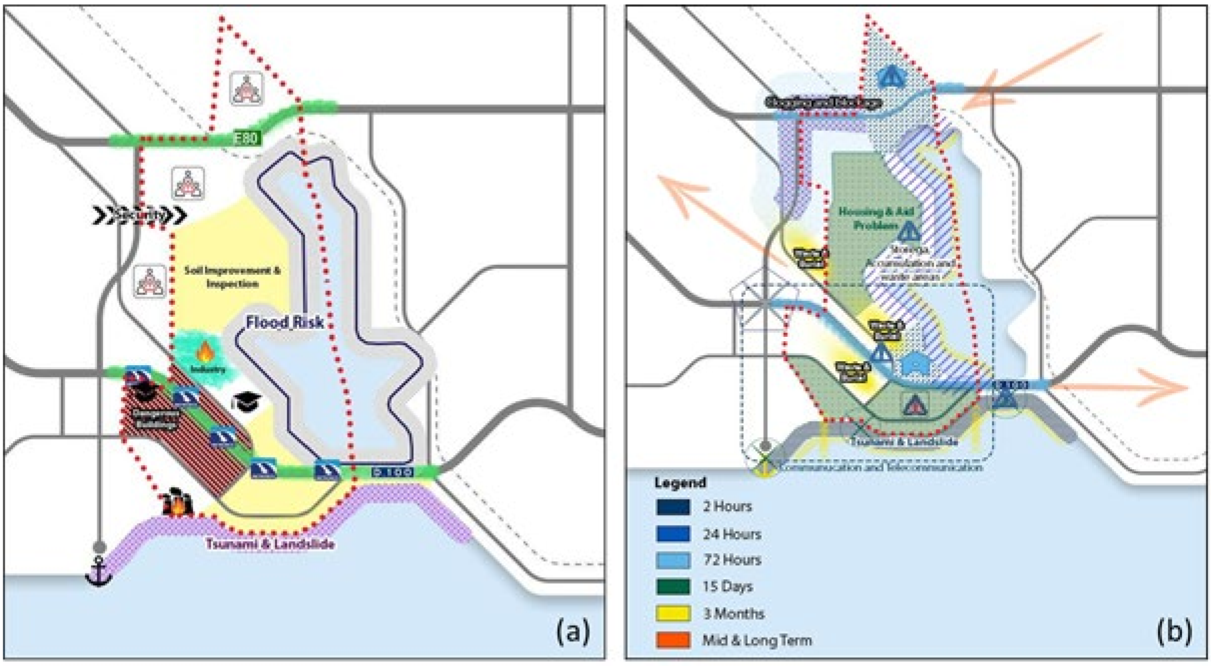

Figure 3.3.9: Risk map (a) and scenario analysis (b) of the Group 3.

Group 4 highlighted Avcılar's critical risks and vulnerabilities, particularly in areas like Ambarlı Port and industrial zones. These zones pose significant fire and explosion hazards due to oil storage facilities, while tsunami risks threaten coastal and lake-adjacent areas, with flooding likely after a Marmara Sea earthquake. Demographic vulnerabilities were noted, with many elderly residents and those living alone in central Avcılar facing mobility and evacuation challenges. Transportation issues around the E5 highway and Mustafa Kemal Paşa neighborhood further complicate post-earthquake logistics. The region also suffers from a lack of gathering areas and outdated, non-earthquake-resistant buildings, increasing risks of destruction and casualties. Hygiene issues, such as limited water and sanitation, could worsen in densely populated areas following an earthquake. Vulnerable groups in Yeşilkent, including migrants and informal workers, face barriers like language, economic challenges, and security concerns. Additionally, land use and ownership issues in Firuzköy and inadequate building regulations hinder recovery and reconstruction. Comprehensive urban transformation, stronger infrastructure, and better planning are necessary to address the risks and improve resilience in Avcılar (Figure 3.3.9a).

According to the scenario of Group 4, the earthquake took place in the spring, on a weekend, between 14:00 and 16:00 (Figure 3.10b). **Immediately after the earthquake**, chaos, and destruction is expected in the first two hours. In the Mustafa Kemal Paşa and University neighborhoods, structural damages will occur, collapse of buildings and transportation and communication problems will be severe. It was also stated that the university open spaces could be used as a sheltered area. Tsunami hazard may cause major destruction in coastal areas. Collapse of filling areas, fire and explosion risks in filling facilities, and disruption of transportation networks are among other expected problems. Under E5 and Industrial Zone, explosions, fires, and chemical leaks will cause additional problems. It is foreseen that people will try to get out of the buildings in panic, and lay people will provide the first interventions. In Tahtakale, only two-thirds of the buildings are expected to remain intact, while the Firuzköy and Yeşilkent neighborhoods will experience destruction, chaos, injuries, and communication disruptions. In the first 24 hours following the earthquake, significant security challenges, including the risk of looting, are anticipated. Rescue efforts to extract the injured and deceased from the rubble will commence, while issues related to personal hygiene and public health are expected to arise. Access to clean water, energy disruptions, and the urgent need for shelter will be among the most pressing concerns. With professional external aid likely to face delays, individuals may find themselves relying heavily on cash to address immediate needs.

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Medium Term (First 72 Hours and First 15 Days): The 72 hours following the earthquake are a critical period marked by escalating security issues and a surge in looting, fueled by unmet food and shelter needs. A growing sense of insecurity will deepen as survivors grapple with the aftermath. Despite the dangers, some may attempt to return to unstable structures, increasing the risk of fires. Efforts to transition into tents, shelters, and other temporary collective living spaces will begin, while attempts to flee the city will rise, hindered by logistical challenges. The arrival of first responders will partially alleviate the lack of assistance, though their support will remain insufficient. After approximately 15 days, as the initial shock subsides, rescue operations will conclude, and debris removal efforts will commence. Mass sheltering and logistical centers will become operational, providing critical services such as mobile laundries, field hospitals, and ship-based healthcare facilities. Disadvantaged groups will require targeted support, cooling warehouses will be established, and the risk of epidemics will increase. Security concerns will persist throughout this phase, necessitating continued vigilance and effective management.

Long Term (3 Months and Beyond): The first three months following the earthquake will be marked by increasing social and economic challenges. The education system will face significant disruptions, psychological issues will rise, and economic hardship will deepen. Slow debris removal and the spread of infectious diseases will be major threats during this period. During the summer vacation, many residents who left the city due to the earthquake will struggle to return, exacerbating transportation demands and complicating efforts to recover belongings. As people begin to return to work, economic recovery will start, but it will be hindered by numerous challenges. In the long term, unemployment and an economic crisis will become prominent concerns. Housing problems will persist, alongside uncontrolled migration and educational setbacks. Psychological issues, legal disputes, and unresolved excavation problems will also emerge. Health risks, particularly lung diseases from asbestos exposure during debris removal, will pose significant threats. An economic downturn, coupled with a slowdown in the construction sector, will lead to social challenges such as gentrification, dispossession, and post-traumatic stress disorder. Unemployment and emigration will intensify economic imbalances, while social consequences will include rising disability rates and developmental issues in children.

Measures to Be Taken and Solution Proposals: In the aftermath of the earthquake, several key measures should be prioritized to ensure effective recovery and resilience in the affected areas. First, urban transformation projects must be accelerated, focusing on block-based developments and the reconstruction of risky buildings. This will help to reduce the vulnerability of the built environment and enhance the overall safety of the community. Additionally, there is an urgent need to increase the number of emergency gathering areas, ensuring that people have access to safe locations in times of crisis. Improving transportation networks will also be crucial, as it will allow for faster evacuations and more efficient delivery of aid to those in need. In terms of risk management, more detailed planning must be done, especially regarding fire and explosion risks in industrial zones. Emergency action plans should also be developed for potential tsunami and landslide hazards, ensuring preparedness for all possible threats. Finally, social support and training are essential. Disadvantaged groups, who may face additional challenges in disaster situations, must be prioritized in rescue and relief operations. Alongside this, post-earthquake psychological support and training initiatives should be implemented swiftly to address the mental health needs of the affected population and help them cope with the trauma of the disaster.

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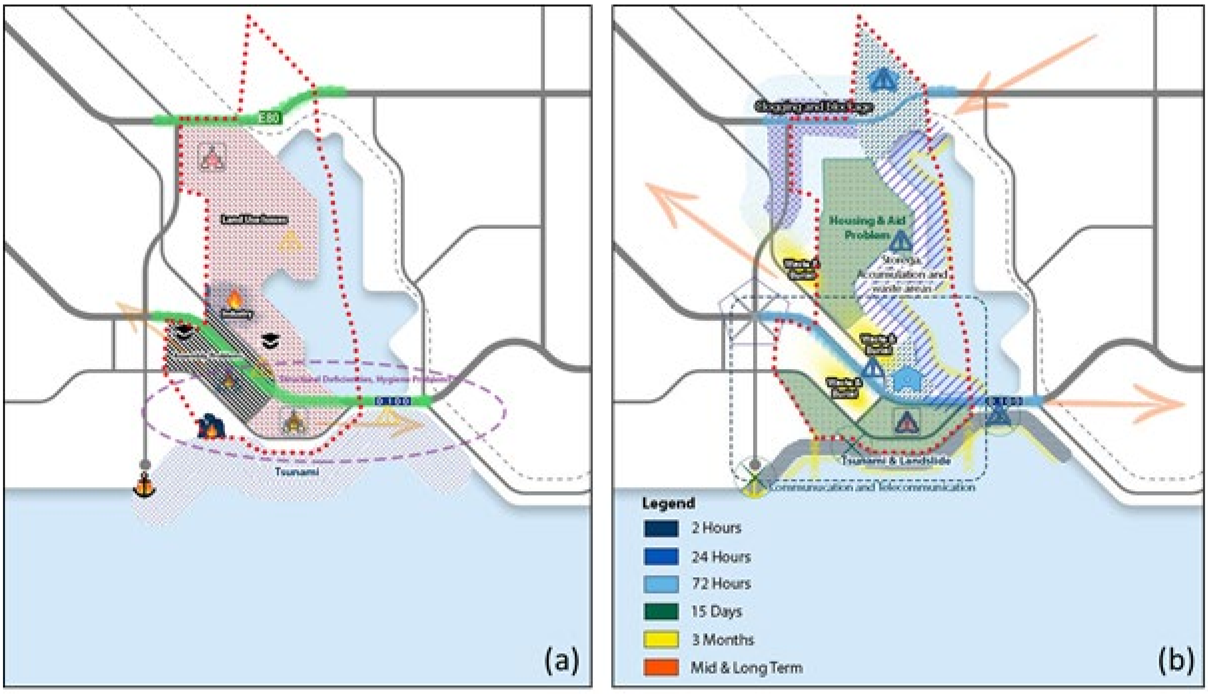

Figure 3.3.10: Risk map (a) and scenario analysis (b) of the Group 4.

In Group 5, Ambarlı and Denizköşkler present critical challenges and risks. In Ambarlı, soil liquefaction poses a serious threat, particularly during earthquakes, heightening the risk of structural collapses. The lack of sufficient gathering areas exacerbates these issues, while the outdated building stock increases the risk of destruction and casualties. The coastal location heightens tsunami risks, with potential flooding threatening the shoreline after a major Marmara earthquake. Moreover, transportation disruptions are expected, especially along the D100 and E80 highway and central routes, complicating emergency response efforts. Additionally, unresolved zoning and development issues in Yeşilkent hinder the implementation of effective urban transformation projects, leaving the area highly vulnerable to disasters (Figure 3.3.10a).

Group 5 scenario, within the first 24 hours of the earthquake, severe challenges will emerge due to the combined effects of winter conditions and infrastructural damage (Figure 3.3.10b). Communication and energy outages will be widespread, cutting off access to electricity, telephone, and internet services, which will hinder both emergency communication and the coordination of aid efforts. These disruptions, combined with the freezing temperatures, will exacerbate heating problems and create significant risks for affected individuals. In the immediate aftermath, many people will struggle to overcome the shock, which will prevent them from organizing or evacuating to safe gathering areas. Security concerns are likely to escalate as the chaos leads to potential looting of food and water supplies, placing additional pressure on local authorities. Delays in external aid due to blocked roads and snow will make it difficult to deliver essential supplies and rescue equipment, further complicating initial response efforts. People displaced from their homes will face critical challenges in securing shelter and warmth, as temporary solutions will be inadequate for the harsh conditions.

Medium Term (First 72 Hours and First 15 Days): In the first 72 hours and extending into the following two weeks, the earthquake's impacts will continue to pose significant challenges. Temporary shelters will remain insufficient to accommodate the growing number of displaced individuals, while access to food, water, and other basic necessities will still be severely limited. Fires caused by gas leaks and damaged electrical systems will threaten urban areas, and landslides triggered by ongoing aftershocks and snowfall will further hinder rescue and relief operations. Although aid will begin to reach affected areas, logistical challenges such as road closures and adverse weather conditions will delay distribution and exacerbate shortages. Security concerns will persist, with the potential for escalating conflicts over limited resources. Health services will struggle to address the high demand for medical care due to a lack of personnel and equipment, leading to untreated

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injuries and increased mortality. Additionally, the psychological toll of the disaster will become more apparent, but mental health support may remain a secondary priority behind physical aid. Efforts to clear debris and restore infrastructure will begin but will progress slowly due to equipment shortages and logistical difficulties, further delaying the recovery process.

Long Term (3 Months and Beyond): In the long term, extending three months and beyond, the region will face prolonged recovery efforts and deep socio-economic challenges. Debris removal will remain a critical issue, as equipment shortages and logistical constraints slow progress, prolonging the return to normalcy. The legal processes related to casualties and property damage will also face delays, compounding the difficulties of rebuilding. The economic impact of the earthquake will become increasingly evident, with widespread job losses resulting from the destruction of workplaces and industrial facilities. Many communities will struggle to regain financial stability, which will hinder broader recovery efforts. Psychological and social issues will intensify, as post-traumatic stress and other mental health challenges emerge more prominently, requiring sustained mental health interventions. Temporary shelters will continue to fall short of meeting the population's needs, and progress on permanent housing and urban regeneration projects will be slow due to financial and logistical constraints. As a result, many individuals will remain in inadequate temporary housing for extended periods, underscoring the need for long-term planning and investment in resilient reconstruction efforts.

Measures to Be Taken and Solution Proposals: To effectively prepare for emergencies, it is essential to establish pre-positioned emergency supplies, such as food, water, and heating materials, in high-risk areas. This proactive approach ensures that resources are readily available when disaster strikes. Additionally, scalable plans must be developed for the rapid deployment of insulated temporary shelters to address the challenges posed by winter conditions, ensuring that those affected by the disaster can find shelter and warmth. Enhancing infrastructure resilience is equally important, particularly communication and power systems. Strengthening these systems will reduce vulnerability to outages, ensuring that vital information and services can continue even in the aftermath of a disaster. In terms of healthcare, it is crucial to mobilize mobile medical units and integrate psychological support teams into disaster response plans. This dual approach will address both physical and mental health needs, providing immediate care and long-term emotional support to those impacted. Logistics and debris management must also be a priority. Investing in snow-resistant equipment will help ensure that aid distribution remains efficient, even in harsh weather conditions. Clear logistical frameworks will facilitate the smooth flow of resources and personnel to the area's most in need. Finally, community involvement plays a key role in emergency preparedness. Conducting training programs will help local communities organize their response efforts, reducing panic and ensuring a coordinated, effective approach to disaster recovery.

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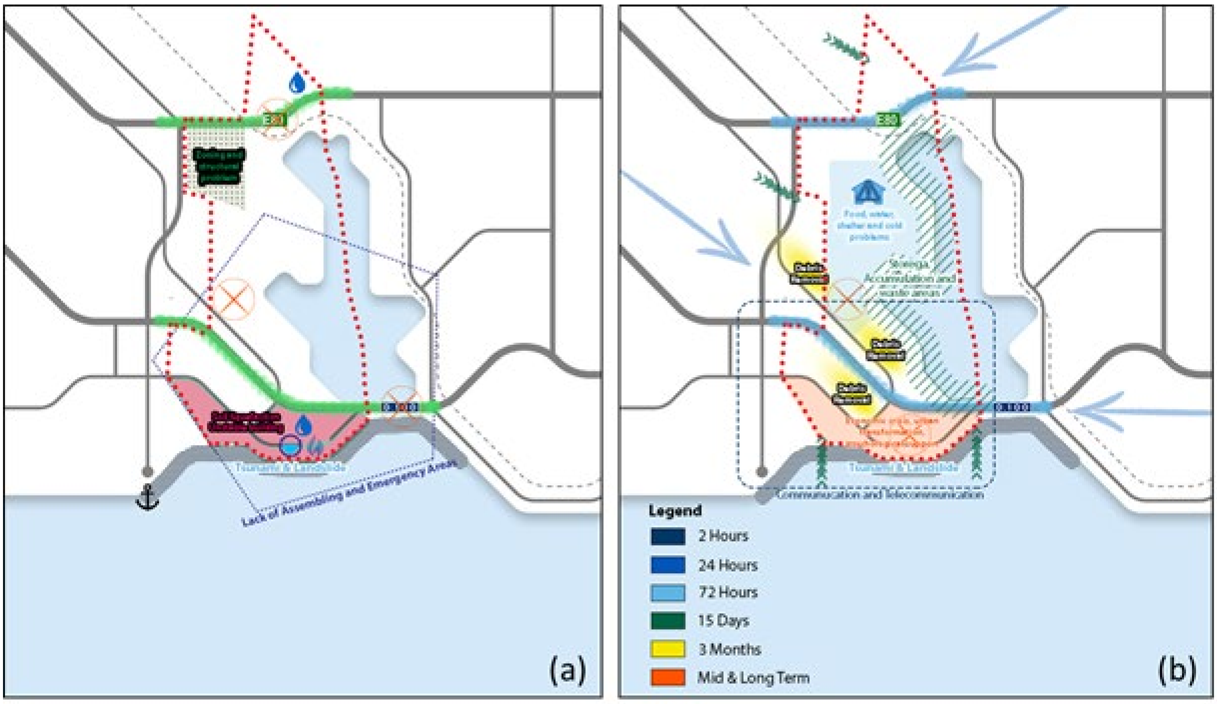

Figure 3.3.11: Risk map (a) and scenario analysis (b) of the Group 5

In Group 6, participants pointed out that the systemic and spatial problems in Avcılar district significantly increase earthquake risks and hinder effective intervention. The region's fragile road networks, including the D-100 (E-5) and E-80 (TEM), and the metrobus starting point, are highly susceptible to transportation disruptions. Secondary disasters like flooding and landslides are major concerns, with coastal areas and inland residential zones facing severe risks. The alluvial soil structure further exacerbates these vulnerabilities, with liquefaction identified as a significant risk. Volunteer organizations face challenges with training and chain of command adherence, and the road network complicates first responders' access. High-density neighborhoods, such as Yeşilkent, face severe accessibility issues, while industrial and residential areas like Denizköşkler and Tahtakale are difficult to reach. The district's fragile housing stock, especially in areas like E-5, and the clustering of critical service areas near vulnerable coastal locations increase risks. The shortage of emergency gathering spaces and the difficulty of reaching key neighborhoods add to the urgency for strategic planning and infrastructure improvements to address these challenges (Figure 3.3.11a).

According to the Group 6 scenario, an earthquake of Mw 7.0 occurred on a Monday in September between 08.00 and 09.00 hours (Figure 3.11b). **In the initial moments** following the earthquake, the most vulnerable groups in Avcılar include the elderly, children, summer residents trying to return home, and people with disabilities. The earthquake's destructive impact will significantly affect the entire Istanbul area, with Avcılar experiencing a micro-scale version of the city's challenges. Key sectors such as telecommunications, which will be overwhelmed by call volume, and road transportation, which will be interrupted due to damaged infrastructure, will face immediate disruptions. Coastal areas and E-5 roads are expected to be heavily damaged, and essential systems like communication, transportation, and energy will be severely impacted. The immediate aftermath will be marked by chaos, with high traffic congestion, early response teams starting to mobilize, and widespread panic observed throughout the city. In the first 24 hours, chronic patients relying on machines or oxygen will become the most vulnerable group due to the earthquake's systemic disruptions. The need for communication, shelter, health care, and security will grow as panic subsides. Search and rescue operations will focus on central residential areas and transportation hubs. The predicted rainy weather will cause flooding in areas like Yeşilkent and near the lake. As the situation progresses, chaos and panic will persist across Istanbul, with a significant demand for hygiene, security, and basic supplies.

Medium Term (First 72 Hours): By the third day, vulnerable groups such as women, migrants, and lost children will be in critical need of support. Survivors will begin transitioning from temporary shelters to more

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permanent spaces, while logistics challenges and basic needs will intensify. The demand for food, hygiene products, and security will peak, and the identification and burial of bodies will become pressing issues. The scale of the devastation and the psychological toll on both survivors and first responders will add to the complexity of the situation.

Medium Term (First 15 Days): In the aftermath of the second earthquake, professional search and rescue teams will be overwhelmed by exhaustion, and psychological stress will affect first responders. The need for hygiene products, health care, shelter, and fumigation will grow, while issues like clothing shortages will continue. Women and children's safety remains a primary concern, and the ongoing challenge of handling the dead and buried bodies will be exacerbated by difficulties in animal care. Despite the start of debris removal, the psychological and physical strain on rescue teams will delay progress.

Long Term (3 Months and Beyond): After the debris is cleared, the focus will shift to addressing long-term challenges such as housing, infrastructure, and urban sanitation. Migrants, students, and those displaced by the disaster will contribute to a growing need for shelter, and psycho-education will become a priority for long-term recovery. The migration out of Avcılar will begin, and the district will face a demographic shift as individuals move to neighboring provinces. While housing issues are likely to be resolved, economic challenges, unemployment, security, environmental problems, and the continued risk of epidemics will persist. The inability to address these challenges quickly will lead to a decline in living conditions and further out-migration.

Measures to Be Taken and Solution Proposals: Immediate actions are needed to address critical vulnerabilities in Avcılar, particularly along the coastal area between the lagoon entrance and the harbor. The service function areas belonging to IMM, the Ministry, and Avcılar Municipality should be relocated from this region without delay to prevent damage. In addition, the drinking water treatment plant and CBRN areas behind the harbor must be reinforced immediately to reduce the risk of destruction. Access issues in neighborhoods like Denizköşkler and Yeşilkent require urgent solutions, including the installation of fire stations and hydrants to ensure fire safety. The building stock along the E-5 and TEM axes, as well as the connecting roads, must be rapidly stabilized to improve resilience. Furthermore, to effectively utilize volunteer organizations during and after disasters, efforts should be intensified to expand accreditation training across Istanbul and accelerate the ongoing initiatives.

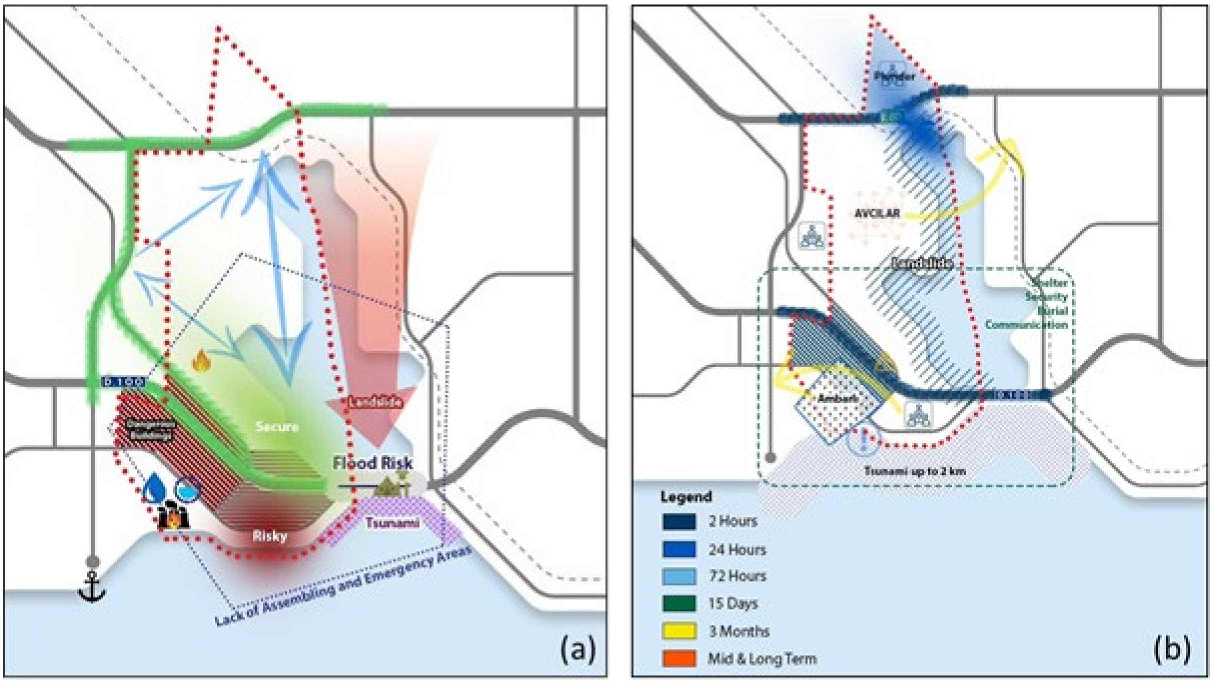

Figure 3.3.12: Risk map (a) and scenario analysis (b) of the Group 6

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In conclusion, the discussions and evaluations in this report underscore the critical measures needed for improving earthquake risk management and enhancing the effectiveness of post-disaster recovery processes in the Avcılar region. One of the key recommendations is the immediate relocation of essential services, especially those in vulnerable coastal zones, to reduce risk exposure. Strengthening key infrastructure, such as water treatment facilities and emergency response stations, is also essential to enhance resilience against future disasters. Furthermore, expanding training programs for volunteer organizations would significantly improve disaster response capabilities across Istanbul. Addressing logistical challenges, such as the availability of fire stations and hydrant access, is crucial for ensuring a timely emergency response. Additionally, prioritizing housing solutions for the affected population and providing psychological support are vital for facilitating long-term community recovery. The discussions also emphasized the importance of establishing evacuation corridors and increasing the number of emergency gathering spaces to streamline disaster management and recovery efforts. Lastly, it was recommended that future maps include depictions of buildings to better illustrate the areas at risk and inform planning decisions.

3.3.2 Follow-up Planning

Following the June 2023 stakeholders' meeting, Avcılar meeting was successful by the means of diversity of the participants and their findings representing critical bottlenecks which would be likely to affect the functioning of the mega-city aftermath a large scale disaster. Furthermore, IMM encourages these district based meetings to compile the information and the perspective of all stakeholders to obtain a greater picture of Istanbul with the notification of critical nucleus which are likely to trigger cascading failures. Therefore, in the upcoming period, the district based workshops will be organized to fulfill the evaluation.

The development of the serious game for Istanbul is under development. The pilot implementation will be set in the district meetings. As these meetings will be numerous, there will be an opportunity to revise the serious game scenario according to the feedbacks of the participants. Likewise, DRS-Hub development will also be fed by the feedbacks of the participants.

The workshops clearly define the current situation of the city confronting a disastrous event as well as vulnerabilities. For the future scenarios to be developed in the WP2, the input related to the vulnerabilities and risky areas will provide to develop further alternatives.

3.3.3. Conclusion

As mentioned in the previous deliverables (Del 6.1, Del 6.2, Del 1.1 and Del 6.3), in the PARATUS Project, Istanbul serves as a representative case for megacities facing natural and human-made threats, such as earthquakes and floods, compounded by emerging risks like population growth, urban expansion, migrant integration, and socioeconomic disparities. These factors increase vulnerability among disadvantaged populations and exacerbate systemic risks. As a primate city, Istanbul plays a key economic and international role, but shocks like the 1999 Kocaeli and 2023 Kahramanmaraş earthquakes demonstrate how such events can propagate impacts nationwide. The application case study focuses on Istanbul's urban dynamics (demographics, social, economic, and built environment) to analyze systemic vulnerabilities. Using impact chain analysis and stakeholder input, future earthquake scenarios are modelled to evaluate systemic risks at the provincial scale and uncover interconnections within the city's dynamics. This multi-scale approach, supported by diverse data, aims to identify problem areas and root causes of systemic risks, narrowing the focus to specific sites for targeted interventions.

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3.4 Bucharest, Romania

3.4.1 Update

The Second Stakeholder Workshop in the Bucharest Case Study took place on the 26th of September 2024 in the conference room provided at a venue of the Minister of Internal Affairs in Romania. It was co-organised by the PARATUS team from the University of Bucharest (UB) under the coordination of the Bucharest Case Study leader, Professor Dr. Iuliana Armaș, the Department for Emergency Situations (DSU) led by State Secretary DR. Raed Arafat, and other PARATUS members, including Associate Professor Dr. Funda Atun from the University of Twente. Michalina Kulakowska from the Centre for Systems Solutions collaborated with the UB team to co-develop the Serious Games, while Serge Monturet from the Fi Group was also present to the event.

The workshop represents a corollary of the research work performed in the Bucharest Case Study in 2024, which also included the building of multiple Impact Chains on earthquakes, floods, and the COVID-19 pandemic with a local (focusing on Bucharest) or national scope, analyses of seismic multi-risk, simulations of the impact of a multi-hazard involving a major earthquake and a subsequent dam-break flood. Other key activities in this case study included survey-based research on earthquake risk perception, as well as focus groups, hybrid workshops, and one-on-one interviews performed with different stakeholders.

The event reunited in the capital of Romania with more than 30 stakeholders from a wide range of emergency management institutions in this country. Invitations were sent to and honoured by first and second responders across the ranking scale within the National Military Command Center, the General Inspectorate for Emergency Situations, the Department for Emergency Situations, and the Special Telecommunication Service. In addition, decision-makers from the Ministry of National Defence, Ministry of Regional Development and Public Administration, Ministry of Transportation, National Administration for State Reserves and Special Problems, the City Hall of Bucharest Municipality, and representatives of the National Insurance Pool against Natural Disasters, State Inspectorate for Constructions, Public Health Department of the Municipality of Bucharest, and the National Institute of Statistics participated in this workshop. Most of these stakeholders were participating in PARATUS activities for the second time, having previously attended the First Stakeholder Workshop in March 2023.

With the participants' consent, the event was recorded and live-streamed on Microsoft Teams to allow other PARATUS members to attend remotely. The workshop was highlighted in the media via a PARATUS Blog post.

The Stakeholder Workshop was structured in five distinctive sections, each with its specific objectives, workflows, and valuable outcomes. The day started with a theoretical presentation titled Introduction to Impact Chains for Future Scenarios, which was followed by a focus group on How to build an Impact Chain for Future Scenarios. After lunch, participants engaged in a Serious Game relevant to the Bucharest Case Study, and in the afternoon, they worked together with the UB team to conduct stress tests on different disaster scenarios focused on Bucharest. The final activity centered on the Disaster Risk Stakeholder Hub, gathering participants' insights on the topic.

3.4.2 Methodological approach

The workshop built on the scientific results obtained by the UB research team during the previous two years, providing the opportunity to refine these findings based on the insights of the invited stakeholders but also to make them known to the local audience.

The results list includes three Impact Chains focused on the historical earthquakes that affected Bucharest in 1100-1900, the recent earthquakes in 1940 and 1977, and a potential earthquake of over 7 MW that would strike Romania's capital in the near future, one multi-hazard Impact Chain revolving around the powerful flood events that impacted Romania in 2020-2021 alongside the Covid-19 pandemic, and one Impact Chain on the effects of the Covid-19 pandemic on the hospital network in Bucharest. All of these Impact Chains supported the development of comprehensive forensic analyses for the (multi-)hazard scenarios at hand.

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Also, the Impact Chain on the potential effects of a future major earthquake hitting Bucharest was enriched with insights from a wide range of relevant stakeholders (e.g., first and second responders – some of them specialised in disaster medicine, military, policymakers, decision-makers, architects, structural civil engineers, academics specialised in Constructions and Seismology, law experts, and representatives from insurance companies), with whom the UB team conducted focus groups, one-on-one interviews, and hybrid workshops at the beginning of 2024.

Introduction to Impact Chains for Future Scenarios

The first part of the workshop aimed to introduce the invited stakeholders to the model of Impact Chains, highlighting their dual role as tools to analyse and learn from past disasters and to analyse future disaster scenarios in order to streamline first response and recovery efforts and enhance preparedness (Figure 1B). Since many of the invited stakeholders had participated in the first workshop in March 2023, the topic was not entirely unfamiliar, and this session served as a refresher. On the other hand, the newly invited stakeholders were at their first contact with the concept of Impact Chains, which sparked significant interest among them.

During the First Stakeholder Workshop, participants were presented with an extensive database of over 39 large earthquakes with magnitudes over 6.5 Mw that affected Bucharest between 1100 and 1900. This was used as a resource in a focus group designed to provide the participants withs foundational, practical skills for building basic Impact Chains. Naturally, the Second Stakeholder Workshop was intended to enhance and refine these skills, enabling participants to construct complex Impact Chains relevant to the Bucharest Case Study and to troubleshoot them using stress testing techniques.

The session began by immersing participants in the seismic disaster scenario designed to reflect the likely impacts of an earthquake exceeding 7 MW in Bucharest in September 2024, while highlighting the city's specific physical and social vulnerabilities. This scenario called for the remembrance of the powerful earthquake in March 1970 (7.4 MW, 94 km focal depth, originating in the Vrancea Zone), which caused over 1,400 fatalities in Bucharest alone (90% of the total human toll registered at the national level, according to Bălan et al., 1982), the collapse of 32 (Bălan et al., 1982) or 33 (Pantea and Constantin, 2013) buildings, and economic loss of approximately 2 billion dollars (representing now 9 billion dollars) at the national level (World Bank, 1978; Balan et al., 1982). The disaster scenario grounded the discussion regarding the organisation, visualisation, storage, sorting, and utilisation of information related to this potential seismic event (Figure 1A). In addressing this range of critical questions for Disaster Risk Management (DRM), Impact Chains were introduced as tools capable of providing solutions to all the raised issues.

We proceeded with a presentation of the basic structure of an Impact Chain (Figure 3.4.1C), detailing its elements (i.e., hazards, impacts, exposed elements, vulnerabilities, and adaptation options) and the connections established among them (i.e., causes, impacts, affects, mitigates, relates to). The theoretical explanations were accompanied by practical exercises of reduced to moderate difficulty on the impacts of various hazards (e.g., earthquakes causing building damage, droughts that limit the availability of water resources, and heatwaves that result in the escalation of health problems and increases in the number of medical emergencies). These were designed to ensure a solid understanding of how Impact Chains are built and work.

The main outcomes of this introductory session are summarised as follows:

- Stakeholders gained a clear understanding of the Impact Chains model, learning how Impact Chains can help streamline first response, recovery effort and enhance preparedness for disaster management.
- Stakeholders became familiar with the elements and connections of Impact Chains, which set the stage for the focus group where they were tasked with building such a model.
- The hands-on exercises enabled participants to apply their theoretical knowledge to real-world examples of hazards, which fuelled their interest in the applications of Impact Chains.

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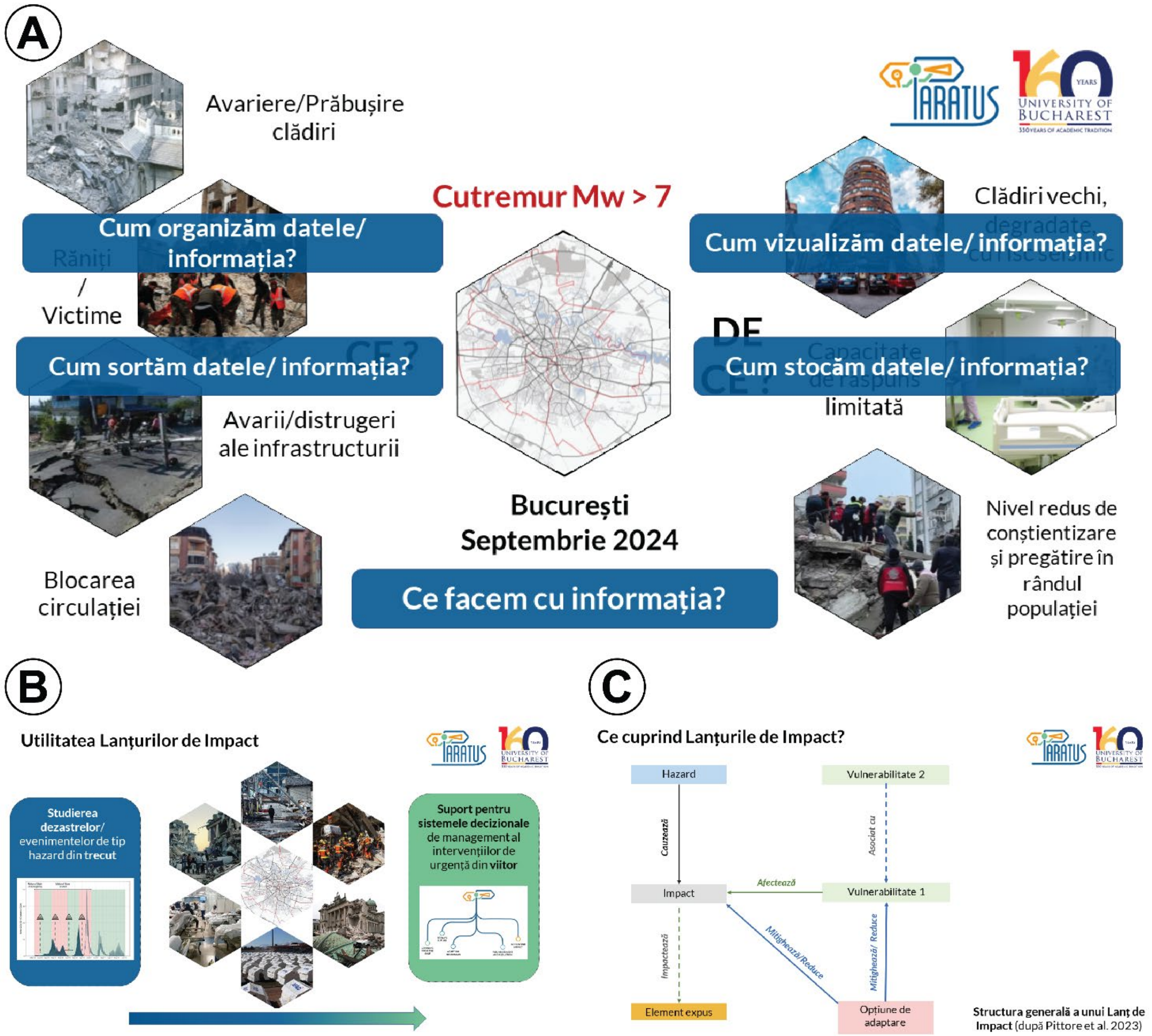

Figure 3.4.1: A – Proposed seismic disaster scenario and key questions (How do we organise the data? How do we visualise the data? How do we sort the data? How do we store the data? What do we do with the data?), B – Utility of Impact Chains, C – General structure of Impact Chains (designed following the guidelines of Pittore et al., 2023)

Focus group: How to build an Impact Chain for Future Scenarios

The Focus group on how to build an Impact Chain started with a presentation of one of the main approaches to construct the model, namely the concentric approach. Under this framework, the first elements introduced in the Impact Chain are the hazards that fit the temporal and spatial scope of the model: a major earthquake striking Bucharest during present times as the primary hazard and earthquake-triggered fires and a dam-break flood as secondary hazards. The process moved to identifying the impacts of each hazard and the exposed elements that are affected by these impacts, proceeding to the vulnerabilities that contribute to the manifestation of the impacts. The construction of the Impact Chain ended with the adaptation options aimed at mitigating impacts and/or vulnerabilities. In the next phase, we showed the participants how each of the elements in the chain can be connected to the other elements through specific links.

Dwelling on the newly acquired knowledge, the stakeholders were tasked to solve an exercise starting from a given Impact Chain that included the three hazards of interest for Bucharest and 15 of their most notable direct (e.g., damage to or collapse of buildings, damage to infrastructure including water infrastructure) and indirect (e.g., human casualties, road traffic disruption, gas/water/power outages, telecommunication disruption, restricted access to intervention sites, overwhelmed hospitals, work overload on first responders, overwhelmed emergency phone lines, population displacement, psychological effects associated with the earthquake experience, communication problems between rescuers and victims) impacts.

Participants were divided into three teams of diverse expertise (Table 3.4.1). Working on the given Impact Chain, each team identified 1) potential vulnerabilities that contribute to the provided impacts, 2) adaptation options that mitigate the impacts. The exercise was solved using an A0 poster displaying the Impact Chain (Figure 3.4.2), post-it notes of different colours for writing down the identified vulnerabilities and adaptation options and writing instruments to draw connections between these new elements and the impacts already present in the Impact Chain (Figure 3.4.3). Participants placed the post-it notes in appropriate positions on the poster and used green lines to represent the "affects" connections and blue lines to denote the "mitigates" connections (as described in the key of the poster), linking the elements accordingly.

Table 3.4.2: Division of stakeholders by working group and their diverse expertise

group	Stakeholders' affiliation	Expertise
Group 1	• National Administration for State Reserves and Special Problems • Romanian Cluster PROECO CBRNE • Association for the Intercommunity Development of the Bucharest Metropolitan Area • National Institute of Statistics • General Department for Emergency Situations, Statistics, and Strategies • State Inspectorate for Constructions • City Hall of Bucharest Municipality • Public Health Department of the Municipality of Bucharest • National Insurance Pool against Natural Disasters	• Management of supplies needed in disaster response and recovery • Management of epidemiological diseases • Physical vulnerability to earthquake • Collection of damage data • Damage assessment
Group 2	• Ministry of National Defence • National Military Command Center • Ministry of Regional Development and Public Administration • General Inspectorate for Emergency Situations • General Inspectorate of the Romanian Police	• Disaster Risk Management • Post-disaster Recovery • Management of public order in disaster contexts
Group 3	• Ministry of Regional Development and Public Administration • Ministry of Transportation • Department for Emergency Situations • General Inspectorate for Emergency Situations • General Inspectorate of the Romanian Police • Special Telecommunication Service • City Hall of Bucharest Municipality	• Disaster Risk Management • Disaster Communications • Physical vulnerability to earthquake • Management of public order in disaster contexts

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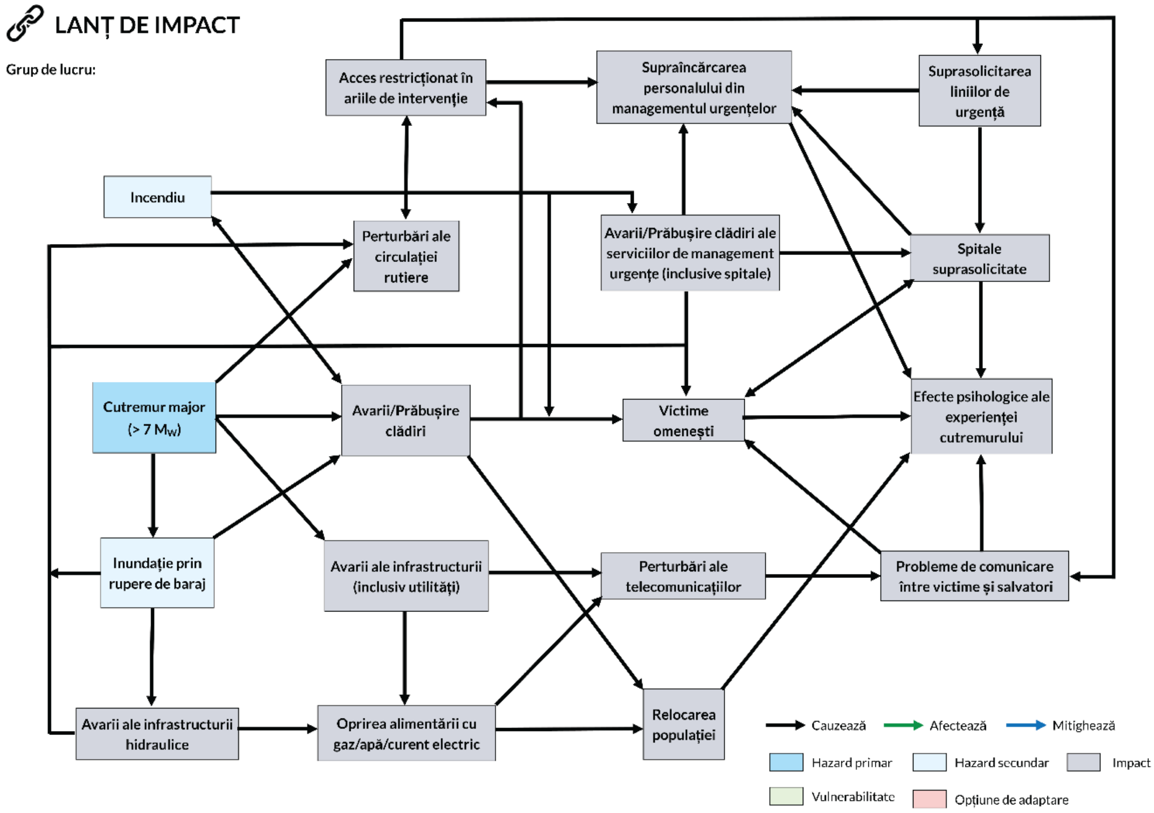

Figure 3.4.2: The Impact Chain used in the Focus Group, Snapshots from the Focus Group.

Figure 3.4.3: Snapshots from the Focus Group.

At the conclusion of the exercise, stakeholders were invited to present their results, which were recorded separately by the organisers to facilitate their analysis and the preparation of workshop reports and related deliverables. These presentations led to a productive discussion on the factors contributing to earthquake impacts in Bucharest and potential measures to address these vulnerabilities proactively.

Preparing for the future: stress testing of scenarios

The stress testing session aimed to make the invited stakeholders aware of the variability in the effectiveness of adaptation options when the underlying conditions of the assessed scenarios change. These conditions may be related to the socio-economic dynamics specific to the study area or to climate change. Such modifications in the underlying conditions have the potential to alter the effectiveness of adaptation options

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designed to mitigate hazard impacts and/or their associated vulnerabilities under current circumstances. Therefore, scientists, decision-makers, and emergency intervention services should prioritise the identification of innovative adaptation options capable of addressing impacts and vulnerabilities once the underlying conditions have changed.

To introduce participants to this topic, we performed a demonstrative exercise focusing on a future seismic disaster scenario with distinct underlying conditions: high population density, increased social inequalities, and higher-level degradation of the building stock in Bucharest (Figure 3.4.4A). The Impact Chain at hand featured a major earthquake as the primary hazard, with earthquake-triggered fires and a dam-break flood as secondary hazards. The selected impacts included human casualties, building damage/collapse, population displacement, damage to infrastructure (including lifelines), telecommunication disruption, limited first response, overwhelmed hospitals, and the overwhelming of emergency lines by the population. The organisers presented the key impacts within this scenario and collaboratively solved the three given tasks with the stakeholders:

1. To identify new impacts that may arise in the proposed scenario.
2. To identify new vulnerabilities that may emerge in the proposed scenario.
3. To identify corresponding adaptation options for the emergent vulnerabilities in the proposed scenario.

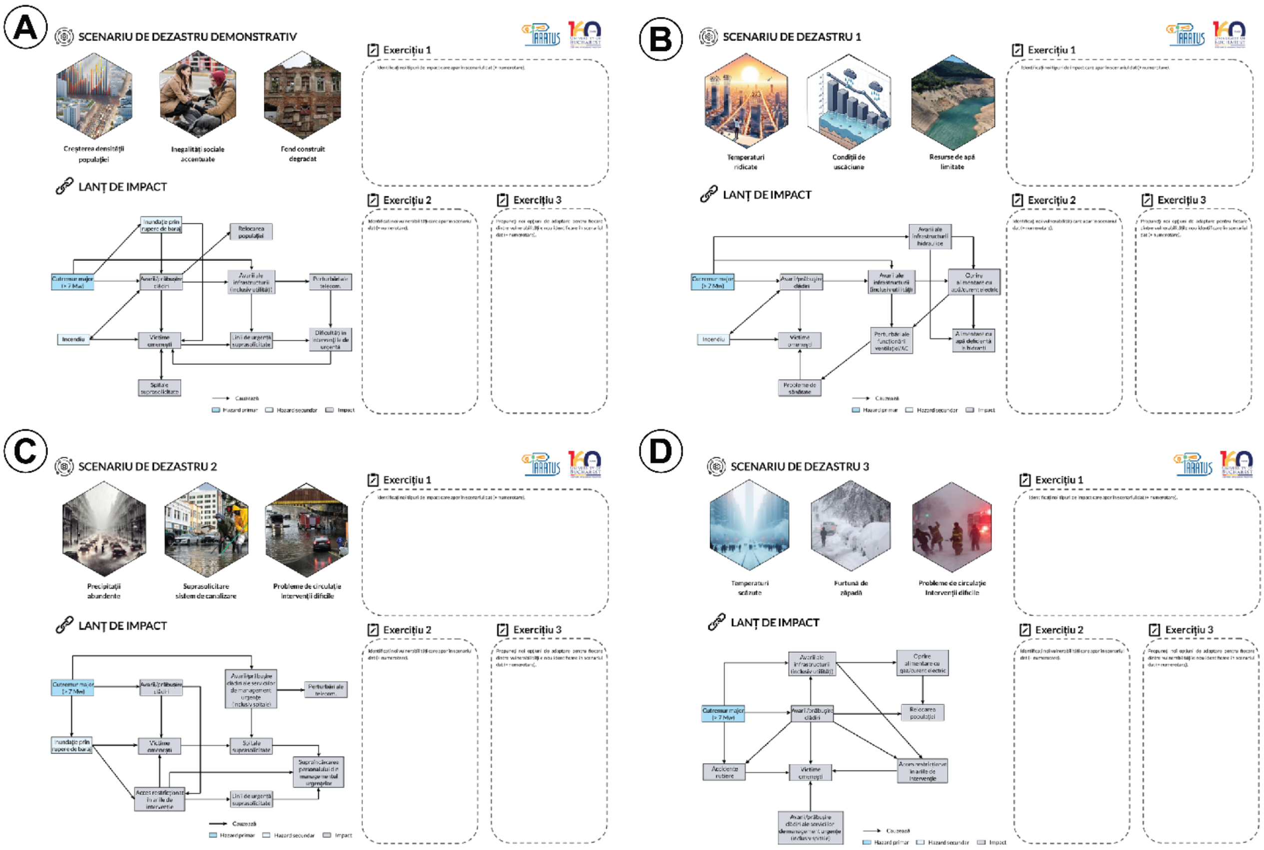

Figure 3.4.4: A- Demonstrative scenario for stress testing, B – Scenario 1, C – Scenario 2, D – Scenario 3.

Participants were instructed to take into account that vulnerability hotspots in Bucharest change depending on the moment of earthquake occurrence. They were presented with a figure depicting the spatial distribution of the most vulnerable areas in Bucharest during day and night in the event of a major earthquake (Figure 3.4.5). During the day, people tend to gather at workplaces, leaving residential areas, so daytime vulnerability hotspots are located in the city's geometric center (packed with administrative, educational, medical, legal, and banking services) or in the northern areas (hosting business quarters). At night, people return to their homes, which shifts the vulnerability hotspots to the residential areas in Bucharest, especially to the neighbourhoods where the building stock is aged and degraded, such as Rahova and Ferentari in the south, and Giulești-Sârbi in the northwest.

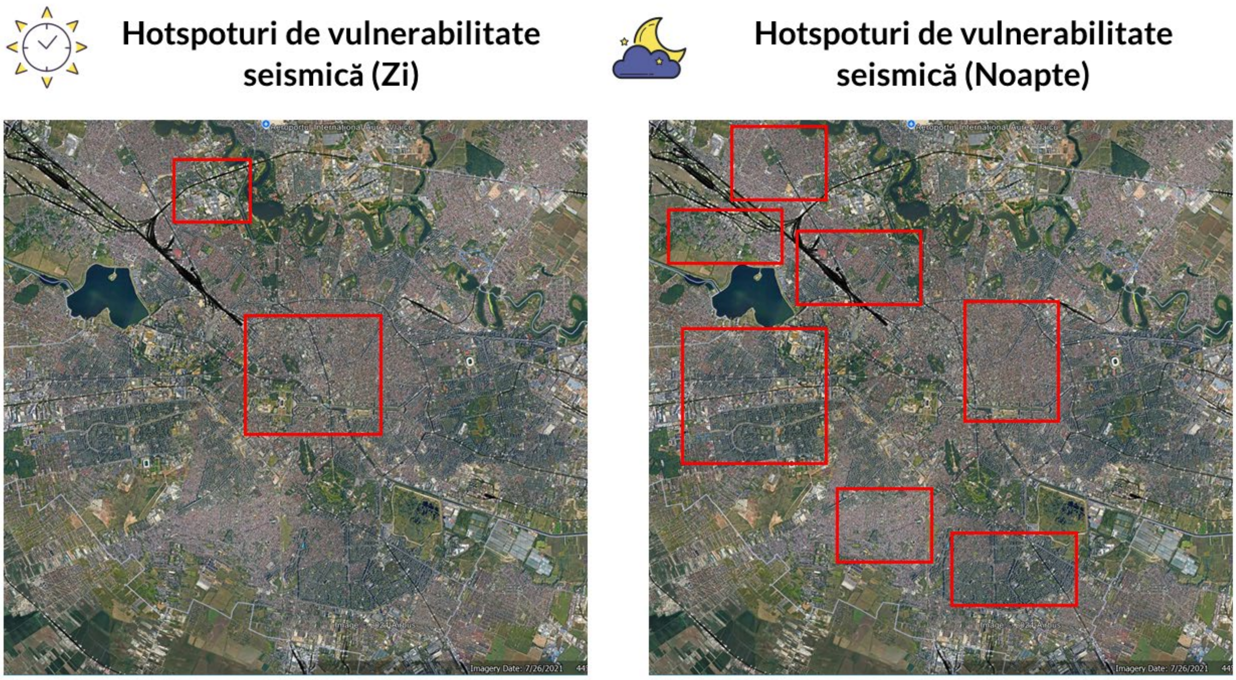

Figure 3.4.5: Shifting locations of vulnerability hotspots in Bucharest depending on the moment of earthquake occurrence (day – left, night – right)

Dwelling on the newly acquired skills and on the demonstrative exercise, the participants were asked to collaboratively work in the previously established teams to solve the same three tasks, but on different Impact Chains and scenarios. The proposed scenarios are grounded in the scientific literature on stress testing (Van de Ven et al., 2014; Wilby et al., 2022) and in the practical expertise of the organisers.

Scenario 1 (Figure 3.4.4B): high temperatures, dry weather conditions, limited water resources

- Hazards included in the specific Impact Chain: major earthquake, earthquake-triggered fires;
- Impacts included in the specific Impact Chain: human casualties, building damage/collapse, damage to infrastructure (including lifelines and water infrastructure), water/power outages, defective water supply to hydrants, disruption of ventilation/air conditioning, and health problems.

Scenario 2 (Figure 3.4.4C): heavy rainfall, overwhelmed sewage system, road transportation disruption, limited first response;

- Hazards included in the specific Impact Chain: major earthquake, dam-break flood;
- Impacts included in the specific Impact Chain: human casualties, building damage/collapse, damage to/collapse of buildings hosting emergency management services (including hospitals), overwhelmed hospitals, restricted access to intervention sites, telecommunication disruption, overwhelming of emergency phone lines, work overload on first responders.

Scenario 3 (Figure 3.4.4D): low temperatures, snowstorms, road transportation disruption, limited first response.

- Hazard included in the specific Impact Chain: major earthquake;
- Impacts included in the specific Impact Chain: human casualties, building damage/collapse, damage to infrastructure (including lifelines), water/power outages, damage to/collapse of buildings hosting

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emergency management services (including hospitals), restricted access to intervention sites, population displacement, road accidents.

To solve the tasks, participants were provided with A0 posters (Figure 3.4.4) divided into three sections: the underlying conditions of the disaster scenario at the top, the Impact Chain at the bottom, and three boxes on the right for filling in the responses to the three tasks. As presented during the demonstration exercise, stakeholders had to fill in the boxes specific to each task, and to number the newly identified impacts, vulnerabilities, and adaptation options. The numbers were used to express the links between these elements, as follows: Vulnerability a affects Impact a, Adaptation option b mitigates Vulnerability b (e.g., Vulnerability 1 affects Impact 1, Adaptation option 2 mitigates Vulnerability 2).

Upon completing the three tasks, the stakeholders were invited to present their findings, which sparked a fruitful discussion on the disaster scenarios and their particularities. The participants showed interest in the scenarios explored by other teams, comparing their specific conditions to the ones assigned to them. On certain occasions, stakeholders from different teams requested clarifications from the representative of the team presenting the results.

Serious Games

As part of the workshop, the stakeholders had the opportunity to participate in a Serious Game developed within PARATUS by Michalina Kulakowska from the Centre for Systems Solutions in Wrocław, Poland. The game was aligned to the seismic disaster context that stood at the core of the event. It divided participants into two teams with specific roles: first responders responsible for saving lives, and citizens reluctant to cooperate. To make the experience more immersive, the game was set in Bucur, a fictional town resembling Bucharest, that was hit by a powerful earthquake. Each player was assigned a specific role with a personal backstory and instructions on how to behave. The roles of the first responders were standardized to rescuers in the emergency response team, tasked with the provision of immediate assistance to people affected by the earthquake. In contrast, the roles of the uncooperative citizens included owners of businesses, young freelancers, retired single parents, factory workers, homeless people, elderly street vendors, and members of national minorities. All the portrayed social categories were characterized by a certain degree of individual vulnerability that motivated their reluctance to cooperate with first responders.

The goal of the Serious Game was that first responders would bring the uncooperative residents of the fictional town Bucur to safety. The game was played in two timed rounds, with a role reversal between rounds. In the second round, former first responders switched roles with the uncooperative residents, and the mission was repeated. At the start of the activity, some stakeholders expressed skepticism, but as the game progressed, they became deeply engaged in the earthquake-focused simulation. In both rounds, the first responders successfully ensured the safety of the uncooperative population within the allotted time, with the second mission completed more quickly than the first.

The game ended with an open discussion, providing the stakeholders an opportunity to reflect on their game experience and their gains from it. They were encouraged to share insights on how the Serious Game had deepened their understanding of communication during emergency interventions and to offer suggestions for improving the game. Their feedback focused on the differences between real-life experience and the simulation, noting that the game could not fully replicate the highly stressful situations in which communication occurs between rescuers and disaster victims. The limited time aspect was highlighted by multiple guests as a factor that greatly influences the effectiveness of such communication. The brief timeframe for response actions during disasters also constrains opportunities to understand the victims better, which is crucial for selecting the most appropriate communication strategies. Nevertheless, participants expressed their appreciation related to the overall game experience, acknowledging that it exceeded their expectations and that it can serve as a useful and also enjoyable training exercise.

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Co-design of Disaster Risk Stakeholder Hub and stakeholders' feedback

The workshop concluded with a presentation of the Disaster Risk Stakeholder (DRS) Hub that stands at the core of the PARATUS Project, delivered by Dr. Funda Atun, Associate Professor at ITC, University of Twente and Project Coordinator. The Hub functions on a pre-existing Online Community Platform called The Crisis Management Innovation Network Europe (CMINE), which hosts a network of global partners. CMINE posits an all-inclusive approach, welcoming feedback from various types of stakeholders and encouraging diversity-focused and innovative thinking.

The DRS-Hub provides guidance to stakeholders in conducting their DRM activities in the PARATUS Case Studies by offering them a repository of key documents relating to multi-hazard risk initiatives and projects, best practices, hazard and risk assessment tools, an Impact Chain wiki, and many other useful features for Disaster Risk Reduction. Additionally, it offers a chat and discussion platform, enabling stakeholders across Europe to interact and collaborate, ultimately strengthening collective resilience.

Participants were introduced to the two core services of the DRS Hub: the Information Service (including Disaster Risk Terminology, Impact Chains, Disaster Data, and Best Practices) and the Simulation Service (including Hazard Assessment Tools, Risk Assessment Tools, Tools for the Risk Reduction Decision-Making, and Serious Games). Next, they explored two of the Impact Chains developed for Bucharest and Romania. This granted them with a clearer picture of the scale at which Impact Chains are constructed, which sparked their interest and appreciation. Further on, the participants asked to use one hazard assessment tool. Fastflood was chosen for this purpose, and the operating principles behind this platform were briefly presented. A flood hazard simulation was performed around Morii Lake in Bucharest, to illustrate the entry point of regular flood risk assessments (i.e., maps of potentially flooded areas). The UB team highlighted that Fastflood can only be used to model the hazard component of risk, which has to be exported and corroborated with exposure and vulnerability maps in other risk assessment tools. This practical activity ended with a constructive discussion on how to build high-quality exposure and vulnerability databases not only for Bucharest but for other cities in Romania. Participants acknowledged the scarcity of such data, pinpointing that collaboration among the institutions in charge of different aspects of disaster management and decision-makers, is critical in overcoming this shortage.

At the end of the presentation, stakeholders were invited to provide their feedback on the DRS Hub through a survey distributed on Google Forms and translated into Romanian. During and in the few weeks following the workshop, 22 responses were collected through the feedback survey from the stakeholders. An increase in the number of responses is anticipated in the coming weeks due to additional dissemination efforts. The main results are summarised as follows:

- Most of the collected responses come from second responders, followed by first responders and consultants.
- Over 70% of stakeholders agree that access to information on DRR technology is very important. Additional terminology requests included "post-disaster recovery", which was not mentioned by the stakeholders from other case studies.
- Access to Impact Chains on past destructive events was rated very important (60%), or somewhat important (40%). More than half of the participants expressed a desire to create their own Impact Chains and share them with others, while about one-third considered that this activity is not important.
- Access to relevant data was considered very important, or at least somewhat important by almost all participants.
- About 70% of the surveyed stakeholders would like to be informed about disaster databases, hazard maps, and risk or exposure data through the DRS Hub. However, only one-third identified information on climate change as a priority topic. This is consistent with other results from the survey: around 60% of respondents reported not using any of the presented disaster databases or tools for risk reduction planning, while nearly half of them do not use any of the presented hazard or

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risk assessment tools. The result reflects stakeholders' desire for continuous improvement in their knowledge and skills.

- Access to 1) best practices, 2) hazard modelling tools, 3) risk modelling tools, 4) risk reduction planning tools was appreciated as very important or somehow important by more than 70% of stakeholders. Also, more than 80% of the stakeholders agreed that such tools should be open access, while more than a third wanted them to have a simple interface.
- Earthquakes and the associated hazards were of interest to nearly all participants (95%), followed by floods (77%), landslides (60%), droughts (46%), and heatwaves (41%).

3.4.3 Key results

Focus group results

The outcomes of the Focus Group are listed in Table 3.4.2. Although the invited stakeholders generally focused on the same hazard impacts, they identified different vulnerabilities for them. For instance, the human casualties are the result of the three hazards but also of the lack of knowledge about earthquake protection behaviour, according to the first two groups, and of the old age of the buildings, as listed by the third group. Regarding building damage or collapse, the first group pointed to the absence of seismic design as a contributing factor. The second group noted illegal modifications to constructions, that weaken their structural integrity, while the third group cited the ageing of buildings again. Another primary impact for which the three groups suggested different vulnerabilities is road traffic disruption, which is the result of the overcrowding of certain areas, according to the second group, and of the undersized infrastructure and low preparedness level of the population, according to the third group. A noteworthy point of consensus emerged regarding the work overload experienced by first responders, for which participants of the first and third groups provided the same vulnerability: the lack of human resources involved in emergency management.

In terms of adaptation options, two working groups proposed awareness or preparedness campaigns to mitigate human casualties, and retrofitting works to mitigate the building damage/collapse. The third group proved to be the most productive, proposing adaptation options with the potential to mitigate multiple impacts (Table 3.4.2). For instance, the preparation of an emergency backpack can help prevent human casualties, telecommunication disruption, and communication problems between victims and rescuers. Similarly, preparedness campaigns were identified as adaptation options for human casualties, psychological effects associated with the earthquake experience, and road traffic disruption.

The third working group also put forward an important insight: population relocation, initially listed as a hazard impact in the provided chain, can also be interpreted as an adaptation option. This group also identified other links of “causes” type among the impacts and/or hazards in the chain, demonstrating a comprehensive understanding of how Impact Chains function. Moreover, several of the vulnerabilities pinpointed by stakeholders leveraging their practical expertise on DRM are also supported by the scientific literature (Armaș, 2006, 2012; Armaș and Gavriș, 2013; Armaș et al., 2016, 2017), confirming their relevance and significance.

Stress test results

The results of the stress testing conducted on future scenarios relevant for Bucharest are depicted in Table 3. As anticipated, the proposed impacts, vulnerabilities, and adaptation options vary across scenarios, reflecting the distinct underlying conditions characteristic of each. One noteworthy commonality is that the teams working on disaster scenario focused on extreme temperatures (i.e., Scenarios 1 and 3) indicated an increase in the criminality rate and voiced concerns related to the disruption of the supply chain.

The group working on Scenario 1 put forward vulnerabilities related to different types of shortages, including of personnel in charge of maintaining public order, medical personnel, and medical material resources. These deficiencies contribute to new impacts that may arise if a major earthquake affects Bucharest during summertime, when temperatures are high and water resources scarce: an increase in the criminality rate,

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disruption of the supply chain, and the overwhelming of hospitals. The adaptation options proposed to mitigate the stated vulnerabilities refer to financial investments and the reactivation of military emergency services (to cover the shortages of staff and resources), resource redistribution from unaffected regions, and requests for European assistance.

The second scenario revolved around what can happen (i.e., new impacts), why (i.e., new vulnerabilities), and what can be done (i.e., adaptation options) to address the disaster situation if a major earthquake and a subsequent dam-break flood temporally overlap heavy rainfall causing sewage overflow, road transportation disruption, and limited response capacity. The identified impacts included compounded economic losses from the earthquake and flood, power and water outages, public panic, population displacement, and homelessness. The increased economic losses were attributed to the low insurance coverage despite its mandatory status (Law 260/2008), the low preparedness level of the population, and the Romanian state's limited capacity to provide accommodation for disaster victims. Such vulnerabilities can be mitigated through public awareness campaigns to promote the benefits of insurance, the establishment of reliable backup systems for power and water supply, and the development of well-equipped temporary emergency shelters.

The team addressing Scenario 3 identified the largest number of potential impacts that could result from a powerful earthquake hitting Bucharest during winter, when temperatures are low, and snowstorms cause road disruption and limit the response capacity. The impacts included: reduced access to digital financial resources and essential goods (e.g., food, water), injuries among emergency management personnel, an increased crime rate, and the closure of educational institutions. The last impact garnered the most attention from this working group, as suggested by the vulnerabilities they proposed as contributing to the closure of schools: the low preparedness level of authorities, alongside the old age and lack of seismic design of school buildings. Disaster management plans, establishing a logistics hub, and acquiring the equipment and services to remove snow were proposed as general adaptation measures.

Table 3.4.3: Results of the Focus Group.

Stakeholder group	Vulnerability affects Impact	Adaptation option mitigates Impacts
Group 1	• Absence of seismic design affects Building damage/collapse • Insufficient backup energy sources affect Telecommunication disruption • Lack of knowledge about earthquake protection behaviour affects Human casualties • Lack of human resources involved in emergency management affects Work overload on first responders • Lack of psychological support services affects Psychological effects associated with the earthquake experience	• Elaboration of psychological protection procedures mitigates Psychological effects associated with the earthquake experience
Group 2	• Undersized access roads affect Restricted access to intervention sites • Overcrowding in certain areas affects road traffic disruption • Illegal works that can negatively affect the resistance structure of the building affect Building damage/collapse	• Supplementation of parking spaces mitigates Road traffic disruption • Retrofitting works mitigate Building damage/collapse • Media-supported awareness raising campaigns on proper response to earthquakes mitigate Human casualties

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	• Absence of knowledge on how to respond to emergency situations affects Human casualties	
Group 3	• Old age of the buildings affects 1) Building damage/collapse, 2) Human casualties • Undersized infrastructure affects Road traffic disruption • Low preparedness level of the population affects 1) Human casualties, 2) Road traffic disruption • Insufficient number of hospitals affects Overwhelmed hospitals • Insufficient emergency management personnel affects Work overload of emergency management personnel	• Retrofitting mitigates Building damage/collapse • Update of the General Urban Plan mitigates 1) Restricted access to intervention sites, 2) Road traffic disruption • Extension of the communication network mitigates the Overwhelming of the emergency lines • Preparedness campaigns mitigate 1) Human casualties, 2) Psychological effects associated with the earthquake experience, 3) Road traffic disruption • Preparation of an emergency backpack mitigates 1) Human casualties, 2) Telecommunication disruptions, 3) Communication problems between victims and rescuers

Table 3.4.4: Results of the stress test of future scenarios.

Stakeholder group/Scenario	New impacts	New vulnerabilities	New adaptation options
Group 1 Scenario 1	1. Increase in criminality rate + negative effects on public order 2. Negative effects on the supply chain (food, water) 3. Overwhelming of hospitals	1. Deficit of personnel in charge of maintaining public order 2. Insufficient available resources 3. Lack of human and material resources, including insufficient medical units	1. Supplementation of public order personnel with staff from unaffected areas 2. Redistribution of resources from the unaffected areas + Supplementation of the funds in the Government emergency fund 3. Request for help from European emergency support agencies 3. Activation of temporary campaign hospitals and of the military medical personnel
Group 2 Scenario 2	1. Increased economic loss 2. Power/water outages 3. Population displacement 4. Panic among the population	1. Low coverage of insurance policies 1, 4 Low preparedness at the individual level	1. Raising awareness about the benefits of insurance 2. Performant backup systems

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	5. Homelessness	5. Limited provisional accommodation from the state	5. Setting up more well-equipped provisional accommodations
Group 3 Scenario 3	1. Unfunctional ATM machines 2. Disruption of access to digital financial resources 3. Injured emergency management personnel + Diminished response capacity 4. Absence of the feeling of safety/Unsettling feeling/Fear 5. Lack of access to essentials (food/water) 6. Increase in the criminality rate (looting/crime/abuse) 7. Closure of schools	6. Low quality of living 7. Authorities' low preparedness level to remove the snow 7. Old age of buildings 7. Lack of adequate seismic design	Disaster management plans The implementation of a logistic hub Acquisition of means and services to remove snow

3.4.4 Follow-up planning

The next steps within the Bucharest Case Study focus on examining potential loss resulting from the cascading occurrence of a major earthquake (over 7 MW) that will trigger a dam break flood. The multi-hazard scenario takes the Morii Lake, located in the northwestern part of Bucharest (upstream of the city center), simulating the compounded impact of a powerful seismic event and of a flood caused by the breaking of the Ciurel Dam or as a result of a levee breach. The interplay of cascading hazards, exposure, and vulnerability is explored through an Impact Chain developed for the present and future situation. The model also integrates a wide range of feedback from relevant stakeholders (i.e., decision-makers, first and second responders, military, architects, academics, insurance companies, and legal experts).

The estimation of the resulting loss and of flood propagation will rely on an exposure and vulnerability database. Data collection will involve satellite images (including from the KH-8 mission in the 1970s and 1980s), deep learning algorithms, and open-source and census data. This database will enable the running of OpenQuake for a near-real-time estimation of seismic losses, proving to be highly valuable for first responders but also for developing scenario-driven preparedness plans. A fully 2D modelling approach will be used for the flood hazard analysis aiming to determine the flooded areas and maximum water height, accounting for the resistance imposed to the water flow by buildings

Additionally, we will perform an analysis of post-multi-hazard road network functionality in Bucharest under different seismic and flood scenarios. The analysis will factor in incidents (such as road blockage due to debris, bridge collapse, or access restrictions caused by flooding) and their impacts on traffic at particular times. Special attention will be dedicated to the changes in the service areas of hospitals in Bucharest, in the aftermath of the earthquake. The Fundeni Clinical Institute will be taken as a case study showcasing the constraints in post-earthquake accessibility due to the potential collapse of nearby vulnerable buildings that will cause road blockages.

Another research direction that the UB team aims to pursue in the next month's concerns earthquake risk perception among the population of Romania's capital and the nexus of this perception and of disaster risk preparedness. This will be investigated through a standardised survey designed starting from the extended version of the Theory of Planned Behaviour (initially developed by Ajzen 1991), as proposed by Ng (2022). The relationships between the theory's constructs will be examined through a robust operational framework

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involving linear, nonlinear, and Bayesian regressions, as well as structural equation modelling. The findings add to the study of risk perception and disaster preparedness behaviour, opening the way to harmonising bottom-up and top-down approaches to Disaster Risk Management in Bucharest. Moreover, they provide a roadmap to improve disaster risk communication, ultimately building credibility, trust, and resilience within communities.

The upcoming stakeholders' workshop will introduce the participants to the results of the multi-hazard and risk perception analyses, alongside other findings. Their insights will contribute to refining multi-risk scenarios tailored to Bucharest. This collaborative approach seeks to deepen our understanding of systemic vulnerability and risk, fostering resilience and preparedness in Bucharest.

3.4.5 Conclusion

The Second Stakeholder Workshop in the Bucharest Case Study stands out as a successful milestone in the activity performed in this case study. To promote the event and collect feedback, a series of brief interviews were conducted with key invited stakeholders. These interviews can be accessed via this link.

The interviewees comprised a diverse group of professionals, each representing prominent institutions relevant to disaster preparedness and response in Romania: the Ministry of Regional Development and Public Administration (Operative Center for Emergency Situations), the Disaster Risk Control Service from the Prevention Department of the General Inspectorate of Emergency Situations, the National Insurance Pool against Natural Disasters, and the Public Health Department of the Municipality of Bucharest.

Here are some extracts of the appreciative feedback from these stakeholders:

"*First, I would like to say that it was my pleasure to take part in the second PARATUS Workshop. [...] I thank you for the opportunity you provided for us through this invitation. [...] My colleagues and I will certainly attend future events like this, and we will call for your support. Your professional expertise speaks very highly of you and motivates our respect for you and your team. It is only by standing together that we can develop a resilient society.*"

"*There were multiple ideas that surprised me. I came with the thought that I would not learn much from this session because I am well informed on how to analyse risks. I found the Impact Chains presented here very interesting, especially the impacts and the connection between vulnerability analysis and Impact Chains. I also enjoyed the serious game we played during this workshop. It sparked an interest at the table where I sit today, and it opened a fruitful dialogue with my colleagues. I believe that this is a strength of this session.*"

"*I am grateful for this invitation and for the opportunity to attend this very interesting workshop. [...] the construction of Impact Chains that are central to your project could yield results that are better than the ones specific to sectoral approaches. I truly appreciate the Impact Chain approach. [...] You consistently present topics that raise the interest of the public and are highly relevant nowadays.*"

"*I am grateful for the new perspectives that I encountered during this workshop.*"

The success of the workshop shows in the unanimous interest expressed by the participants to engage in future events of this type. This enthusiasm highlights the workshop's dual significance: an achievement in the project's progression and a testament to the effectiveness of our team in translating scientific results into practical applications for Disaster Risk Management in Romania. Through its well-structured discussions and interactive format, the workshop facilitated innovative thinking on how to design more productive disaster mitigation strategies and reinforced partnerships. This collaborative momentum will prove essential for advancing the next phases of the Bucharest Case Study.

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Appendix 1

Figure A1: Results of the group work on the sector traffic and transport (Source: Andlinger, 2024).

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Figure A2: Results of the group work on the sector tourism and economy (Source: Andlinger, 2024).

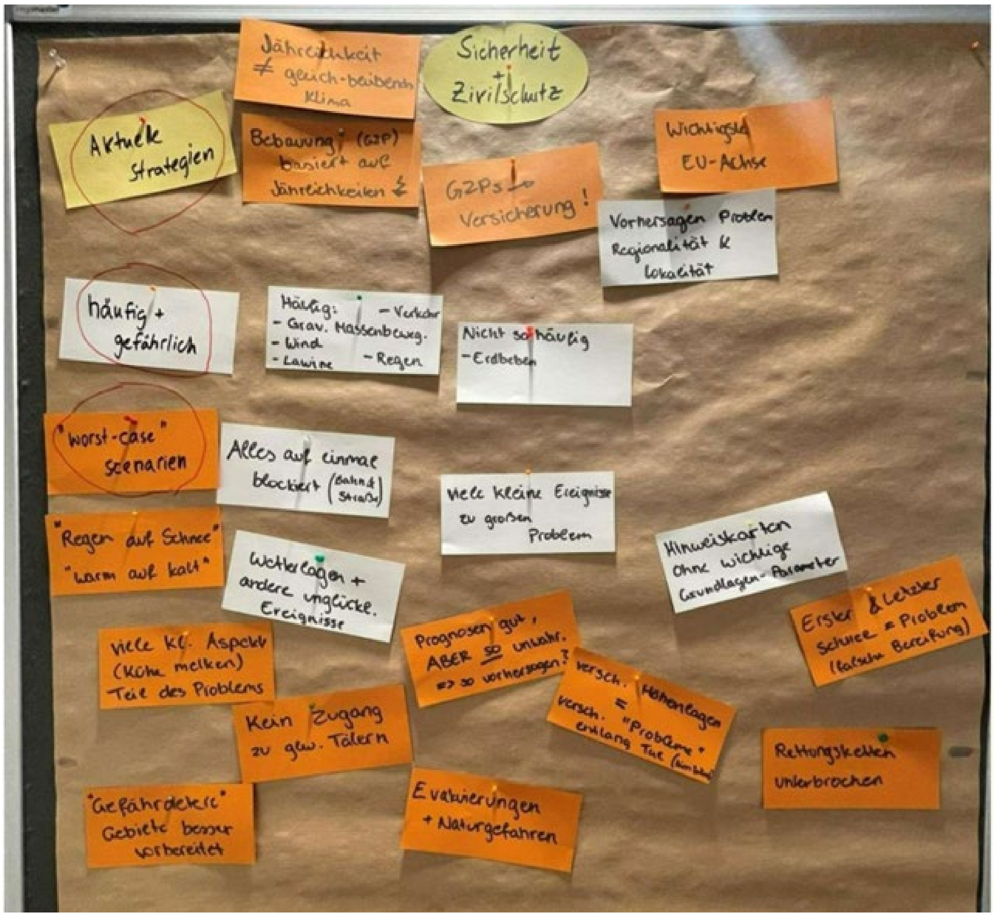

Figure A3: Results of the group work on the sector safety and civil protection (Source: Andlinger, 2024).

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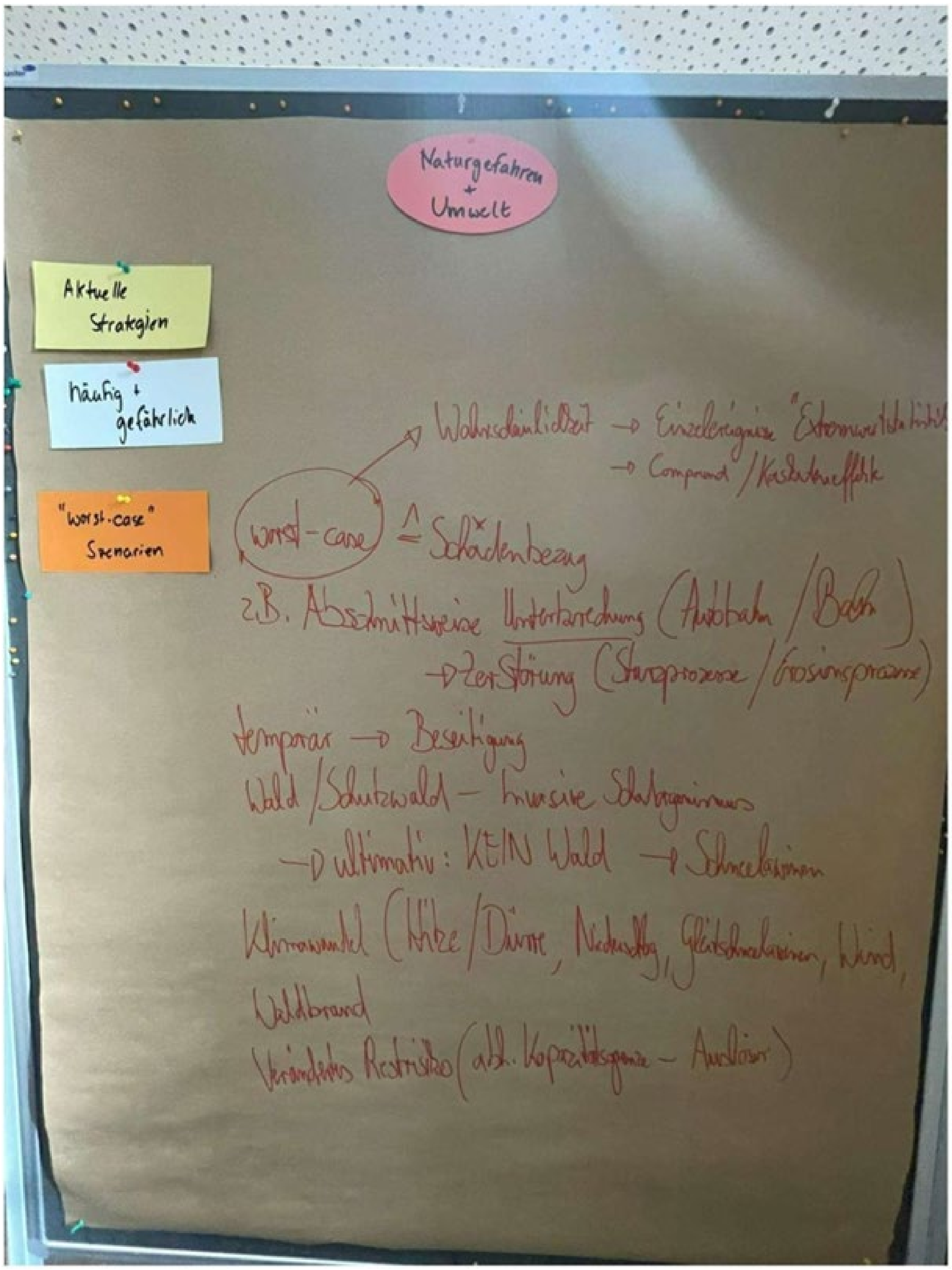

Figure A4: Results of the group work on the sector natural hazards and environment (Source: Andlinger, 2024).

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Appendix 2 – The Istanbul workshop program

PARATUS WORKSHOP PROGRAM

24th September 2024

İstanbul Kaya Ramada Hotel / Gökevler, 2317. Sk No:1, 34513 Esenyurt / Istanbul

09:00	Registration
09:30	Welcome speeches
10:00	Introduction of PARATUS Project and DRS Hub
11:15	Break
11:30	1. Session: Mapping risks in Avcılar
12:30	Lunch Break
13:30	2. Session: Stress Test scenarios for Avcılar
15:30	Break
15:45	3. Session: Group presentations
16:45	Closure

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Appendix 3 – Career table of participants in the Istanbul workshop

First Session		Disasters Experienced During Your Career									Roles in Disasters								
		Earthquake	Flood	Overflow	Tsunami	Tsunami	Snow	Pandemic	Fire	Terror	Damage Mitigation	Preparedness	Response	Recovery	Research/Data Production	Policy Development	Communication	Organization	Administration/Management
TABLE 1	Participant 1	X										X	X					X	
	Participant 2	X				X					X	X		X	X	X	X	X	X
	Participant 3	X	X			X									X				
	Participant 4						X						X					X	
	Participant 5	X										X							
	Participant 6	X		X							X	X							
	Participant 7										X	X			X	X		X	
	Participant 8	X											X						
	Participant 9	X										X		X				X	X
	Participant 10	X	X		X						X	X			X	X			
	Participant 11	X															X	X	X
	Participant 12	X									X				X	X			
	Participant 13	X									X		X	X				X	X
	Participant 14	X												X			X	X	
TABLE 2	Participant 1	X												X					
	Participant 2	X													X				X
	Participant 3	X						X				X					X	X	
	Participant 4	X										X		X				X	
	Participant 5	X						X					X		X			X	
	Participant 6	X		X				X			X	X	X	X		X	X	X	X
	Participant 7																X	X	
	Participant 8	X																	X
	Participant 9	X										X	X				X		X
TABLE 3	Participant 1	x																x	x
	Participant 2	x		x	x			x						x			x		
	Participant 3	x						x			x	x	x						
	Participant 4							x									x	x	
	Participant 5							x										x	
	Participant 6	x						x				x		x	x				
	Participant 7	x											x					x	x
	Participant 8	x		x	x			x			x	x	x	x			x	x	x
	Participant 9	x									x	x	x	x	x	x	x	x	x
	Participant 10	x																	
	Participant 11	x		x	x									x	x				
	Participant 12	x						x			x			x					
TABLE 4	Participant 1												x					x	x
	Participant 2											x	x						
	Participant 3	x		x									x					x	
	Participant 4											x							
	Participant 5											x	x		x	x		x	
	Participant 6	x												x				x	x
	Participant 7	x											x	x					
	Participant 8	x																x	
	Participant 9	x									x								
	Participant 10	x													x				
	Participant 11	x														x		x	x
	Participant 12	x											x	x					x
	Participant 13	x													x				
TABLE 5	Participant 1	x												x			x		
	Participant 2	x	x	x							x	x	x	x				x	x
	Participant 3										x	x	x						x
	Participant 4	x																x	
	Participant 5	x													x				
TABLE 6	Participant 1	x		x								x	x					x	x
	Participant 2	x			x							x			x				
	Participant 3	x														x			
	Participant 4	x								x	x	x	x	x	x			x	x
	Participant 5	x									x	x			x	x			
	Participant 6	x		x	x				x									x	x
	Participant 7											x						x	
	Participant 8	x									x			x				x	
	Participant 9	x											x	x				x	x

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Appendix 4 - Scenario papers

Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Hafta içi akşam 18:00-19:00 civarı.

Nüfusun yoğun bulunduğu alanlar: İşten çıkış saatleri, yol, köprü, metro, vapur.

Hava koşulları: Kuvvetli yağışların bir süre daha devam edeceği biliniyor. Kentin bazı kesimlerimde su baskını ve sel tehlikesi için uyarılar verildi.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
- Depremin 72. Saatine kadar geçen sürede devam edebilecek olumsuzlukları mekânsal, sektörel ve sistemler üzerinden belirtiniz. (10 dk)
- Depremin 72. Saatine kadar geçen sürede müdahaleye destek olacak bölgeleri, sektörleri ve sistemleri belirtiniz. (10 dk)
- Depremin 15. Gününe kadar geçen sürede kayıplar ve hasarlar nedeniyle yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin 3. Ayına kadar geçen sürede yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)

Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Temmuz-Ağustos ayları, 03:00-05:00 civarı.

Nüfusun yoğun bulunduğu alanlar: Konut alanları, uyku hali.

Hava koşulları: Sıcaklıklar mevsim normallerinin üzerinde seyrediyor. İlerleyen günlerde yeni bir sıcak hava dalgası bekleniyor.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
- Depremin 72. Saatine kadar geçen sürede devam edebilecek olumsuzlukları mekânsal, sektörel ve sistemler üzerinden belirtiniz. (10 dk)
- Depremin 72. Saatine kadar geçen sürede müdahaleye destek olacak bölgeleri, sektörleri ve sistemleri belirtiniz. (10 dk)
- Depremin 15. Gününe kadar geçen sürede kayıplar ve hasarlar nedeniyle yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin 3. Ayına kadar geçen sürede yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)

Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Bahar ayları, hafta sonu, 14:00-16:00 civarı.

Nüfusun yoğun bulunduğu alanlar: Sahil, park, orman, AVM, tiyatro, sinema.

Hava koşulları: Baharın ilk günleri, güneşli bir gün.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
- Depremin 72. Saatine kadar geçen sürede devam edebilecek olumsuzlukları mekânsal, sektörel ve sistemler üzerinden belirtiniz. (10 dk)
- Depremin 72. Saatine kadar geçen sürede müdahaleye destek olacak bölgeleri, sektörleri ve sistemleri belirtiniz. (10 dk)
- Depremin 15. Gününe kadar geçen sürede kayıplar ve hasarlar nedeniyle yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin 3. Ayına kadar geçen sürede yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)

Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Kış ayları, hafta sonu, 14:00-16:00 civarı.

Nüfusun yoğun bulunduğu alanlar: Konut.

Hava koşulları: Yoğun kar yağışının bir süre daha devam etmesi bekleniyor. İlerleyen günler için kar fırtınası uyarısı yapıldı.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
- Depremin 72. Saatine kadar geçen sürede devam edebilecek olumsuzlukları mekânsal, sektörel ve sistemler üzerinden belirtiniz. (10 dk)
- Depremin 72. Saatine kadar geçen sürede müdahaleye destek olacak bölgeleri, sektörleri ve sistemleri belirtiniz. (10 dk)
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- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)

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Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Hafta içi, sabah 09:00-10:00 civarı.

Nüfusun yoğun bulunduğu alanlar: Çalışanlar iş yerlerine ulaşmış, öğrenciler derste.

Hava koşulları: Parçalı bulutlu, yağış beklenmiyor.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
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- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)

Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Eylül ayı, Pazartesi sabah 08:00-09:00 civarı.

Nüfusun yoğun bulunduğu alanlar: Yollar. Yazlıkçıların dönüş yaptığı, üniversitelerin öğrenime başladığı zamanki yoğunluk.

Hava koşulları: Hafif yağışlı bir gün. Ara ara kuvvetli dolu geçişleri bekleniyor. Sürücülerin dikkatli olması konusunda uyarılar yapıldı.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
- Depremin 72. Saatine kadar geçen sürede devam edebilecek olumsuzlukları mekânsal, sektörel ve sistemler üzerinden belirtiniz. (10 dk)
- Depremin 72. Saatine kadar geçen sürede müdahaleye destek olacak bölgeleri, sektörleri ve sistemleri belirtiniz. (10 dk)
- Depremin 15. Gününe kadar geçen sürede kayıplar ve hasarlar nedeniyle yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin 3. Ayına kadar geçen sürede yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)

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Appendix 5 – Scenario papers (cont.)

Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Eylül ayı, Pazartesi sabah 08:00-09:00 civarı.

Nüfusun yoğun bulunduğu alanlar: Yollar. Yazlıkçıların dönüş yaptığı, üniversitelerin öğrenime başladığı zamanki yoğunluk.

Hava koşulları: Hafif yağışlı bir gün. Ara ara kuvvetli dolu geçişleri bekleniyor. Sürücülerin dikkatli olması konusunda uyarılar yapıldı.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
- Depremin 72. Saatine kadar geçen sürede devam edebilecek olumsuzlukları mekânsal, sektörel ve sistemler üzerinden belirtiniz. (10 dk)
- Depremin 72. Saatine kadar geçen sürede müdahaleye destek olacak bölgeleri, sektörleri ve sistemleri belirtiniz. (10 dk)
- Depremin 15. Gününe kadar geçen sürede kayıplar ve hasarlar nedeniyle yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin 3. Ayına kadar geçen sürede yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)

Değerli Katılımcılar,

Marmara Denizi'nde İstanbul açıklarında Mw 7.0 üzeri bir deprem meydana geldi.

Depremin ardından ilk 72 saatte Mw6.0 üzeri 4 ve Mw5.0 üzeri 28 artçı deprem meydana geldi.

Depremin saati: Hafta içi, sabah 09:00-10:00 civarı.

Nüfusun yoğun bulunduğu alanlar: Çalışanlar iş yerlerine ulaşmış, öğrenciler derste.

Hava koşulları: Parçalı bulutlu, yağış beklenmiyor.

Senaryo doğrultusunda aşağıdaki sorulara cevap verebilecek mekânsal gösterim ya da diyagram şeklinde anlatım teknikleri kullanılabilir.

- Depremin ilk 1-2 saatinde öne çıkan problem alanları, sektörler ya da sistemler nelerdir? (15 dk)
- Depremin 24. Saatine kadar geçen sürede hasar alan bölgeler, sektörler ve sistemler nedeniyle nerelerde ne tür sorunların yaşanması beklenebilir? Bu bölgelerin, sektörlerin ve sistemlerin kırılgan/zayıf olmasının nedenleri nelerdir? (15 dk)
- Depremin 72. Saatine kadar geçen sürede devam edebilecek olumsuzlukları mekânsal, sektörel ve sistemler üzerinden belirtiniz. (10 dk)
- Depremin 72. Saatine kadar geçen sürede müdahaleye destek olacak bölgeleri, sektörleri ve sistemleri belirtiniz. (10 dk)
- Depremin 15. Gününe kadar geçen sürede kayıplar ve hasarlar nedeniyle yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin 3. Ayına kadar geçen sürede yaşanabilecek sistemik etkiler nelerdir? (10 dk)
- Depremin orta vadeli etkileri nelerdir? (5 dk)
- Depremin uzun vadeli etkileri nelerdir? (5 dk)

Bu oturumda belirttiğiniz yıkıcı etkileri önlemek için (çoğunlukla oturum 1'de belirttiğiniz sorunlu alanlara dayanarak), önereceğiniz müdahaleler neler olurdu? Ve bu müdahaleler öngördüğünüz zincirleme etkileri nasıl değiştirirdi? (30 dk.)