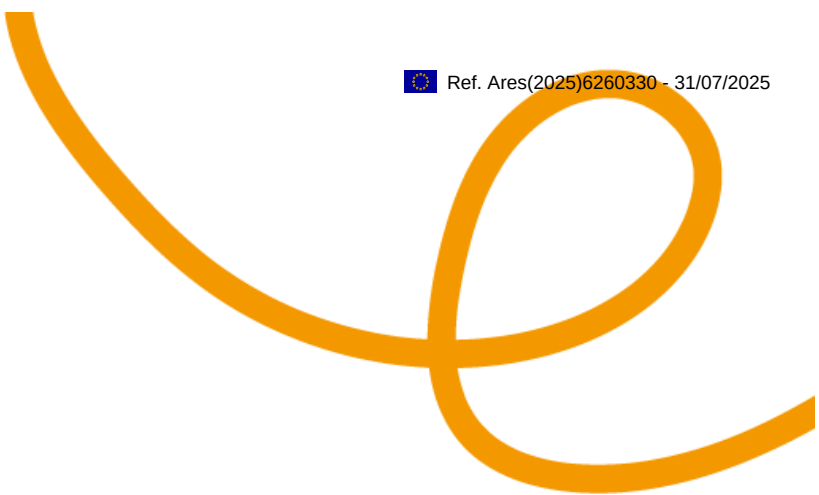




Deliverable 3.4

Serious games

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Abstract

The deliverable 3.4 presents the co-development and testing of serious games within the PARATUS project as tools to support multi-hazard risk awareness, stakeholder engagement, and decision-making under uncertainty. Grounded in established methodologies such as the CompleCSus framework, Design Thinking the report outlines a four-phase workflow: research and conceptualization, scenario and role design, prototyping and iterative testing, and implementation and evaluation. Multiple games tailored to specific case study needs—ranging from cross-border collaboration in the Alps to crisis communication in Bucharest—were co-developed and tested with diverse stakeholders, including emergency responders, policymakers, and community actors. The games were designed to simulate cascading risks, foster strategic decision-making, and enhance participatory learning. Supporting materials were created to ensure future adaptability, ease of facilitation, and long-term use beyond the project's lifecycle.

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V3	31/07/25	Final	Cees van Westen	Final deliverable for submission

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The deliverable D3.4 has been submitted to the European Commission on 31 July 2025 and is waiting for approval by the Research Executive Agency. Therefore, this current version may not represent the final version of the deliverable.

About PARATUS:

The PARATUS project aims to increase the preparedness of first and second responders in the face of multi-hazard events and to reduce the risks related to impacts on various sectors resulting from complex disasters. The outcome is a 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 in 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 with stakeholders and developed in four case study areas (including the Caribbean, Bucharest, Istanbul, and Alpine regions).

List of Acronyms

Acronym	Definition
AR	Augmented Reality
ASFINAG	ASFINAG Alpenstraßen GmbH
CompleCSus	Complexity-Collaboration-Sustainability
CRS	Centre for Systems Solutions
D	Deliverable
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EU	European Union
EURAC	EURAC Research
GIS	Geographic Information System
HILP	High Impact Low Probability
IMM	Istanbul Metropolitan Municipality
ITC	Faculty of Geo-Information Sciences and Earth Observation
ITU	Istanbul Technical University
IMM	Istanbul Metropolitan Municipality
KNMI	Royal Netherlands Meteorological Institute
M	Month
MHR	Multi-Hazard Risk
NGO	Non-Governmental Organization
PARATUS	Increasing Preparedness and Resilience of European Communities by Co-Developing Services Using Dynamic Systemic Risk Assessment
RCCC	Red Cross Red Crescent Climate Centre
UB	Universitatea din Bucuresti
UNIVIE	Universität Wien
UT	University of Twente
UX	User Experience
WP	Work Package

Executive Summary

This deliverable describes the co-development process and introduces the 4 serious games that were developed under PARATUS to support multi-hazard risk awareness, stakeholder engagement and decision-making under uncertainty. These games are the High Water Pantano, Bucur Simulation, Saltum Montem, The Interactive Multi-Hazard Systemic Risk Mapping. Simulating real-world disaster scenarios provides an experiential learning environment where users—first responders, policymakers, infrastructure managers, and humanitarian actors - can test adaptive strategies and risk mitigation measures in a safe, controlled setting.

Deliverable 3.4 outlines the methodology behind the game's development, including its scientific background, UX design, and stakeholder-driven approach. The co-design process applied in the process ensured that the game experience is relevant to the needs of the different stakeholder groups.

The deliverable also presents the evaluation and observation methods applied during testing, using structured assessment protocols to measure the games' effectiveness. In addition, it provides detailed descriptions of the developed games, including their specific applications, target audiences, and gameplay mechanics.

Finally, it highlights the broader impact of the games in supporting multi-hazard risk awareness, and decision-making under uncertainty, supporting transdisciplinary collaboration, and informing policy development.

This document is structured as follows:

- **Methodology:** Outlines the scientific and design foundations for developing serious games.
- **Serious Games Co-Design Process:** Describes the stakeholder engagement and iterative development approach.
- **Evaluation & Observation Protocols:** Defines the methods used to assess participant interactions and learning outcomes.
- **Results & Impact:** Summarizes the key findings and contributions of the game to disaster risk reduction.
- **Serious Games Developed:** Provides an overview of the specific games, including High Water Pantano, Bucur Simulation, Saltum Montem, the Interactive Multi-Hazard Systemic Risk Mapping.
- **Recommendations for Use:** Provides guidelines for applying the serious game in policy, research, and training contexts.

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1. Introduction to deliverable

Deliverable D3.4 introduces serious games designed to enhance disaster preparedness, systemic risk awareness, and decision-making in multi-hazard environments. The games serve as an interactive training and policy-testing tool for stakeholders involved in increasing disaster resilience. D3.4 aligns closely with the PARATUS project's objectives of co-developing innovative, user-centred tools for risk assessment and disaster preparedness. It integrates insights from multiple work packages (WPs) and tasks to ensure a cohesive, transdisciplinary approach. While the original proposal envisioned the development of only one single serious game, the mapping of needs across the PARATUS application case studies revealed a diversity of contexts and learning objectives that, we decided, could not be addressed by a single tool. As a result, a series of 4 games were developed: Highwater Pantano, Bucur Simulation, Saltum Montem, and The Interactive Multi-Hazard Systemic Risk Mapping.

In PARATUS, the overall purpose of the serious games is to provide stakeholders with a tool to explore the effect of risk reduction decisions on cascading and compounding events. To achieve this, the games were co-designed with stakeholders to provide learning experience based on the real-world disaster risk challenges and to strengthen engagement through learning. Additionally, by integrating case studies from diverse socio-economic and geographic contexts, the games were developed to be scalable, adaptable, and relevant across different geographical settings and user groups. PARATUS games are co-developed with first responders, policymakers, and researchers.

Deliverable 3.4 includes key Inputs from other PARATUS project deliverables:

- D1.3 Impact, Damage and Loss Data: Enables realistic, evidence-based scenario modeling.
- D3.2 Guide to Stress Test Future Decision Making: Ensures the robustness of decision-making pathways in the games.
- D3.3 Report of Adaptation Options: The real-world-tested adaptation strategies are included in the games.
- D5.1 PARATUS Impact Strategy (Draft) and D5.2 PARATUS Impact Strategy (Final): Supports inclusive stakeholder participation and knowledge co-creation from early project stages, feeding directly into the broader engagement and transferability approach during the game co-design process.

Key outputs of D3.4 to other PARATUS WPs and some specific tasks and deliverables.

- WP2: D2.2 Report of scenarios for future changes in terms of hazard, vulnerability and exposure: The games will be used to support systemic risk modeling. In addition, throughout the duration of the project the games will support the tasks T2.2, T2.3 in WP2.
- WP3: T3.2 Co-development of Adaptation/Mitigation Options: The games facilitate stakeholder co-creation of adaptation and disaster risk reduction strategies through interactive, participatory formats that support collaborative exploration of planning options. We will continue this task until month 34 as it provides inputs to the tools that we are developing in WP4. Additionally, D3.4 lays the groundwork for future tools by establishing a tested, scalable game model that informs the design and development of the AR-based extension and the output of D3.4 will be an input for D3.5 Augmented Reality.
- WP4 User Centered Risk Assessment and Mitigation Service: The games are hosted in Disaster Risk Stakeholder Hub. They are freely available and accessible tools and support the learning environment in the Disaster Stakeholder Hubs. Other funded projects upload their games to the hub as well.
- WP5 External Cooperation, impact and transferability: The games help us to engage various stakeholders in the upcoming activities of PARATUS project. The games are used to enhance communication of project outcomes through workshops, media outreach, blogs, and serious game demonstration (T5.3 Communication and Dissemination Activities) and contribute to the

sustainability and exploitation blueprint by offering replicable, modular tools with potential for customization and integration into standardized DRM practices (T5.4 Exploitation and Standardization).

D3.4 directly supports EU and international strategies for disaster risk reduction and climate adaptation, reinforcing evidence-based policy development and digital transformation:

European and International Frameworks:

- European Green Deal & EU Mission on Adaptation to Climate Change¹: Helps policymakers and emergency responders explore mitigation strategies for climate-related disasters (Serious Games: High Water Pantano, Saltum Montem).
- Europe Fit for the Digital Age² – Uses cloud-based platforms to enhance risk assessment accessibility (Serious Games: High Water Pantano, Saltum Montem, Bucur Simulation).
- European Disaster Resilience Goals³: Improves risk anticipation, assessment, and disaster response planning through interactive serious games (Serious Games: all).
- Sendai Framework for Disaster Risk Reduction 2015-2030⁴: Strengthens risk understanding and governance through scenario-based training (Serious Games: all).
- UN Sustainable Development Goals⁵ (SDGs 11⁶ & 13⁷): Promotes resilience-building and climate adaptation through inclusive, interactive learning (Serious Games: all).

The D3.4 serious game is highly adaptable and user-centered, serving a broad range of stakeholders involved in disaster preparedness and risk assessment:

Primary Users – directly involved in the co-development process via workshops in PARATUS case study areas:

- First responders & emergency agencies (firefighters, civil protection teams).
- Policymakers & urban planners (local, regional, and EU decision-makers).
- Critical infrastructure operators (transport, energy, and communication sectors).
- Scientific researchers & climate risk modelers.
- Humanitarian organizations & NGOs (e.g., Red Cross, UN agencies).

Secondary Users, so the organizations that may have not participated in the co-development process, but might benefit from using the tools:

- Educators & academic institutions: Using the game as a training resource.
- Insurance & financial sector: Exploring disaster risk financing models.
- Civil society groups & local communities: Raising public awareness of disaster preparedness.

D3.4 serves as a cornerstone of the PARATUS project, integrating scientific risk assessment, stakeholder engagement, and digital innovation into an interactive, experiential learning tool. The games are designed in multi-languages, usable across diverse geographic and socio-economic settings, scalable, and foster cross-sector collaboration and policy innovation.

¹https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

²https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age_en

³https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/european-disaster-risk-management/european-disaster-resilience-goals_en

⁴<https://www.undrr.org/implementing-sendai-framework/what-sendai-framework>

⁵<https://sdgs.un.org>

⁶<https://sdgs.un.org/goals/goal11>

⁷<https://sdgs.un.org/goals/goal13>

Table 1 Overview of deliverables WP3.

#	Name	Due date (month)	Description
D3.1	Virtual compilation of the toolbox	18	Lead Beneficiary: RAN Strategy, case study protocols, including a template for follow-up
D3.2	Guide to stress test future decision making	26	Lead Beneficiary: RCCC A co-produced guide to stress testing decision making.
D3.3	Report of adaptation options	32 (updated to 33)	Lead Beneficiary: RCCC A co-designed guide of adaptation options, resulting from Case Studies.
D3.4	Serious game	34	Lead Beneficiary: CRS One serious game based on immersive user experience has been designed and tested
D3.5	Augmented reality game	44	Lead Beneficiary: CRS One AR game has been designed and tested and is publicly available.

2. Background to the methods

We adopted our game development methodology based on the three main studies. First, Complexity-Collaboration-Sustainability framework (CompleCSus) provided us with a step-by-step process for developing serious games in complex systems (Figure 1). Second, key features for enhancing DRM effectiveness explored in the study "An overview of serious games for disaster risk management" (Solińska-Nowak et al. 2018). Last but not least, user-centered methodologies including Design Thinking, ensuring continuous stakeholder engagement and iterative refinement (Plattner et al., 2011).

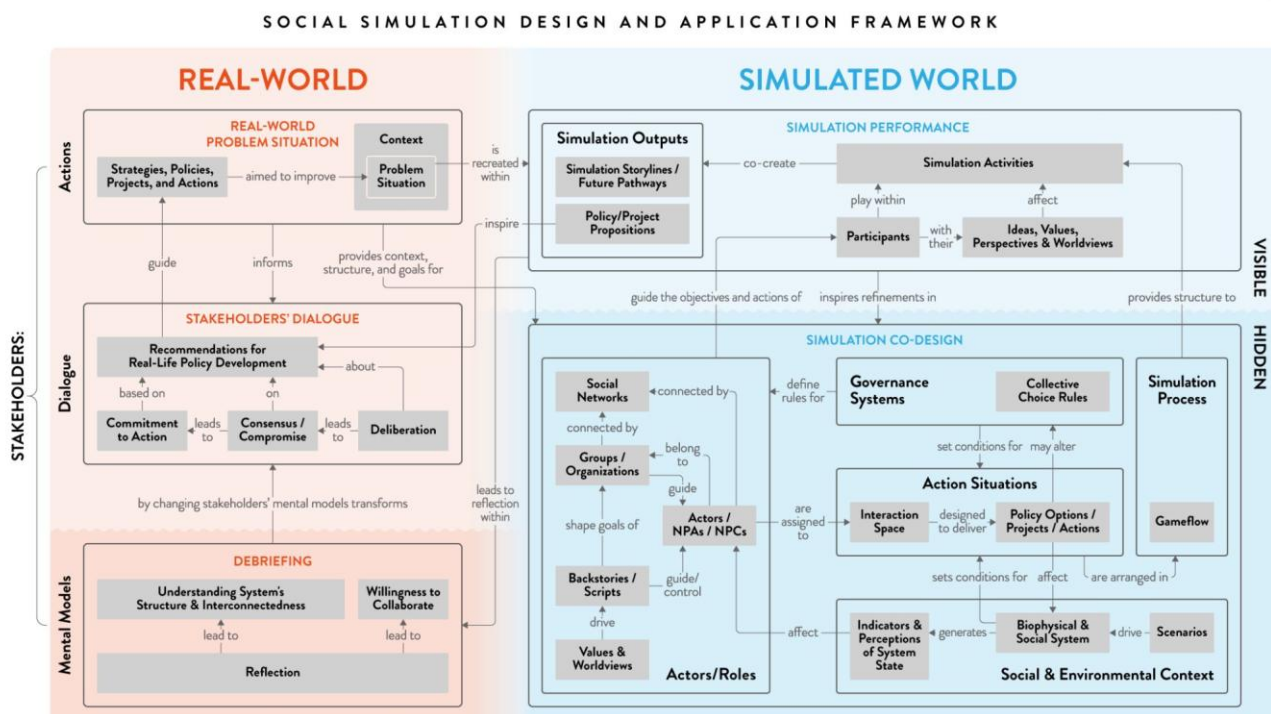


Figure 1 CompleCSus framework as described in Mochizuki et al. 2021. The graphic is the property of the Centre for Systems Solutions.

The CompleCSus framework guided the structured design of the serious game, ensuring scientific rigor, stakeholder relevance, and iterative improvements. The process unfolded in two key phases: 1) research and concept development, 2) game structuring and prototyping. The CompleCSus framework ensured that the game's mechanics, roles, and decision pathways reflected real-world DRM challenges. (Table 2)

"An Overview of Serious Games for Disaster Risk Management" by Solińska-Nowak et al. (2018) identifies critical success factors that can improve the effectiveness and impact of serious games in disaster risk contexts. This widely cited paper provides a comprehensive analysis of how serious games can be effectively applied in disaster risk contexts and outlines several critical success factors necessary for ensuring that such tools are not only engaging but also educationally and operationally meaningful.

Finally, the Design Thinking methodology (Plattner et al., 2011) emphasizes a human-centered, iterative process for solving complex problems. Rather than assuming stakeholder needs, the methodology guides users to explore these needs directly through continuous engagement using interviews, co-design workshops, prototyping sessions, and iterative feedback loops.

Table 2 Overview of CompleCSus phases.

Phase 1: Research & Concept Development	Phase 2: Game Structuring & Prototyping
Literature review on DRM and serious game methodologies.	Development of player roles, decision-making mechanics, and scenario structures.
Expert consultations and stakeholder interviews to identify challenges.	Prototyping and iterative testing with Learning Labs and pilot groups.
Selection of disaster scenarios relevant to multi-hazard risk assessment.	Refinements based on feedback, ensuring usability and effectiveness.

3. PARATUS methodology for serious games

In the PARATUS project, serious games combine elements of role-playing, systems analysis, and scenario building to immerse participants in complex, real-world scenarios. By adopting various roles, individuals can explore intricate systems, experiment with different strategies, and observe the consequences of their actions in a controlled environment. This approach fosters a deeper understanding of multifaceted issues and promotes collaborative problem-solving (Kułakowska & Solińska-Nowak, 2021). They leverage interactive and immersive elements to facilitate learning, behavior change, skill development, awareness raising and problem-solving. By immersing players in simulated scenarios, these games have the power to cultivate empathy, critical thinking, and a deeper understanding of the interconnectedness of global issues (Salen & Zimmerman, 2003). Building on the key learnings from the co-design process, the development of the PARATUS serious games reflects the practical insights gained from two years of engagement with diverse stakeholder groups. The need for accessibility, stakeholder ownership, flexible formats, and realistic but engaging content directly informed the design of each serious game. These lessons shaped not only how the games look and feel, but also how they function as tools for discussion, reflection, and strategy-building in complex disaster scenarios.

In PARATUS, we followed a four-step approach while developing serious games. The development of serious games in PARATUS was guided by a structured, literature-informed methodology. While Chapter 2 (Background to the methods) presented a high-level, two-phase design logic based on the CompleCSus framework (Mochizuki et al., 2021), namely, Research & Concept Development and Game Structuring & Prototyping, this chapter expands that model into a four-step development process that reflects how those phases were operationalized in practice.

Table 3 PARATUS serious games methodology with relevant literature which was used during each phase.

Phase	Activities	Relevant sources
Phase 1: Research and Conceptualization	1. Literature review and expert consultations, including with consortium partners. 2. Identification of learning objectives in each case study area aligned with multi-hazard DRM strategies.	Mochizuki et al., 2021; Solińska-Nowak et al., 2018; Plattner et al., 2011; Brookings Institution, 2016; Armaş et al., 2016;
Phase 2: Scenario and Role Design	1. Development of a narrative-driven learning experience with multi-hazard games. 2. Role-playing design allowing players to assume key decision-making positions in DRM. 3. Creation of interactive mechanics (risk assessment, resource allocation, emergency response).	Mochizuki et al., 2021 Solińska-Nowak et al., 2018 Plattner et al., 2011 Karaman & Erden, 2014 Caribbean Export Development Agency, 2016 CBS, 2023 D1.3 Impact, damage and loss data related to the considered events in the four core cases. Wiki-type structured Database, PARATUS ⁸ D3.2 Guide to Stress Test Future decision making, PARATUS ⁹
Phase 3: Prototyping and Iterative Testing	1. Initial prototyping tested in the Case Study Learning Labs and with expert panels. 2. Adjustments based on user experience (UX) and game engagement data. 3. Testing with diverse user groups to refine mechanics and accessibility.	D6.2 Report 1 of Workshops in Application Case Studies, PARATUS ¹⁰ D6.3 Report 2 of Workshops in Application Case Studies, PARATUS ¹¹ D6.4 Report 3 of Workshops in Application Case Studies, PARATUS ¹² Fass-Holmes, 2022
Phase 4: Implementation and Evaluation	1. Finalization of game mechanics, learning objectives, and stakeholder engagement strategies. 2. Deployment in training workshops, policy discussions, and resilience-building exercises. 3. Evaluation through observation protocols, user feedback, and impact assessments.	Fass-Holmes, 2022

⁸ <https://www.paratus-project.eu/portfolio-items/d1-3/?portfolioCats=4>

⁹ <https://www.paratus-project.eu/portfolio-items/d3-2/?portfolioCats=4>

¹⁰ <https://www.paratus-project.eu/portfolio-items/d6-2/?portfolioCats=4>

¹¹ <https://www.paratus-project.eu/portfolio-items/d6-3/?portfolioCats=4>

¹² <https://www.paratus-project.eu/portfolio-items/d6-4/?portfolioCats=4>

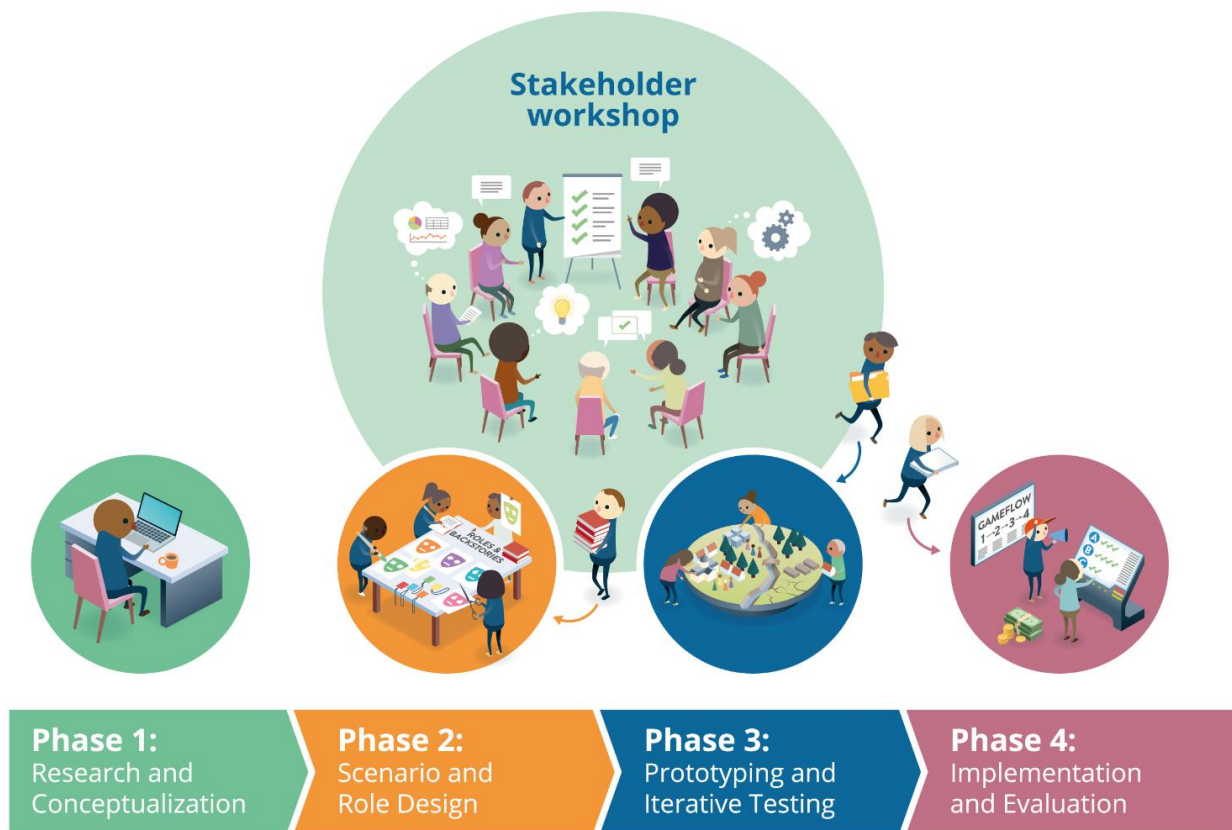


Figure 2 Diagram illustrating 4-step process of the development of serious games in PARATUS.

In the process of co-developing of the games, we aligned the process with the 5 level Stakeholder engagement strategies defined in deliverables D5.1 and D5.2, particularly the participatory engagement approach (Section 3.1), the use of inclusive digital formats (Section 3.4), and the goal of capacity building for diverse end-user groups. In line with the Impact Strategy, D3.4 facilitates stakeholder-driven co-development across all 5 levels of the engagement, while supporting the long-term impact objectives of PARATUS through scalable learning tools that can be reused across regions and sectors. The serious games developed in PARATUS reflect all five levels of engagement. Initially, stakeholders were informed (level 1) and consulted (level 2) during early workshops and interviews to identify challenges and priorities. As development progressed, they were involved (level 3) and collaborated (level 4) in the co-design of game mechanics and scenarios and ultimately empowered (level 5) to use the games independently for training, planning, and awareness-raising in their own contexts.

3.1. Phase 1: Research and conceptualisation

Phase 1 of the process focused on literature review, analysis of the available inputs from other work packages and identification of learning objectives aligned with the overarching goal of T3.3 and the project as a whole. Additionally, we conducted a comparative analysis of the PARATUS case studies to identify objectives for the serious games. This effort aimed to identify common patterns, recurring challenges, and shared stakeholder types across different geographical and institutional contexts. By exploring these similarities, we sought to design tools that could be scaled up or down and adapted to varying local needs, so we ensured that the serious games are co-designed with project stakeholders, would not only reflect their specific interests and set-ups, but also hold relevance and transferability beyond the PARATUS project.

To support the analysis, data from each case study were gathered and mapped using the collaborative platform Miro. The mapping process was structured around key dimensions such as disaster risk reduction (DRR), response, recovery, and vulnerability phases. This visual and comparative approach allowed the team to assess which game elements and materials could be reused across case studies, enhancing both design efficiency and scalability.

We also explored the tools and visuals that stakeholders usually use in their work - such as maps, dashboards, alerts, and checklists - to make sure that similar formats are used in the games to increase realism and the ease of immersion. In addition, we reviewed public safety advertisements, emergency awareness campaigns, and media coverage from different countries to understand how disaster-related topics are communicated to the public. This helped us tailor the design language and storytelling elements of the games to resonate with local communication styles and enhance their relevance and credibility.

Another important element was looking closely at the impact chains co-developed together with the stakeholders. This process allowed us to understand how different stakeholder groups perceive and prioritize risks and hazards within their specific contexts. By comparing impact chains across case studies, we identified patterns and recurring themes—such as the vulnerability of transport systems—which appeared consistently despite vast differences in geography, hazard types, and institutional settings. The structure and logic of the impact chain methodology were later directly reflected in the flow of the workshops, guiding participants through the interconnected nature of hazards, vulnerabilities, and cascading impacts.

We drafted a plan for the co-development workshops with stakeholders. This plan served as a flexible framework and was adapted according to the specific stakeholder groups involved and the type of serious game or tool being co-developed. Below, we present the general structure of the co-development workshops, framed as questions:

- What would you like players to learn from the game?
- Who should be using the game(s)?
- Who should be playing the game(s)?
- What could stop you from using/playing the game(s)?
- What challenges & problems related to the topic are important to you?
- Question regarding values, emotions & feelings, e.g., What are the things that are important to you in a state of emergency?
- How can local knowledge and stakeholder values enhance the understanding of risk propagation through various aspects of the system [specific case study context]?
- Priorities: How would you prioritize the potential users of the game? Which stakeholder groups should be involved first, and why?
- Priorities: What are the key learning outcomes you want players to gain from the game? What knowledge, skills, or perspectives should they walk away with?

The co-development workshop plan was initially designed for use of the Miro platform to facilitate participation and collaboration in both online and hybrid settings. This approach aimed to facilitate coordination across geographically dispersed partners and stakeholders. The use of online tools helped lower participation barriers in many cases; however, the Caribbean case study revealed additional challenges. Due to limited connectivity and difficulties with remote engagement, online communication proved to be less effective, highlighting the importance of adapting the approach to local conditions. With this process, we focused on mapping stakeholder needs based on stakeholder input from previous workshops, and internal partner discussions effects of which are described in detail in the next sections. The plan served not only as a structure for the PARATUS workshops but also offers potential guidance for similar co-creation processes elsewhere—suggesting the use of digital platforms where appropriate, while emphasizing the continued value of in-person engagement to deepen understanding and to build trust.

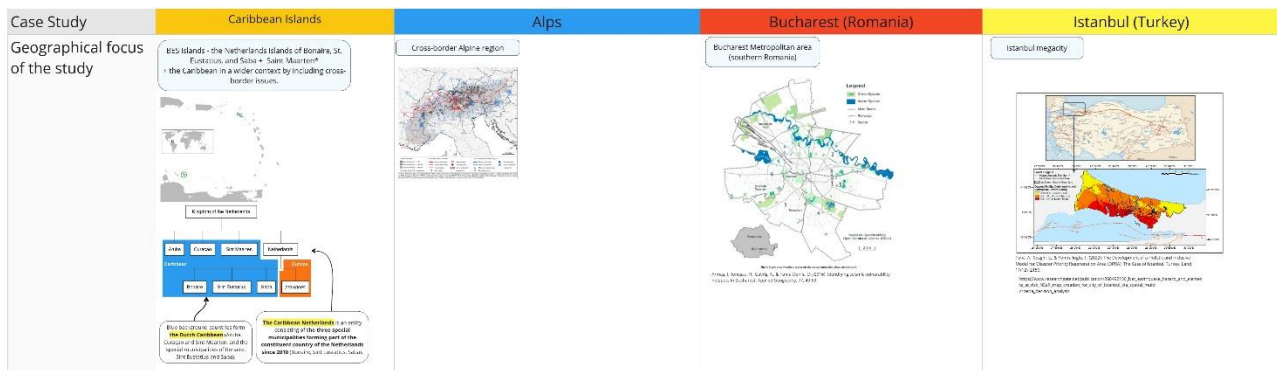


Figure 3 A segment of the Miro board to compare PARATUS case studies prepared by the team working on the serious games.

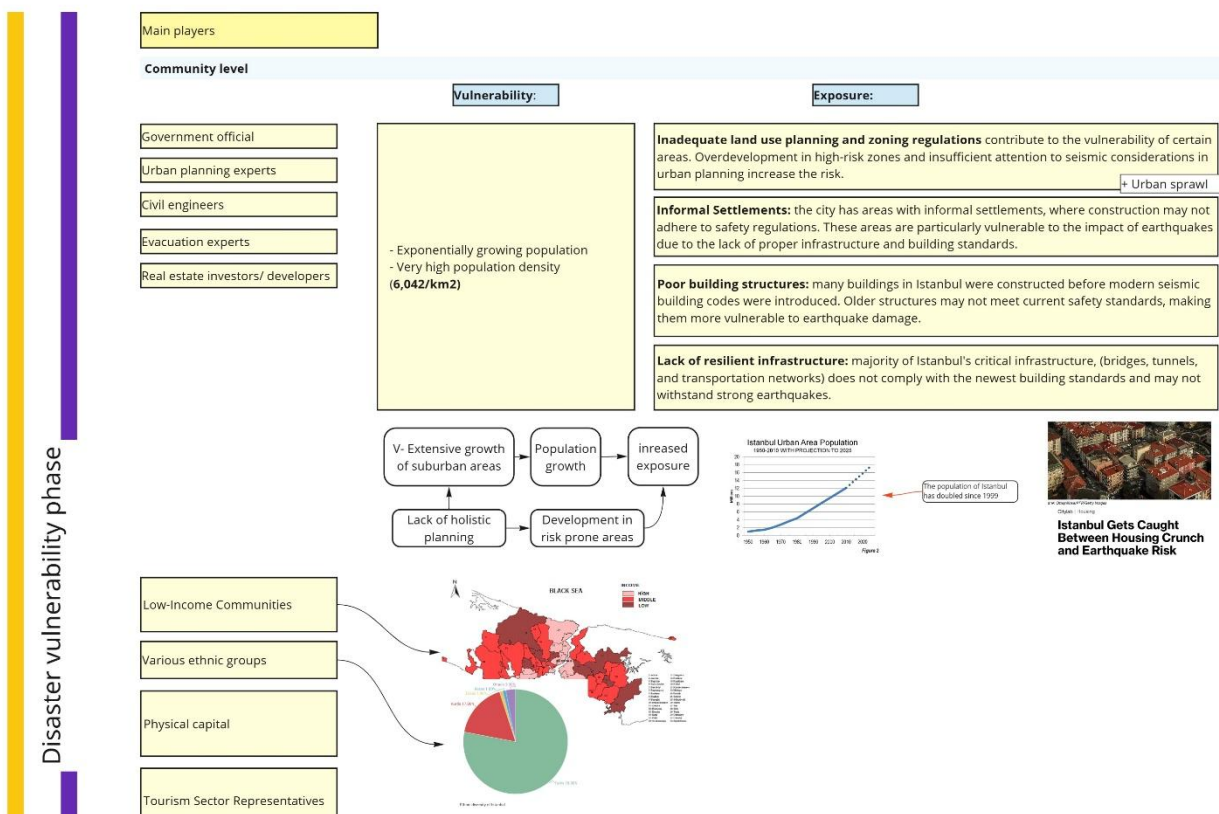


Figure 4 An example of the information compiled on the stakeholders in Istanbul, Türkiye.

The mapping of the expected learning outcomes gained some interesting differences for the case study areas. In discussions stakeholders expressed their expected learning outcome, the game audiences and identified other needs. This initial mapping guided all further game development process and is the reason why we decided to develop a series of 4 games that are tailored to the challenges raised.

Table 4 Mapping needs in the Case Study areas.

Case Study	Expected learning outcome	Stakeholders engaged	Design needs identified
Bucharest	To raise awareness about how to support the first responders in dealing with aggressive, insubordinate groups in a compounding disaster response scenario.	Governmental Actors (i.e. municipal governments, civil protections agencies). Operational and Response Services (i.e. first responders), Scientific and Technical Stakeholders (i.e. risk modelers, psychology, students), and more.	Stakeholders time for workshop participation is limited – the tools used have to be short. Power dynamics between participants should be considered.
Alps	To create a joint learning experience around cross border collaboration between institutions, exploring scenarios in different seasons and understanding the perspectives of other stakeholders. To support cross-institutional exchange.	Governmental Actors (i.e. regional planners, national parks); Private Sector (insurance companies; Infrastructure and Service Providers (i.e. road authorities); Scientific and Technical Stakeholders (i.e. meteorologists, geologists) and more.	The game must be played simultaneously in two languages (German and Italian) due to the transboundary and multi-language setting of workshops. The mechanism to enable such simultaneous play has to be considered for transboundary scenarios.
Istanbul	To identify critical bottlenecks and exposure points across multiple sectors in the city of Istanbul (e.g., housing, transportation, emergency services) and to support local capacity building and institutional coordination for emergency preparedness. To inform spatial planning and adaptation strategies and contribute to the development of a dynamic, multi-scalar, and systemically-informed risk management framework for the Istanbul metropolitan area. To experience realistic scenarios, considering inherent uncertainty regarding the timing, intensity, and cascading nature of disasters. To support coordination across scales considering systemic risks and cascading effects requiring cross-jurisdictional coordination	Governmental Actors (i.e. municipal governments, civil protections agencies). Operational and Response Services (i.e. first responders), Infrastructure and Service Providers (i.e. road authorities, public utilities), Civil Society and Community Actors (i.e. NGOs, community organizations, community leaders), Scientific and Technical Stakeholders (i.e. risk modelers, psychology, students) and more.	The aspects of the role-play among municipal representatives raised some questions. This highlights the need for careful consideration of role clarity and institutional framing in game development. face some doubts.
Caribbean	To strengthen the anticipatory capacity for multi-hazard scenarios including hurricanes, volcanic eruptions, and cascading impacts such as landslides, flooding, and infrastructure failures. Furthermore, to enhance institutional coordination across local and regional actors while fostering inclusive disaster preparedness through participatory planning.	Governmental Actors (i.e. municipal governments, civil protections agencies). Operational and Response Services (i.e. first responders), Infrastructure and Service Providers (i.e. road authorities, public utilities), Civil Society and Community Actors (i.e. NGOs, community organizations, community leaders, humanitarian organizations), Scientific and Technical Stakeholders (i.e. climate experts, resilience experts, disaster preparedness experts, risk modelers, students) and more.	Infrastructure and connectivity constraints required offline and hybrid formats to ensure engagement. Fragmented institutional landscape and complex governance structures made it difficult to ensure coordinated stakeholder participation and knowledge exchange.

4.2. Phase 2: Scenario and role design

In Phase 2, the focus was on translating real-world risks, institutional challenges, and stakeholder perspectives into interactive narratives and playable roles. Scenario and role design served as the bridge between research insights (e.g. impact chains, hazard scenarios) and the immersive, experiential nature of the games. While each case study required a tailored approach, the design principles remained consistent across the project.

Scenarios were rooted in co-developed impact chains and reflected multi-hazard dynamics specific to each case study. To encourage immersion and emotional engagement, multimedia materials such as introductory videos, moodboards, and character backstories were used to establish the tone and setting. Roles were developed to mirror the responsibilities and dilemmas of actual actors - emergency responders, policy makers, infrastructure managers, or community leaders and were often co-created with the stakeholders themselves to ensure accuracy and relevance.

The scenarios were rooted in real-world patterns and data from the PARATUS case studies. For instance, in the High Water Pantano, one of the impact chains was developed based on the patterns identified in the impact chains developed by stakeholders (see Figure 5) and was used to craft the immersive storyline. A portion of this chain (outlined in red) was then translated into a short video scenario (Figure 6) used during the game introduction. This video served as an immersion tool, helping participants emotionally and cognitively connect with the fictionalized yet plausible disaster context.

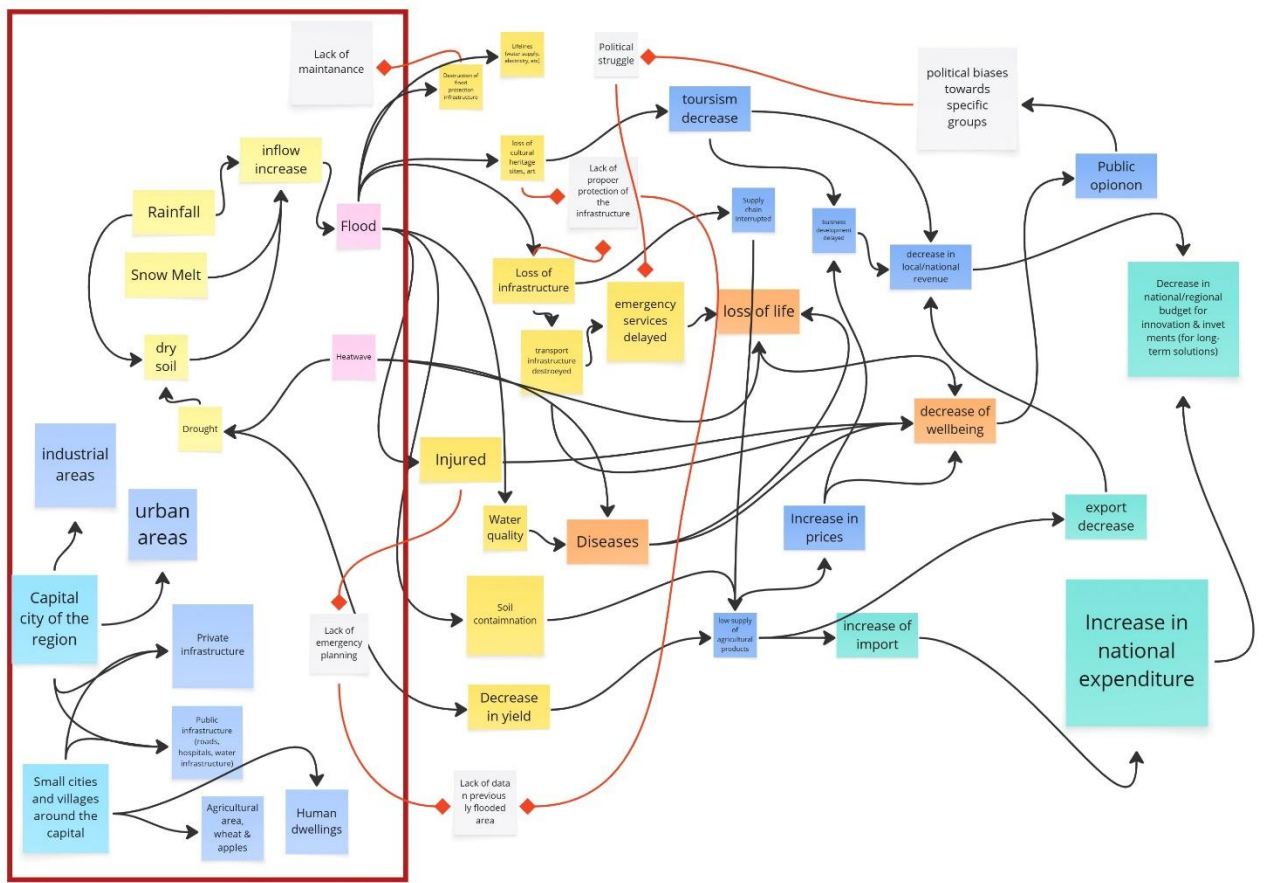


Figure 5 An example of an impact chain used for Pantano High Water.

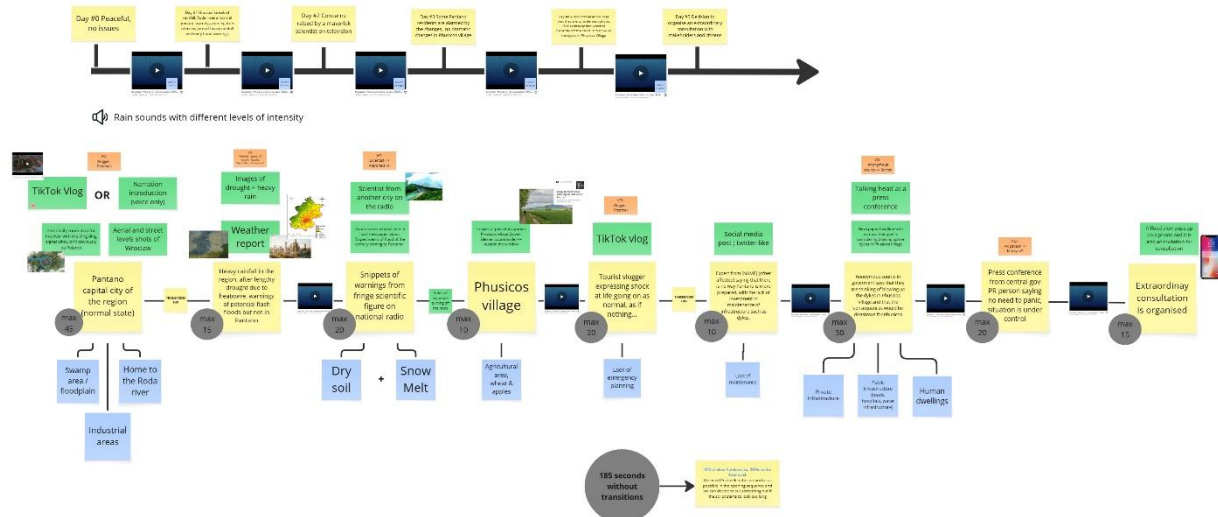


Figure 6 An example of a video story board, based on the impact chain prepared for the High Water Pantano.

In the Saltum Montem, a fictional alpine region was designed to explore cross-border disaster governance rooted in the Alps case study. Participants represented institutions such as regional authorities, transport companies, and civil protection agencies. Scenario design involved allocating each working group with sector-specific data and challenging them to negotiate trade-offs, balancing short-term emergency response with long-term resilience goals.

Similarly, the Bucur Simulation placed players in the roles of first responders and residents in a crisis triggered by an earthquake and dam failure-based scenarios were carefully crafted to simulate the communication breakdowns, institutional fragmentation, and coordination challenges common in urban emergencies. The setting, based on a fictional city inspired by Bucharest but incorporating some of the characteristics of Istanbul operations, was intentionally neutral to avoid triggering past trauma, while still reflecting real hazards and governance issues relevant to the region.

The Interactive Multi-Hazard Risk-Mapping provided a more open-ended and facilitative format for building shared understanding across diverse stakeholders. Here, scenario building was emergent, participants collaboratively constructed impact chains using a card-based toolkit, enabling them to visualize risk systems and co-design potential adaptation options. Though less narrative, this exercise offered valuable input to the scenario logic used in other games and supported integration of stakeholder perspectives.

To support immersive engagement and emotional resonance, teams also developed moodboards and visual materials to guide tone and style. For example, in High Water Pantano, a video introduction was produced to immerse players in the context of the scenario, while role cards and briefing templates were developed to ensure clarity and depth in character-driven interactions.

Text templates, collaborative design canvases, and visual assets (e.g., scenario maps, moodboards, character sheets) were reused and adapted across all games, creating a shared design language while respecting each case study's unique characteristics.

This phase was highly collaborative and iterative, with partners, case study owners and stakeholders engaged in reviewing scenario logic, role design, and learning objectives through workshops focused on the scenario building and impact chain building workshops, described in more detail in the next subchapter. By grounding scenario development in both scientific data and local experience, PARATUS serious games were able to balance realism with playability, while making abstract systemic risks tangible and emotionally compelling.

Evaluation survey and observation questionnaires were used to evaluate the general usefulness of the tools, pinpoint the interest in the medium, and find gaps in the tool.

4.3. Phase 3: Prototyping and iterative testing

In Phase 3, we began prototyping the serious games through the learning labs in the case study areas and with expert panels. These sessions allowed us to test initial concepts with a mix of researchers, practitioners, and future users. Their feedback helped us check whether the roles, scenarios, and decisions felt realistic and understandable. Importantly, it also gave us a chance to see how different stakeholder groups interacted with the game structure and each other.

As we moved forward, we made a number of adjustments based on how participants engaged with the tool during stakeholder workshops. We closely observed what worked well and what caused confusion. For example, we simplified some of the instructions, restructured decision-making phases, and introduced stronger visual and narrative elements to help participants immerse themselves more fully in the game. These improvements were informed not only by direct feedback, but also by observing how participants interacted with the roles, materials, and with each other.

We also paid close attention to the facilitation methods used in the stakeholder workshops, which provided valuable insights into how group dynamics, collaboration styles, and institutional hierarchies shaped gameplay and learning outcomes. To ensure the tools would be useful and accessible in real-world settings, the games were tested with a wide range of users, including scientists, civil protection officers, community leaders, and educators across multiple PARATUS case studies. These sessions helped us identify and address barriers related to digital access, language, and role clarity. Materials were adapted for both offline and hybrid settings, ensuring flexibility and relevance. For example, during test sessions in the Alpine case study, each table or group was accompanied by a PARATUS team member who provided on-the-spot support, helped clarify instructions, and guided participants through the games when needed, ensuring smooth facilitation and capturing user feedback in real time. This inclusive, iterative process was critical to developing games that are adaptable, user-friendly, and suitable for diverse disaster preparedness and response contexts.



Figure 7 Game testing during the Alp stakeholder workshop - using app to make decisions on the adaptation / mitigation strategies in Saltum Montem.



Figure 8 Tests of the games required a lot of social interactions. Here: testing of the potential mechanics for the games during PARATUS consortium meeting in 2023.



Figure 9 Instructions in Romanian for the Bucur Simulation during workshop in Bucharest.



Figure 11 Participants of the transboundary Alps stakeholder workshop watching a multilanguage introduction video for the Saltum Montem.



Figure 10 Photos taken in various meetings to test the Multi-Hazard Systemic Risk Mapping Exercise.

Table 5 Overview of stakeholder activities linked with the games design.

Date	Case Study Area	Workshop/Event	Location	Game related activity
May 4, 2023	Caribbean	Stakeholder workshop, Caribbean Case Study	Online	Exploring challenges and start scenario building
May 15–19, 2023	(Vienna University)	PARATUS Summer School	Vienna, Austria	Testing of High Water Pantano
June 1, 2023	Istanbul	Stakeholder workshops, Istanbul Case Study	Istanbul, Türkiye	Exploring scenario-building session with stakeholders to inform game design
June 19, 2023	Bucharest	Stakeholder workshop, Bucharest Case Study	Bucharest, Romania	Stakeholder input on evacuation dynamics; informed the Bucur Simulation
July 6, 2023	Alps	Stakeholder workshop, Alps Case Study	Bolzano, Italy	Stakeholder mapping and systemic impact chain exploration; informed Saltum Montem
September 2023	Caribbean	Stakeholder workshop, Caribbean Case Study	Online	Review of previous outcomes and refinement of cascading risk scenarios
October 6, 2023	Istanbul	Stakeholder Workshop, Istanbul Case Study	Online	Further development of impact chains and validation of stakeholder roles
November 16, 2023	Alps	Stakeholder Workshop, Alps Case Study	Online	Final validation of systemic risk chains; preparation for prototyping phase

January 2024	All Case Studies	Testing of High Water Pantano	Online	Prototype evaluation with external stakeholders; visual/narrative elements tested
Spring 2024	Bucharest Alps	Co-development Workshops	Bucharest Alps	Testing and evaluation of games (Bucur, Saltum Montem, The Interactive Multi-Hazard Systemic Risk Mapping) under development across case studies
March 2025	Game presentation & play	Meeting in Kyoto University, Japan	Kyoto, Japan	Testing the interactive multi-hazard systemic risk mapping game with the Kyoto University colleagues and conference participants
April 2025	Game presentation & play	EGU Conference, serious game night	Vienna, Austria	Testing the interactive multi-hazard systemic risk mapping game during the serious game in EGU Conference.
May 2025	Game presentation & play	CERIS event, European Commission	Brussels, Belgium	Testing the interactive risk game with participants of the event
June 2025	Game presentation & play	PARATUS GIS Training	Caribbean	Playing the interactive multi-hazard systemic risk mapping game before the GIS training to conceptualize better the concepts in the training.
July 2025	Game presentation & play	RESILIAGE Project Summer School	Torino, Italy	Playing the interactive multi-hazard systemic risk mapping game for educational purposes

4.4. Phase 4: Implementation and evaluation

Phase 4 marked the transition from prototyping to real-world use of the PARATUS serious games. The final round of stakeholder workshops across the case studies served a dual purpose: validating the tools through hands-on stakeholder engagement and implementing them in real-life decision-making, planning, and training settings. Evaluation and observation protocols were systematically applied during these sessions to assess user engagement, learning outcomes, and game dynamics. Insights from this phase led to concrete improvements in the game formats and the development of supporting materials for future facilitators, ensuring the tools can be easily adopted, adapted, and sustained beyond the project.

4.4.1. Evaluation

To assess the usability and learning impact of the serious games developed in the PARATUS project, we designed and tested two evaluation surveys alongside an observation protocol. These tools aimed to capture participant feedback on game design, usability, learning outcomes, and attitudes toward the serious game format.

The evaluation surveys were structured with a mix of quantitative and open-ended qualitative questions. They were piloted internally and with project partners across various formats—online, hybrid, and in-person. This approach allowed us to gather feedback on different elements such as gameplay, immersion, technical challenges, and information clarity.

Participants were asked which elements enhanced their immersion in the simulation. Videos were found to be the most effective, followed by moderator involvement and voice communication tools. Other tools like mobile phone apps and in-game emails also contributed to the immersive experience, albeit to a lesser extent.

We also inquired about the types of in-game information participants noticed and interacted with. Adaptation measures names and videos were the most visible to players, with email messages and chat features also being frequently accessed. However, critical elements such as working group descriptions, which were supposed to help players structure their experience, or letters describing goals and motivations were underutilized, suggesting a need for stronger visual emphasis or clearer integration.

Technical preferences regarding multitasking between communication and gameplay were also examined. A significant portion of players preferred using separate devices for gameplay and communication, highlighting the need to streamline cross-platform interaction.

Open-ended responses revealed several common themes for enhancing the serious game experience. Participants requested more maps, a clearer impact chain, better visual aids outlining their roles and tasks, and additional time to explore their characters and prepare responses and propositions for new adaptation measures. Suggestions ranged from interface and realism issues to the inclusion of additional media and background data.

The evaluation revealed that immersive elements like videos and strong moderation significantly enhanced participant engagement, while feedback highlighted a need for more contextual materials such as maps, impact chains, and clearer role descriptions. Participants also preferred using separate devices for gameplay and communication. Stakeholders highlighted the engaging gaming experience, decision-making and action-taking processes, and interactive elements such as polls, voting, breakout rooms, and the game app as the strongest aspects of the simulation. Additionally, they appreciated the simulation's focus on future-oriented policy thinking and the integration of multimedia tools like videos and social media to enhance immersion.

Despite the structured approach, consistent use of the evaluation surveys across all workshops proved challenging due to survey fatigue, a phenomenon where participants become less responsive to surveys over time. This issue is well-documented in research, particularly within European projects, where repeated survey requests can lead to decreased response rates and data quality. For instance, a study by Fass-Holmes (2022) highlights the implications of survey fatigue in academic settings. To mitigate this, we complemented the surveys with an observation protocol, detailed in the next subchapter. This approach allowed for real-time assessment of participant engagement and decision-making processes without adding to their survey burden. These insights underscore the importance of streamlined user-friendly tools and a mixed-method evaluation approach for effective learning and stakeholder engagement, and its monitoring. Nevertheless, an online evaluation survey and its printable form will be a part of the package provided to moderators of each game to make sure that the tools could be refined and adapted beyond the project.

4.4.2 Observation Protocol

While surveys captured user attitudes, our workshops also relied on an observation protocol to assess real-time dynamics, behaviors, and decision-making. This approach was especially valuable in interactive settings and multilingual contexts, where written responses alone could not reflect the full richness of participation (Kolb and Kolb 2005).

Our reasoning for using structured observation included capturing spontaneous, authentic interactions that written feedback might miss, avoiding bias from self-reporting or social desirability effects and allowing facilitators to adjust in real time, improving the game and learning experience.

The observation protocol was particularly helpful for tracking non-verbal communication, leadership emergence, turn-taking, and engagement levels. We also documented key decisions, use of props or tools (like maps and tokens), and emotional cues such as frustration or celebration.

In workshops where observers did not speak the simulation language, we used an adapted template that focused on body language, group dynamics, timing, and physical cues, supported by a debrief with facilitators afterward. This approach proved effective in multinational and multilingual project settings.

All observations were documented through observers logs and visual documentation. These insights were later cross-referenced with surveys and facilitator and players reflections from the session, allowing us to triangulate our findings and improve the simulation design.

Similar to the evaluation survey, the observation protocol, together with template for acquiring informed consent is available as part of the games materials to support broader use. Future moderators will be encouraged to share their observations and feedback with CRS. The data will be used exclusively for research and educational purposes to support continuous improvement and knowledge exchange. It will be stored securely by CRS beyond the project lifespan.

4.5. Key takeaways from the co-design process

Over the course of two years of stakeholder workshops, and testing across different regions and formats, we gathered a range of insights that were instrumental in shaping both the serious game and the broader methodology of the PARATUS project. A recurring lesson was the importance of offering low-tech, offline or “print-to-play” versions of the game. In areas where digital infrastructure is limited or where face-to-face engagement is preferred, these analog formats proved essential for accessibility and inclusiveness.

We also observed that involving diverse stakeholder groups (from emergency responders to local planners) enriched the co-design process significantly. While it wasn’t always feasible to involve all stakeholders at every stage, especially in early prototyping, their feedback later in the process deepened the realism and relevance of the scenarios. Notably, participants often expressed a wish to be involved earlier at the proposal or problem-framing stage. This underscores the need for participatory planning from the outset, not just in tool delivery.

Engagement varied across formats and with some stakeholders preferring the opportunity to interact with the game at their own pace, particularly in online environments. The flexible approach of the PARATUS project towards design of serious games, enabled stakeholders to engage at multiple levels – through learning more about the game medium (level 1 – informed), via sharing their needs (level 2 – consulted) via early workshops and interviews. As the co-design process progressed, they became more involved in the play, testing and evaluation, and debriefing sessions (level 3 – involved, level 4 – collaborated) to shape the game mechanics and contents. By providing opportunities for independent exploration and decision-making within the games and giving them the possibility to discover features at their own pace and share their feedback through different venues – they were empowered (level 5) and encouraged to uptake the tool and take ownership of outcomes. This highlights the value of designing for flexibility, such as offering modular or asynchronous gameplay. Interestingly, even when participants expressed frustration, often about realism or decision constraints, it led to richer reflection and learning. Their critical engagement indicated that serious games, when paired with facilitation and debriefing, can provide powerful, experiential insight into complex risk scenarios. However, our experience confirms that these tools work best as part of a wider learning process and not as standalone solutions.

5. Serious Games developed in the project

To ensure broad applicability and long-term usability, all games were developed with adaptability in mind. Materials are designed to be easily translated, printed (including black-and-white versions), and implemented by facilitators with varying levels of experience. Each simulation is accompanied by clear guidance, including detailed instructions and, in some cases, ready-to-use workshop scripts.

The **High Water Pantano**¹³ was developed within the PARATUS project to explore how impact chains and findings from other work packages (WPs) could be translated into serious game environments. The simulation served as a prototype for testing formats and methodologies that could later be applied to full-scale case studies. Inspired by the 1997 Central European Flood in Wrocław, Poland, it was not a direct historical reconstruction but rather a model designed to explore decision-making under crisis conditions. The serious game was built based on an impact chain developed by CRS team members with firsthand experience of the Central European Flood. The impact chain, which shares a lot of common patterns with PARATUS case studies, was translated into a simulation scenario to test how complex disaster interactions could be modelled in a serious game environment.

The **Bucur Simulation**¹⁴ is a training-focused serious game developed within the PARATUS project to address crisis communication and decision-making challenges faced by first responders in disaster scenarios. Designed as part of the co-design activities in Bucharest, the simulation provides an interactive, experiential learning environment where participants explore multi-hazard disaster response, crisis negotiation, and self-organization under uncertainty. The scenario is set in a fictional city inspired by Bucharest and Istanbul, where participants engage in an evacuation exercise amid an escalating crisis triggered by an earthquake and a potential dam failure. The game is designed to improve communication strategies, enhance coordination under stress, and simulate real-world decision-making dynamics in a controlled environment.

The **Saltum Montem**¹⁵ is an interactive serious game developed as part of the PARATUS project to explore multi-hazard risk assessment, cross-border collaboration, and decision-making under uncertainty in mountainous regions. Inspired by real challenges faced in the Alps, the simulation is set in a fictional transboundary region to allow participants to navigate crisis scenarios without the constraints of real-world geopolitical sensitivities. The simulation is designed to help practitioners assess cascading disaster impacts, stress-test adaptation strategies, and improve institutional coordination in a multilingual, multi-stakeholder setting. Participants engage in public consultations where they must negotiate responses to emerging disaster risks, balancing resource allocation, ensuring economic stability, risk mitigation, and long-term resilience planning.

The Interactive Multi-Hazard Systemic Risk Mapping was developed within the PARATUS project to support systemic disaster risk assessment and stakeholder collaboration. It enables participants to co-create impact chains visual diagrams that trace how hazards interact with vulnerabilities and exposures to create cascading impacts using a flexible card-based method grounded in the PARATUS approach. The exercise helps clarify cause-and-effect relationships and supports informed, participatory decision-making on risk reduction and adaptation strategies. Participants build impact chains using color-coded cards representing hazards, impacts, exposures, and vulnerabilities, supplemented by system elements and optional adaptation measures. The exercises was co-designed through iterative testing with case study leaders, emergency experts in Japan, students and will be updated based on the further feedback.

The game applications created within the project will be supported and hosted on the CRS server to ensure their long-term accessibility and usability. An overview of the PARATUS games along with access to downloadable materials are on the Disaster Risk Stakeholder hub in CMINE platform. The downloadable

¹³ To further enhance immersion, the team developed a [video](#).

¹⁴ [Bucur Simulation \(Video 1\)](#) and [Bucur Simulation \(Video 2\)](#)

¹⁵ [Saltum Montem Simulation Video](#)

materials are printables and instructions and designed to support easy implementation and facilitation of the games. The landing page will be updated to reflect the addition of new additional materials if necessary, and new language versions as they become available to the public. All the games developed in the project will be promoted through various channels, including Games4Sustainability¹⁶.

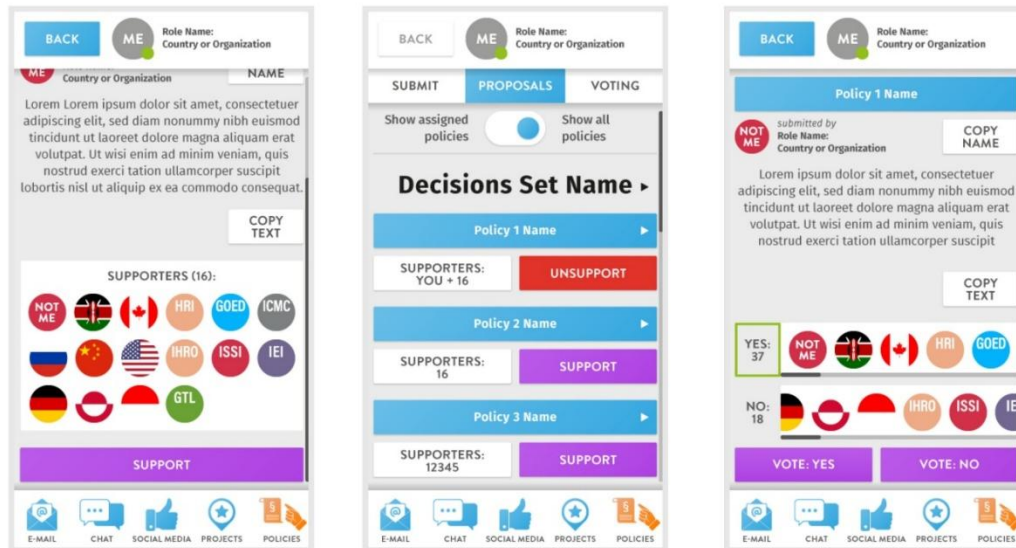


Figure 12 Example of the screen (mobile device) of the digital environment used for serious games in PARATUS.



Figure 13 An example of a map used in the Bucur Simulation.

¹⁶ <https://games4sustainability.org>

Table 6 Figure 13 An overview of the serious games tools developed in PARATUS project and currently available.

Serious Game	Objectives	Key requirements	Themes
High Water Pantano https://www.cmine.eu/topics/35391/page/paratus-games-high-water-pantano (Appendix 1)	Clarify complex, interconnected disaster risks through participatory mapping. Strengthen understanding of systemic vulnerabilities and exposure pathways. Support identification of risk reduction strategies and critical intervention points. Foster dialogue across sectors and disciplines.	Participants: Flexible group sizes. Duration: 1.5–2.5 hours. Language: English (adaptable for local contexts). Materials: Printable maps and ID badges. Role play: Yes Setting: Urban and rural, flood risk and secondary hazards Format: Can be played online or in person with mobile devices	Cascading risks and systemic interdependencies. Communication and structuring of complex risk scenarios. Collaborative planning and prioritization of risk reduction actions.
Bucur Simulation https://www.cmine.eu/topics/35391/page/paratus-games-bucur-simulation (Appendix 2)	Enhance communication skills in high-pressure situations. Test coordination strategies among emergency teams and affected residents. Increase understanding of multi-hazard disaster scenarios and their cascading effects. Facilitate role-playing to allow participants to experience both responder and civilian perspectives.	Participants: Flexible, adaptable to group sizes, up to 40 people. Duration: 0,5–2 hours, including debriefing. Language: English, Romanian (adaptable for local contexts). Materials: Printable maps, ID badges and cards, printable instructions. Role-play: Yes, limited to hierarchical aspects of the first responder team. Setting: Urban megacity, earthquake, flood risk, diverse community. Format: Can be played only in person, completely analog or with app use.	Effective crisis communication in disaster situations. Decision-making under uncertainty and adapting strategies in real time. Collaborative problem-solving and self-organization within emergency response teams.
Saltum Montem https://www.cmine.eu/topics/35391/page/paratus-games-saltum-montem (Appendix 3)	Provide a tool to support the understanding of cascading disaster impacts. Test institutional and cross-border collaboration mechanisms in crisis scenarios. Increase awareness of multi-hazard disaster risk in risk-prone regions. Simulate decision-making under resource constraints and uncertainty.	Participants: Up to 60 players, divided into working groups based on institutional roles. Duration: 2–3 hours, including introduction, role-based decision-making, and debriefing. Language: English, Italian, German, supports multiple languages during one session (adaptable for local contexts). Materials: Printable maps, and ID badge. Role-play: Yes	Multi-hazard disaster risk assessment. Cross-border collaboration in crisis scenarios. Systemic risks and cascading effects in disaster management. Resource allocation and decision-making under uncertainty. Long-term adaptation planning and resilience-building in mountainous regions.

		Setting: A fictional transboundary alpine region with key sectors including transportation, tourism, Format: Can be played online or in person with mobile devices.	
The Interactive Multi-Hazard Systemic Risk Mapping https://www.cmine.eu/topics/35391/page/paratus-games-interactive-risk-mapping-exercise (Appendix 4)	Clarify complex, interconnected disaster risks through participatory mapping. Strengthen understanding exposure pathways, vulnerabilities and multi-hazard systemic risks. Support identification of risk reduction strategies and critical intervention points. Foster stakeholder dialogue across disciplines and sectors.	Participants: Flexible – suitable for small or large groups. Duration: 1.5-2.5 hours. Language: English; (adaptable to local contexts), Turkish versions are ready. It will be translated into Italian, German and Romanian as well. Materials: Printable magnetic cards, or normal cards. Role-play: Optional Setting: abstract, and adaptable to the real case-study. Format: available only in-person, analog.	Cascading risks and systemic interdependencies. Risk mapping and identification of vulnerabilities. Multi-stakeholder dialogue and collaboration for disaster risk reduction.



Figure 14 Map of the fictional region used as the setting of the Saltum Montem, with potential disaster risk indicated as warning triangles.

6. Conclusions

The serious games presented in this report are more than educational tools, they provide players with dynamic environments for exploration of the effect of risk reduction decisions on cascading and compounding events. Designed through a co-creative and iterative process, and tested across diverse socio-geographic contexts, these tools have proven adaptable to real-world challenges and institutional settings.

One of the key contributions of these serious games is their ability to support the exploration of compounding and cascading risks, a central focus of the PARATUS project. By simulating interconnected systems and allowing participants to role-play stakeholders with varying priorities, constraints, and institutional responsibilities, the games enable users to uncover hidden dependencies and potential points of failure within complex socio-technical systems. This systems-thinking approach provides a safe, structured environment in which players can experiment with strategic interventions, weigh trade-offs, and reflect on unintended consequences of their decisions.

The games also reveal how governance structures, communication dynamics, and institutional silos influence risk mitigation outcomes. They highlight the importance of early preparedness, proactive planning, and coordinated cross-sectoral action in the face of uncertainty. Through engagement with realistic, high-pressure scenarios, the games help participants internalize the urgency and complexity of multi-hazard crisis situations in ways that traditional training methods often fail to achieve.

Beyond immediate training and awareness-raising, the serious games developed within PARATUS serve as boundary tools that support shared understanding across disciplines and decision-making levels. They can be used to initiate discussions among policymakers, civil protection agencies, researchers, educators, and community members, acting as platforms for joint scenario building, capacity development, and participatory planning.

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APPENDIX 1 - High Water Pantano – Cascading Flood Risk Serious Game¹⁷

Floods don't happen in isolation. They can trigger cascading effects across infrastructure, public safety, and communities. This game shows how people's choices affect others, and how working together can lead to better preparedness and response. High Water Pantano is a role-based serious game that helps participants explore how decisions made by various stakeholders, i.e. governmental actors, operations and response, civil society, and community actors can shape the impact of a large-scale flood. Inspired by real events, this game simulates a fictional crisis where collaboration and strategic thinking are key to building resilience.

Why play this game?

The game enhances awareness of players by clarifying flood related complex and interconnected disaster risks through participatory mapping. The game provides participants with insights into how decisions ripple through complex systems, Supports identification of risk reduction strategies and critical intervention points. Players collaborate under pressure and foster dialogue across sectors and disciplines (Figure 15).

Who is it for?

- Governmental Actors (i.e. regional authorities, municipal governments, civil protection agencies, urban planners),
- Operations and Response Services (i.e. first responders),
- Infrastructure and Service Providers (i.e. critical infrastructure operators – transport and telecommunication),
- Scientific and Technical Stakeholders (i.e. disaster risk experts, environmental experts, impact chains / risk analysts),
- Civil Society and Community Actors (i.e. NGOs, community leaders).

What do you need?

- 6-36 participants
- A moderator (training materials provided)
- Access to a laptop or mobile device for each participant
- Printable role cards and maps (color recommended)
- ~2.-3 hours of your time

How is it played?

The game is played in two main phases. In the first, you prepare for a potential flood. In the second, you face a rapidly unfolding crisis. The simulation is hosted on the **engage.socialsimulations.org** platform and can be played in person or remotely. Each player takes on a role and must make strategic decisions, negotiate with others, and vote on measures to reduce risks. Players are divided among four tables, each corresponding to a specific stakeholder group (Figure 16). Within these groups, participants discuss potential measures to mitigate flood risk and collectively vote on proposed solutions. Throughout the session, additional visuals, such as maps (Figure 17) and statistics integrated into the digital platform engage, provide new information about changing situations, and different areas of risk. At the end, players are invited to develop their own measures, expanding on those presented in the game scenario. Guided by structured questions on cost-effectiveness, responsibilities and implementation timeframes, they engage in cross-group negotiations to

¹⁷ To access all the printable materials: <https://www.cmine.eu/topics/35391/page/paratus-games-high-water-pantano>, and to get free access to play the game in the digital setting contact us at contact@socialsimulations.org

create realistic interventions. The game concludes with a debriefing that bridges the experiences from the game to the real life.

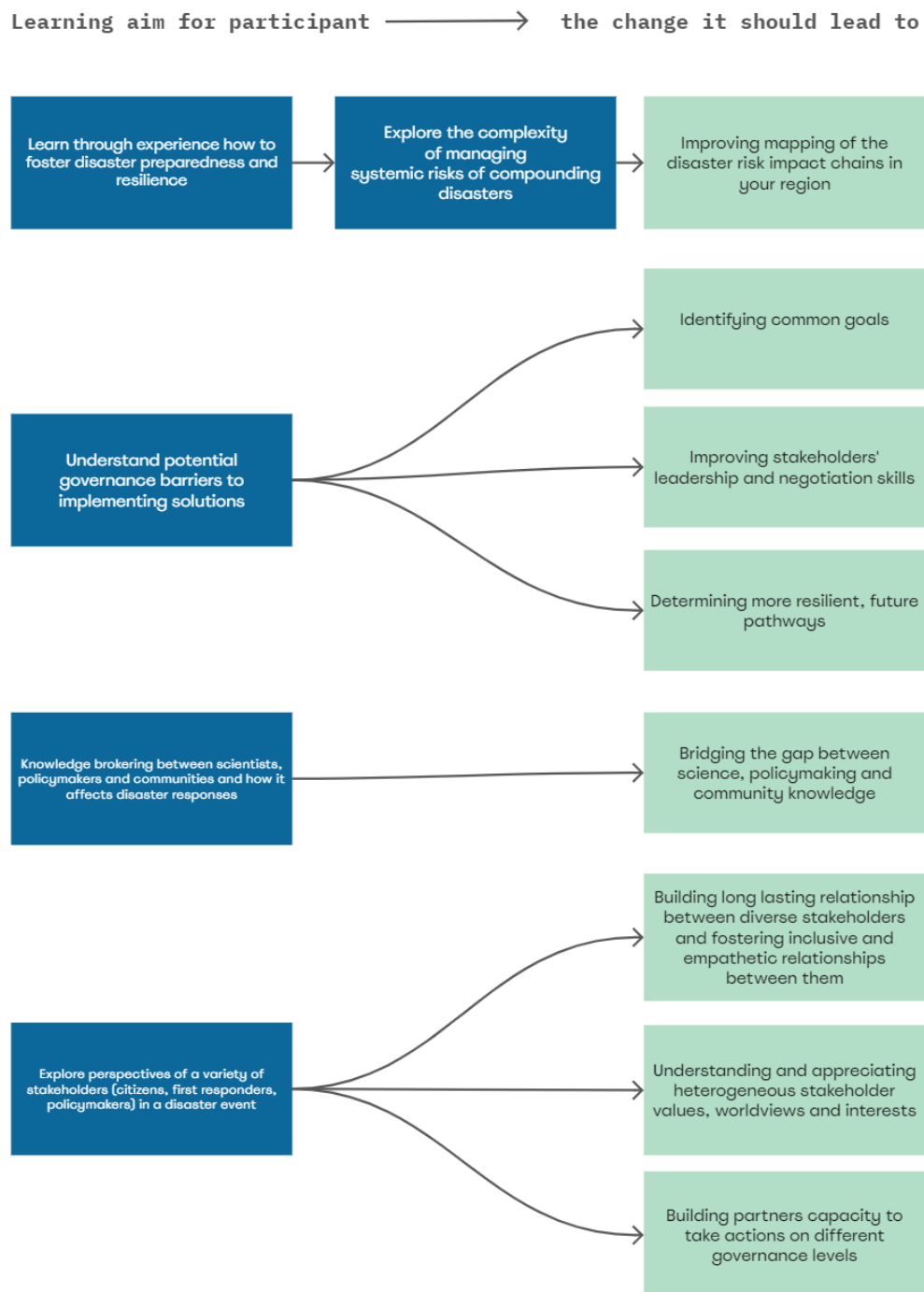


Figure 15 Learning objectives and their potential impacts for High Water Pantano.

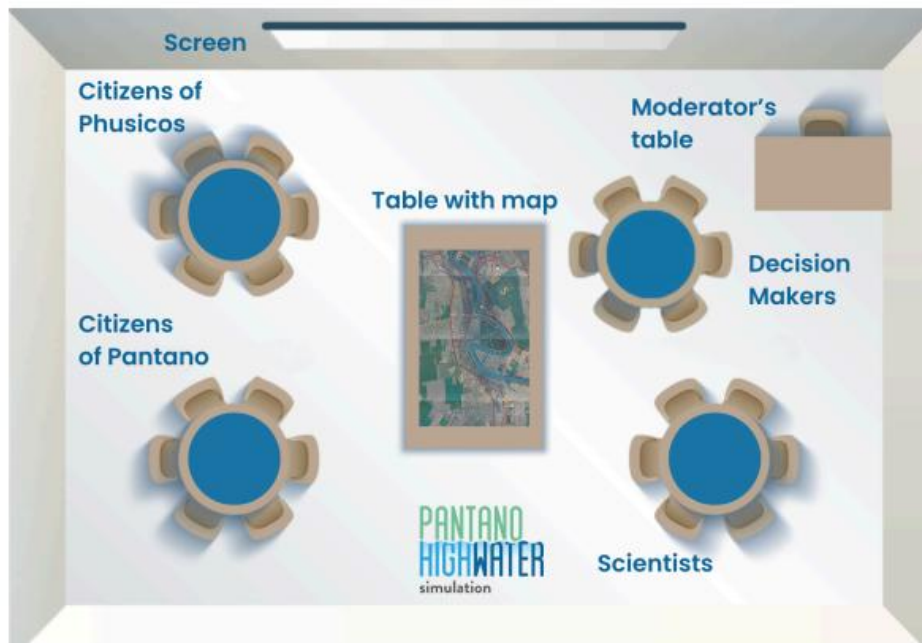


Figure 16 Recommended setup of the room for a face-to-face workshop with High Water Pantano.



Figure 17 An example of data integrated within the engage.socialsimulation.org platform.

APPENDIX 2 - Bucur Simulation – Coordinating Earthquake Response¹⁸

Bucur is a fast-paced, role-based simulation that explores how emergency services, local authorities, and civilians respond to a major earthquake and cascading risks. Inspired by Bucharest’s unique risk profile, this game simulates critical response actions and communication challenges. Earthquakes strike suddenly, but coordination must happen fast. This game gives participants the opportunity to practice decision-making under pressure, understand communication pitfalls, and improve their teamwork in complex conditions.

Why play this game?

Bucur Simulation provides players with Hands-on practice in high-pressure to coordinate earthquake response. The game facilitates role-playing to allow participants to experience both responder and civilian perspectives. Players, together, test the coordination strategies. The game helps players to enhance their communication skills in high pressure situations and enhance empathy skills as both responders and citizens understand each other better in the game (Figure 18).

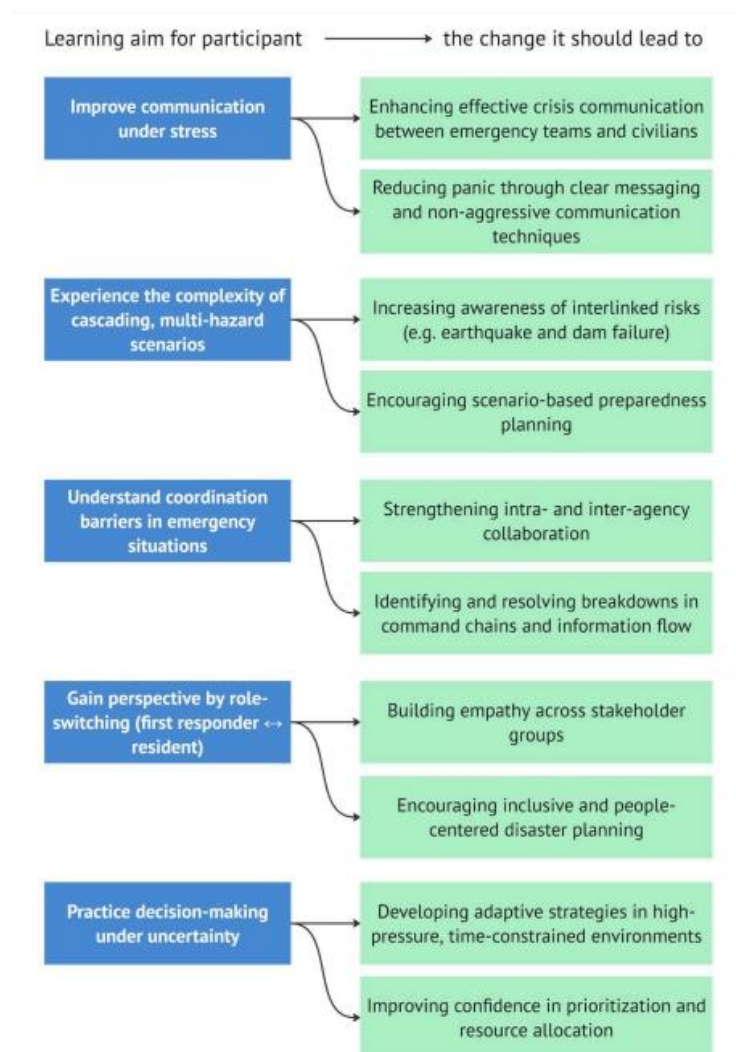


Figure 18 Learning objectives and their potential impacts for High Water Pantano.

¹⁸ To access all the materials: <https://www.cmine.eu/topics/35391/page/paratus-games-buccur-simulation>

Who is it for?

- Operational and Response Services (i.e. first responders)
- Governmental Actors (i.e. regional authorities, municipal governments, civil protection agencies)
- Civil Society and Community Actors (i.e. NGOs, community leaders)
- Scientific and Technical Stakeholders (i.e. risk modelers)

What do you need?

- Flexible group size (10 - 30 participants)
- A moderator
- Printable role cards (translated versions available)
- ~1.5 - 2 hours including debrief
- Big room

How is it played?

Bucur takes place over two main rounds, starting with real-time emergency decisions and ending with a shift to the civilian perspective. Participants experience both ends of the crisis, switching roles and seeing how information and decisions travel, or break down, in a tense, high-stakes environment. During the game, players, who are assigned the role of first responders, can move freely around the space, engaging with residents and coordinating evacuation efforts. Players, who are assigned the residents role, on the other hand, do not move from their designated spots unless they are persuaded by first responders to relocate.

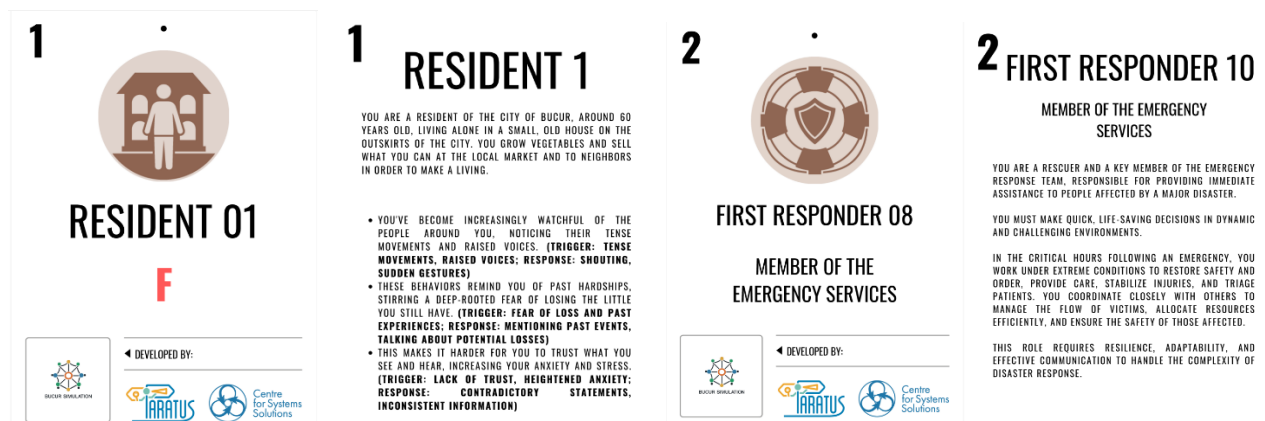


Figure 19 Examples of materials provided to participants in the analog version of Bucur Simulation.

APPENDIX 3 - Saltum Montem - Cross Border Risk and Crisis¹⁹

Mountain regions are complex and interdependent—what happens on one side of a border often impacts the other. This game focuses on cross-border collaboration, resource sharing, and crisis negotiation under pressure. Saltum Montem is a simulation game set in a fictional Alpine region. Players must respond to a cascading disaster scenario that crosses national borders, involving infrastructure disruptions, natural hazards, and political tensions.

Why play this game?

Saltum Montem supports players to deepen their knowledge on multi-hazard risks in transboundary region. The game is a learning experience to enhance multi-stakeholder coordination, especially in the inter-institutional and cross-border settings. The game and its unfolding in it scenario helps participants to excel their crisis negotiation skills and decision making under uncertainty (Figure 20).

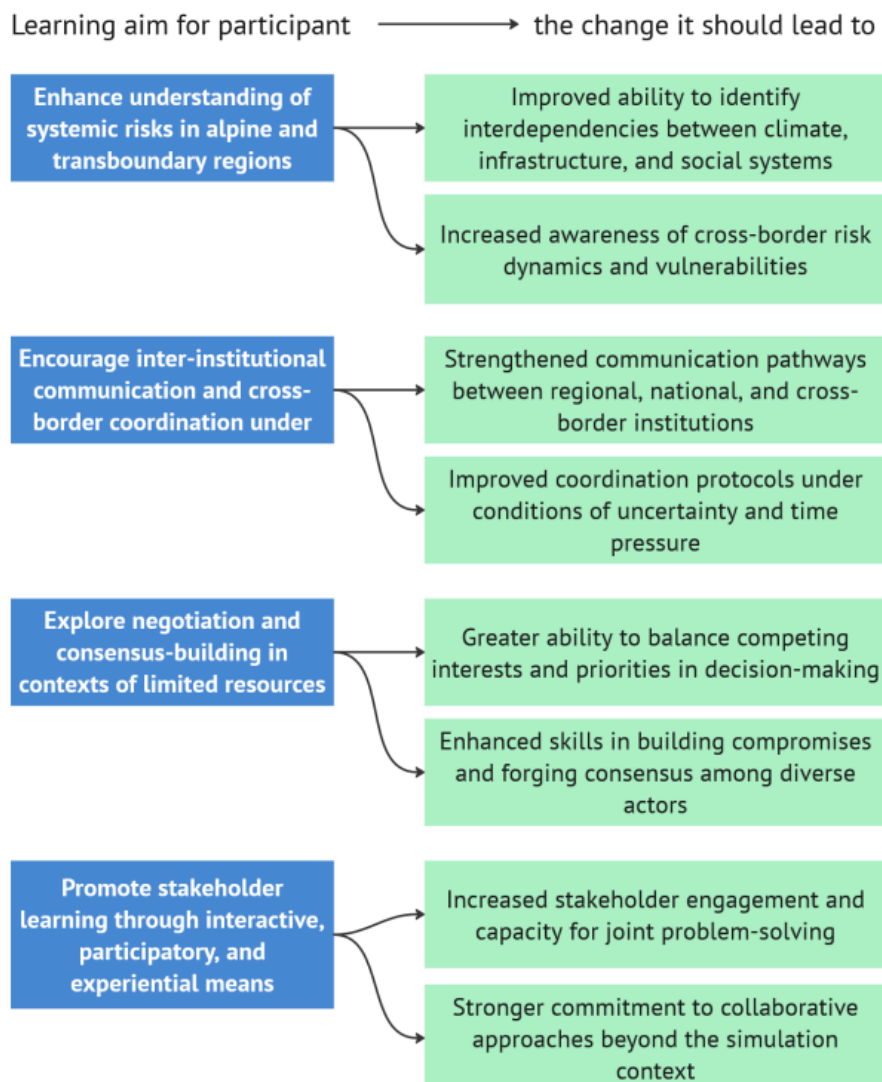


Figure 20 Learning objectives and their potential impacts for Saltum Montem.

¹⁹ To access all the materials: <https://www.cmine.eu/topics/35391/page/paratus-games-saltum-montem> and to get free access to play the game in the digital setting contact us at contact@socialsimulations.org

Who is it for?

- Governmental Actors (i.e. regional authorities, cross-border governance bodies, civil protection agencies),
- Operational and Response Services (i.e. first responders),
- Infrastructure and Service Providers (i.e. critical infrastructure operators – especially transport),
- Scientific and Technical Stakeholders (i.e. risk modelers, hydrological experts, geological experts, students).

What do you need?

- 10-40 participants in group setting
- A moderator
- Printable role cards, maps, and facilitator instructions
- 2.5-3 hours of your time

How is it played?

Participants take on the roles of national and local authorities, infrastructure operators, and other stakeholders. They must coordinate their actions, respond to escalating challenges, and navigate political and social tensions - all while facing limited resources and conflicting interests. Saltum Montem is structured around four to five sequential phases, each reflecting a moment of escalating crisis in the fictional Saltum Montem region. The setup of the room (Figure 21) or breakout rooms in case of an online meeting, is designed to a physical (or digital) divide between players representing interests of different fictional countries. The simulation begins with a role introduction phase, where participants are assigned stakeholder roles within two fictional countries and receive scenario briefings. This is followed by country-specific discussions and voting on urgent measures, and then a cross-border plenary session that encourages negotiation and collaborative planning. In the final phase, participants vote on joint crisis responses, with the simulation revealing the cascading impacts of their decisions in real time.



Figure 21 Recommended setup of the room for a face-to-face workshop with Saltum Montem.

APPENDIX 4 – The Interactive Multi-Hazard Systemic Risk Mapping²⁰

PARATUS project develops new exposure and vulnerability analysis methods that enable systemic risk assessment across sectors. The PARATUS Multi-Hazard Systemic Risk Mapping is based on the various methodologies developed during the project. The game helps players to discuss and analyse the cause-and-effect relationships, changing risk dynamics across the space and sectors to develop scenarios and risk mitigation options together. Each card corresponds to an essential component—hazard, vulnerability, exposure, impact, response, recovery, adaptation measures and mitigation measures. The game allows us to discuss/select the best available adaptation/mitigation measure to reduce systemic risk based on a single or multi-hazard for specific vulnerability conditions. This hands-on, analog exercise helps participants map out disaster risk impact chains and collaboratively design measures to reduce those risks. It's an accessible, flexible tool for group learning and local engagement.

Why play this game?

Understanding multi-hazard systemic risk is the first step toward reducing it. The game allows participants to get a clearer understanding of multi-hazard systemic risk, discuss, collaborate and test the adaptation and disaster risk reduction actions. The multi-hazard systemic risk map developed by the participants provide a tangible outcome that supports future decision making.

Who is it for?

The game can be played by anyone who is interested in multi-hazard systemic risk mapping. But especially by:

- Governmental Actors (i.e. regional authorities, municipal government),
- Civil Society and Community Actors (i.e. NGOs, community leaders, citizens),
- Scientific and Technical Authorities (i.e. risk modelers, academics, students)

What do you need?

- Any group size (ideal: 6 - 8 people per table)
- Printable magnetic cards, or normal cards, markers, flipcharts (black-and-white compatible)
- Optional role cards for immersive play
- ~1.5 - 2.5 hours

How is it played?

The game has three main parts.

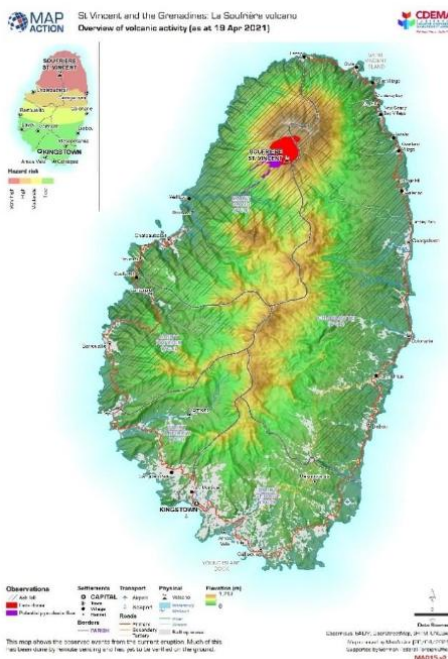
- **Learning from the past** Players select a past event, discuss how the hazardous event impacted different sectors, and map the cause-effect relationship using the cards.
- **Today's future: how current hazards and risks might change in the future**
- **Adapting to changes, evaluate the effect of the risk mitigation measures**

STEPS in the game: Play the game to

- Select a hazard scenario (i.e. Saint Vincent Volcanic eruption, April 2021 (Figure 22).
- Identify the hazards and their cascading hazards using the hazard cards (meteorological, space, geo, societal, technological, biological, environmental hazards) (Figure 23).
- Analyse the pre-disaster conditions based on the vulnerabilities using the physical, social, economic and institutional vulnerability cards (Figure 24).
- Build a story adding the exposure cards on the map (Figure 25).

²⁰ To access all the materials <https://www.cmine.eu/topics/35391/page/paratus-games-interactive-risk-mapping-exercise>

- Lay the impact cards for a desired timescale and assess the impact of the disaster on different exposed elements (Figure 26).
- Brainstorm as a team with action cards to enhance the area's resilience to such disasters and reducing their impact (Figure 27).
- You can also play different roles (such as policy maker, urban planner, rescue officer, insurance company, scientist, municipality, etc.) while playing the game, to gain a better understanding of how easy/difficult planning could be.



Scenario: Saint Vincent Volcanic eruption, April 2021

April 2021, during the COVID-19 pandemic, the Caribbean island of Saint Vincent experienced a significant volcanic crisis when La Soufrière volcano erupted explosively for the first time since 1979. The eruption began on April 9, sending ash plumes over 10 kilometres into the atmosphere and blanketing the island and neighbouring regions with volcanic ash. Approximately 20,000 residents were evacuated from high-risk zones, with many seeking refuge in shelters or aboard cruise ships dispatched to assist in the evacuation. The ashfall disrupted essential services, leaving the entire population without clean water and electricity. In crowded shelters and evacuation centres, concerns about virus transmission were raised due to the ongoing COVID-19 pandemic.

In late April, heavy rainfall from a passing weather system triggered lahars—dangerous volcanic mudflows—that swept down the volcano's slopes, causing additional damage to infrastructure and hampering relief efforts.

The compounded crises of volcanic activity, pandemic-related challenges, and subsequent lahars underscored the vulnerability of island nations to multiple, simultaneous natural disasters.

Figure 22 Saint Vincent Volcanic eruption, April 2021, scenario.



Figure 23 Examples to hazard cards.

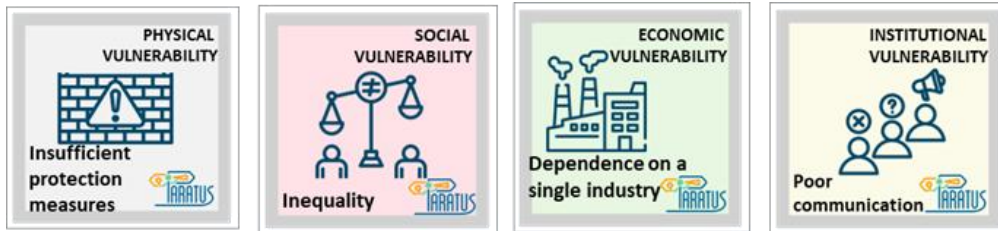


Figure 24 Examples to vulnerability cards

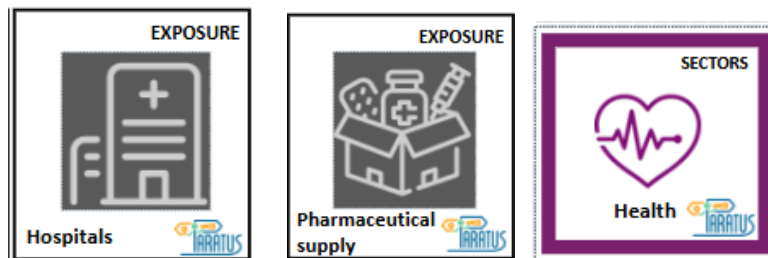


Figure 25 An example to exposure and sector cards.

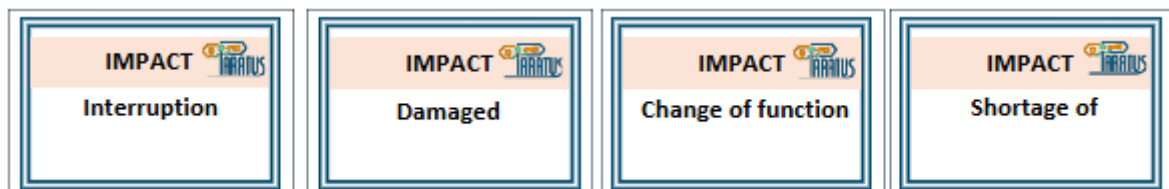


Figure 26 Examples of impact cards.

ACTION CARDS	
Anticipate	Improving risk assessment, anticipation and disaster risk management ` planning;
Prepare	Increasing risk awareness and preparedness of the population;
Alert	Enhancing early warning and other alert mechanisms
Respond	Enhancing the Union Civil Protection Mechanism response capacity;
Secure	Ensuring a robust civil protection system.
ANTICIPATE Vulnerability assessment € ⌚ 👤	PREPARE Training public € ⌚ 👤
ALERT Disseminating warning € ⌚ 👤	RESPOND Repairing € ⌚ 👤
SECURE Stress testing emergency operation systems € ⌚ 👤	

Figure 27 Examples to action cards based on the five resilience goals defined by the European Commission.