

Rapid Multi-Risk Needs Evaluation and Planning Platform

101193586 - EMERGE - UCPM-2024-KAPP-PV

Comprehensive Multi-Risk Assessment Platform for Needs Prioritization and Planning

Review of Best National, European, and International Methodologies and
Practices for Multi-Risk Assessment and Needs Planning

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TABLE OF CONTENTS

TABLE OF CONTENTS.....	ii
LIST OF FIGURES	iii
EXECUTIVE SUMMARY	1
1. Introduction.....	1
2. Overview of relevant projects	1
2.1. Overview of European and other international projects	1
2.2. Overview of national projects	8
3. Practices and methodologies for Multi-Hazard Risk Assessment and Needs Planning	13
3.1 European and worldwide level	13
3.2 National level	30
3.2.1 Albania	30
3.2.2 Greece	32
3.2.3 North Macedonia	35
4. Concluding remarks	40
References	41

LIST OF FIGURES

Figure 1.	Subnational Risk Inform Index.....	19
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Executive summary

Deliverable D2.1 provides a critical input to the conceptual design and early development of the EMERGE platform, as described in the project's Description of the Action (Annex 1 of the Grant Agreement). It systematically maps, reviews, and synthesizes established methodologies and practices for multi-hazard risk assessment and post-disaster needs prioritization, with a view to informing the platform's technical architecture and operational relevance.

The report analyzes more than 30 relevant international, European, and national projects—such as MATRIX, STREST, MYRIAD-EU, MEDiate, and BORIS—which were selected for their contributions to scenario-based risk modeling, cascading hazard interactions, and user-centered decision-support systems. A key focus lies in the transition from siloed, single-hazard approaches toward integrated, multi-risk, cross-sectoral, and cross-border frameworks, supported increasingly by real-time digital platforms.

At the European and global levels, Deliverable D2.1 identifies growing trends in the use of interoperable tools for probabilistic loss modeling and risk-informed planning tailored to the needs of civil protection authorities. At the national level, case studies from Albania, Greece, and North Macedonia highlight efforts to strengthen disaster resilience through locally adapted risk assessment methodologies. These include tools and frameworks developed through UCPM and UNDP-supported initiatives, most notably the CRISIS project, upon which EMERGE directly builds.

Aligned with EMERGE's overall objectives, the deliverable underscores the need to harmonize risk assessment methodologies and ensure coherence with Union Civil Protection Mechanism (UCPM) strategies. It also points to several key gaps in existing approaches, such as the limited integration of vulnerability data and the lack of practical usability for real-time emergency planning. These findings are instrumental in shaping EMERGE's subsequent development phases, particularly in the integration of hazard layers, design of needs mapping functionalities, and prioritization logic for rapid multi-risk assessment.

In conclusion, Deliverable D2.1 establishes the scientific and operational foundation for the EMERGE platform. It ensures that future platform components are not only technically robust but also directly aligned with the needs of emergency managers, enabling faster, evidence-based decision-making in disaster response across the Western Balkans and the wider EU neighborhood.

1. Introduction

Multi-hazards involve multiple individual hazards affecting a specific region and their interrelationships (UNDRR, 2016). These latter include triggering (e.g., earthquake triggering landslides), amplifying (e.g., drought increasing wildfire probability), compound (e.g., simultaneous earthquake and storm), and consecutive events (e.g., two earthquakes which hit the same region in the same month). In literature, an extensive discussion is focused on hazard interrelationship classifications and terminology. However, in this document the term multi-hazard risk refers to risks generated by multiple hazards and their interrelationships (e.g. Ward et al., 2022; Šakić Trogrlić et al., 2024).

International policies and strategies highlight the importance of focusing on multi-hazard risk analysis. The Agenda 21 (UN Sustainable Development, 1992) calls for multi-hazard risk research, while international Disaster Risk Reduction (DRR) frameworks, such as the Hyogo Framework for Action (UNISDR, 2005) and the Sendai Framework for DRR (UNDRR, 2015), remark the relevance of multi-hazard risk assessment and management. The European Parliament, 2021 invited to include multi-hazard risk scenarios in the national risk assessments (NRA) carried out within the Union Civil Protection Mechanism framework.

This document aims to identify state-of-the-art methodologies and practices for multi-hazard risk assessment and needs planning.

2. Overview of relevant projects

2.1. Overview of European and other international projects

Project Acronym	Title and Funding program	Period (start - end year)	Main Outcomes	Scale (European/ International)
CRESTA	Catastrophe risk evaluation and standardizing target accumulations (Joint project by Swiss, Cologne and Munich Reinsurance Companies)	1977 - ongoing	The global risk zoning system that classifies regions by exposure to hazards such as earthquakes, storms, and floods, widely used by the insurance industry for premium assessment and risk management.	Global
MATRIX	New multi-hazard and multi-risk assessment	2010 - 2013	Existing single hazard and vulnerability assessment models and methods were	European

	methods for Europe (FP7- Enviroment)		harmonized within a multi-risk framework and tested in three selected areas and one virtual city.	
RISK	Risk management via an innovative system based on knowledge	2012 - 2014	Methodology to harmonize community-level risk data, strengthen decision-makers' ability to assess disaster risk and vulnerability, track changes over time, evaluate the impact of policies, and highlight gaps for targeted intervention.	European
STREST	Harmonized approach to stress tests for critical infrastructures against natural hazards	2013 - 2016	Stress tests developed for specific infrastructures combining different natural hazards. Six different types of critical infrastructures were used for experimental application.	European
SNOWBALL	Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools (FP7 CORDIS)	2014 - 2017	Analyzing cascading effects, creating methods to predict them, and developing a decision support system that displays real-time crisis monitoring alongside outcomes of simulated decisions incorporating these effects.	European
MELOGIC	An integrated methodological framework for emergency logistics	2014 - 2016	An e-library of best practices and a decision-support toolbox were developed to improve preparedness. Existing single-hazard models were harmonized into a multi-risk framework and tested in three regions and one virtual city.	European

NRA NLD	National risk assessment in the Netherlands	2014 - 2025	The outcome of the sixty analyzed scenarios is used as input for a variation of decision-making models again on three different levels.	Netherlands
ITERATE	Improved tools for disaster risk mitigation in Algeria (DG-ECHO)	2017 - 2019	Supporting seismic risk reduction in Algeria by introducing modern assessment tools, updated risk models, and a real-time loss estimation platform. It also boosted national capacity and public awareness to improve prevention efforts.	Europe
METIS	Methods and tools for innovation for seismic risk assessment (HORIZON 2020)	2020 - 2025	Develop and improve tools and methodologies employed in seismic safety assessments of nuclear reactors and translate this research into practice for industry use enabling risk-informed decision making.	European
BORIS	Cross-border risk assessment for increased prevention and preparedness in Europe	2021 - 2022	A shared methodology and a platform for single and multi-hazard risk assessment were applied in two cross-border areas, focusing on seismic and flood risk assessment.	European/ Italian-Slovenian-Austrian borders
MYRIAD-EU	Multi-hazard and systemic framework for enhancing risk-informed management and decision-making in the EU	2021 - 2025	Multi-risk, multi-sector, systemic approach to risk management, including a web-based dashboard and a laboratory of systemic multi-hazard risk assessment and management for five multi-scale pilots.	European
MEDiate	Multi-hazard and risk informed system for enhanced local	2022 - 2025	Decision support framework in the form of service-orientated web tool providing testbed	European

	and regional disaster risk management (HORIZON-CL3-2021-DRS-01)		end users (four selected areas) with the ability to build scenarios to model potential impact of mitigation and adaptation actions.	
ARISTOTLE	All risk integrated system towards trans-boundary holistic early warning	2022 - 2028	The project established a multi-hazard scientific advisory service for ERCC, delivering rapid assessments of natural disasters (earthquakes, tsunamis, severe weather, floods, wildfires, and volcanic activity) through partnership of expert institutions across Europe.	Global
FORCE	Forecasting and communicating earthquake hazard and risk (USAID Bureau for Humanitarian Assistance)	2022 - 2025	Improving earthquake risk forecasting by predicting changes in the built environment and population, integrating infrastructure into exposure models, modeling hazard and risk in small communities, and advancing the communication and dissemination of risk information.	Global
FIRMITAS	Multi-hazard assessment, control and retrofit of bridges for enhanced robustness using smart industrialized solutions (Italian Ministry of Education and Research)	2022 - 2024	The project focused on reducing the collapse risk of roadway bridges by proposing intervention strategies, smart maintenance solutions, and multi-scale robustness assessments. It addressed both natural and human-induced hazards, including cascading events like earthquake-triggered landslides.	European/ Italian

COASTWAVE	Strengthening resilience of coastal communities against tsunamis and other coastal hazards	2022 - 2024	Raising tsunami awareness, mapping hazards and evacuation routes, developing local protocols and Standard Operating Procedures (SOPs), and testing them through a local tsunami exercise.	European/ UNESCO
SERENE	Optimal seismic and energy retrofit of buildings considering economic and environmental impacts (Portuguese Foundation for Science and Technology)	2023 - 2025	Developing a framework that integrates seismic and energy retrofitting to reduce risk, cost, and environmental impact while supporting sustainable renovation.	Portugal
Prior-Built	Prioritisation of Italian regions for seismic and energy performance upgrading of existing buildings	2023 - 2025	Development of an integrated prioritisation framework for Italian regions using key metrics such as expected loss of life, economic loss, energy use for heating, CO ₂ emissions, and socioeconomic factors. The framework supports multiple prioritisation patterns and refinement levels, from provincial to national scale.	Italy
MIRACA	Multi-hazard infrastructure risk assessment for climate adaptation (HORIZON-MISS-2021-CLIMA)	2023 - 2026	Developing a decision-support toolkit that will assist authorities in appraising and implementing climate adaptation measures.	European
ICARIA	Improving climate resilience of critical assets	2023 - 2025	Targeting critical infrastructure and assets not designed for climate change impacts (housing and natural areas), applying	European

	(HORIZON-MISS-2021-CLIMA)		advanced climate modeling and multi-risk assessment in three EU regions to evaluate future life-cycle costs and support decision-makers in choosing effective adaptation strategies.	
SNOWBALL	Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools (European Union's Seventh Framework Programme for research, technological development and demonstration, GA 606742)	2014-2017	To analyze cascading effects, to develop methods to anticipate them and a Decision Support System able to display current crisis monitoring and results of simulated decisions integrating cascading effects.	European
COMET GEM	Collaboration between Centre for observation and modelling of earthquakes, volcanoes and tectonics (COMET) and Global Earthquake Model (GEM) (NERC)	2023 - 2025	Creating a publicly accessible seismic hazard and risk model for Central Asia, using advanced methods like satellite geodesy and palaeoseismology. It supports communities, researchers, and policymakers with reliable assessments to guide disaster risk reduction and preparedness.	Global
BORIS2	Cross border risk assessment for increased prevention and preparedness in Europe: way forward	2024 - 2025	Upgrading of the multi-risk analysis methodology and tool applied in BORIS to support stakeholders in undertaking strategic decisions to improve emergency planning.	European/ Italian-Slovenian-Austrian borders

WFP-ADAM	World food program - advanced disaster analysis and mapping (WFP Innovation)	2024 - 2025	Improved spatial risk assessment using high-resolution data and ADAM validation for faster post-earthquake impact analysis with rapid population estimates and detailed results within two days.	Global
DPC-RELUIS	Assessment of integrated seismic and energy performance retrofitting schemes (Italian Department of Civil Protection)	2024 - 2026	The project aims to promote the reduction of emissions and the ecological transition of the built environment by adopting an extended concept of sustainability that integrates eco-efficiency and life cycle thinking with safety, reliability, robustness, functionality and resilience.	Italian
EPOS ON	The European plate observing system - optimization and evolution (EC HORIZON)	2024 - 2027	Strengthening and advancing the EPOS Research Infrastructure by expanding its services, supporting new thematic core services, and improving access to data across Europe and globally.	Global
NEAM COMMITMENT	North -Eastern Atlantic and Mediterranean tsunami risk management and planning (EU Civil Protection and Humanitarian Aid Operations)	2025 - 2027	The project will contribute to capacity building by assessing and mapping tsunami hazards nationally and improving local evacuation planning using a new multi-hazard approach.	European
NIAG study 295	Strategic political military assisted decision making	/	The study gives an opportunity to combine and integrate written, oral and video footage into certified data and assumptions to improve decision making on various levels.	NATO nations and partners

2.2. Overview of national projects

In this section, presentation of projects & initiatives on national and regional level for North Macedonia, Albania, and Greece are presented.

Project Acronym	Title and Funding program	Period (start - end year)	Main Outcomes	National scale
(N/A)	Strengthening the capacities of the CMC (UNDP)	2008 - 2011	Developing of a unified methodology and legal framework for hazard and risk assessments in North Macedonia, resulting in the official adoption of risk assessments by municipalities. A key result was the adoption of the Decree on the methodology for risk and hazard assessments (Official Gazette of RM 13/2011), establishing standards for content, structure, maintenance, and access.	N. Macedonia
MKFFIS	Integrated system for prevention and early warning for forest fires MKFFIS - "Macedonian Forest Fire Information System"	2011 - 2014	Development of a Methodology for assessing the risk of forest https://mkffis.cuk.gov.mk/broshura/MKFFIS-en.pdf	N. Macedonia
(N/A)	Strengthening the capacities of the CMC (UNDP)	2015	Creating a unified methodology for hazard and risk assessments and a regulation to guide the preparation of future assessments.	N. Macedonia
IPA DRAM	Programme for Disaster Risk Assessment and Mapping (DG ECHO)	2016-2019	The main goal of the project was to improve the capacities of partner countries in natural disaster risk management https://www.cimafoundation.org/en/project/ipa-dram/	Western Balkans and Turkey

(N/A)	Improving Resilience to Floods in the Polog Region (UNDP)	2017 - 2023	Improved understanding of flood risks in the Polog region, enhanced disaster preparedness of institutions and communities, and improvement of the national legal and regulatory framework for disaster risk reduction.	N. Macedonia
(N/A)	Technical support for the development of climate – resistant projects, guidelines for the public enterprise for state Roads of the Republic of N. Macedonia (World Bank)	2019	This Guide and methodology aim to clarify the impact of floods and landslides on North Macedonia's road network, outline intervention options, and identify investment priorities.	National
RESEAL	Municipal DRR Framework in Lezha Municipality (UNDP, AKMC)	2020	Preparing risk assessment, disaster risk reduction, as well as vulnerability and capacity assessment documents for Lezha Municipality, including seismic and landslide risks.	Albania
RESEAL	Resilience strengthening in Albania, (UNDP, AKMC)	2020 - 2024	Risk assessment documents were prepared for all Fier Municipalities, covering seismic and landslide risks. A Vulnerability and Capacity Assessment (VCA) was also developed as part of this effort.	Albania
COMMAND d	Commanding and operations mechanism for multisector analysis of nexus disaster data (EU Civil Protection and Humanitarian Aid Operations)	2020 - 2022	Decision making support (risk assessment) methodology for North Macedonia.	N. Macedonia
CRISIS	Multi-hazard risk assessment of	2020 - 2022	Seismic and landslide hazard mapping,	Cross – border (N.

	basic services and transport infrastructure (EU Civil Protection and Humanitarian Aid Operations)		harmonized risk methodologies.	Macedonia, Greece and Albania) with national implications
(N/A)	IPA floods and fires program, flood prevention and forest fires risk management in the Western Balkans and Turkey (EU Civil Protection and Humanitarian Aid Operations)	2020 - 2024	Strengthened flood and forest fire risk management through improved legal frameworks, harmonized risk assessments, enhanced early warning systems, capacity building, public awareness, and regional cooperation aligned with EU standards.	Western Balkans and Turkey
R2R	Emergency preparedness and response assessment for North Macedonia (World Bank and GFDRR)	2021	Comprehensive EP&R capacity assessment and recommendations for DRM improvements.	N. Macedonia
L2BR	Learn to be resilient (EU Civil Protection and Humanitarian Aid Operations)	2021- 2022	Comprehensive toolbox and strengthened cross-sectoral cooperation improving earthquake prevention, preparedness, and response during pandemic crisis.	Cross – border (Croatia, Montenegro, N. Macedonia, Albania) with national implications
X-STOCK	Improving cross-border preparedness through joint management of emergency stocks in Southeast Europe (EU Civil Protection and Humanitarian Aid Operations)	2021 - 2023	Enhanced cross-border emergency preparedness and interoperability in five Balkan countries through joint stock management, a shared software system, and coordinated policy and procedural improvements.	Cross - border region (which countries?)
FLOOD SHIELD	Joint flood risk governance and management in	2021- 2023	Improving flood risk management by creating joint response teams, setting up early warning	Regional (Greece and N. Macedonia)

	the Axios/ Vardar cross border area (INTERREG IPA Cross Border Cooperation Programme)		systems, training local authorities, and developing a shared digital platform. It will also raise public awareness and ensure smooth coordination and communication.	
VOLUnteer	Integrated framework for the management of natural hazards based on Civil Protection VOLUnteers towards reinforcing cross-border readiness, prevention, response and improvement of resilience (INTERREG IPA)	2022 - 2023	The project creates a cross-border civil protection network to improve wildfire response, train volunteers, and protect vulnerable areas. It builds on past projects and includes public awareness efforts to strengthen regional preparedness.	Regional (Greece and N. Macedonia)
Disaster AWARE	Balkans Regional Early Warning System	2022 - 2023	The PDC team presented Disaster AWARE Pro as the initial Balkans EWS platform. A tailored version may follow in Phase 2. The NCPA and stakeholders like JICA and GIZ showed strong support for its use.	Albania
NRA MK	National risk assessment in North Macedonia (UCPKN)	2023 - 2025	Information on risks affecting people, assets, and the environment, risk scenarios, matrices and maps, and evaluation of resources within North Macedonia's rescue and protection system.	N. Macedonia
IPA CARE	IPA III Multi-Country Action Program - Capacity for earthquake and health crisis risk management (Pre-accession Assistance (IPA III))	2023 - 2029	Enhanced institutional and legal framework and capacities, increased prevention, preparedness and response capability, and increased IPA III beneficiaries' participation in and cooperation with the UCPM including regional	Western Balkans and Turkey

	supported under UCPM)		cross-border cooperation.	
MCR2030	Making cities resilient 2030 (UNDRR)	2023 - 2030	Municipal risk integration into national strategies; urban resilience enhancement.	N. Macedonia (municipal level with national coordination)
(N/A)	Multi-hazard vulnerability assessment in Makedonska Kamenica municipality (Academic article)	2024	Hazard modeling using GIS and remote sensing; regional vulnerability mapping.	N. Macedonia (regional focus, nationally applicable)
(N/A)	North Macedonia national platform for disaster risk reduction, (Government of N. Macedonia)	Ongoing	National DRR coordination, early warning and prevention systems.	N. Macedonia
BEYOND	Earthquake, fire and flood risk assessment in the Region of Attica, Greece (Region of Attica)	(2021-2024)	Development of a user-friendly web GIS platform, including risk maps, critical points and escape routes, to support crisis management in the Region of Attica, Greece	Greece (Region of Attica)
INFRARES	Towards resilient transportation infrastructure in a multi-hazard environment (Hellenic Foundation for Research and Innovation)	(2022-2025)	Development of a comprehensive methodology and a relevant software for the risk and resilience assessment of critical transportation infrastructure components (i.e., bridges and tunnels) in a multi-hazard environment.	Greece

3. Practices and methodologies for Multi-Hazard Risk Assessment and Needs Planning

3.1 European and worldwide level

CRESTA – Catastrophe Risk Evaluation and Standardizing Target Accumulations (1977 - ongoing), funded by few major insurance companies

<https://www.element.nl/en/maps-data/cresta/>

The CRESTA project is the global standard to analyze natural risks and hazards such as earthquakes, storms, floods, and terrorist attacks. In today's climate change, demand has increased for the geospatial intelligence offered by digital mapping to manage risks and reduce exposure. CRESTA was founded by a few major insurance companies with the aim of establishing a globally uniform system for the accumulation risk control of natural hazards.

Insurance professionals need accurate and reliable maps and databases. Global CRESTA Plus offers insurers an important basis for aggregated risk assessment, exposure management, and reinsurance negotiation and reporting. Since the world is constantly changing, CRESTA is an evolving standard with countries being newly zoned or redefined each year. An annual maintenance program is carried out, featuring quarterly updates through Global CRESTA Plus.

Objectives of the project are:

- Standardize risk zoning for natural hazards by creating a consistent, global framework for dividing geographic areas into CRESTA zones based on exposure to natural hazards such as earthquakes, storms, and floods.
- Improve risk accumulation management by helping insurers and reinsurers manage the risk of large losses from multiple insured assets being affected by the same catastrophic event.
- Enable efficient data exchange by facilitating the efficient, standardized exchange of exposure data among insurers, reinsurers, brokers, and catastrophe modeling firms.
- Ensure regular updates and scientific relevance by keeping CRESTA zones and associated data up-to-date with the latest hazard research, urban development patterns, and population shifts. This also includes ensuring continued accuracy and relevance in a changing climate and evolving risk landscape.

MATRIX - New Multi-Hazard and Multi-Risk Assessment Methods for Europe (2010 - 2013), funded by the EU CORDIS programme

<https://cordis.europa.eu/project/id/265138>

MATRIX project aimed at developing methods and tools that account for interdependencies among different hazards to generate comprehensive risk assessments, leading to better mitigation and response plans. The goals of MATRIX may be summarized as follows:

- Assess the state-of-the-art in single- and multi-type hazard and risk assessment methodologies and tools to build a solid foundation.
- Develop a multi-hazard and risk assessment framework that considers the various interactions and dependencies that may arise within such a multi-type of environment.
- Examine under what conditions multi-type risk assessments provide better (or not) results compared with single-type assessments.
- Provide tools to support the decision-making processes required by civil protection and disaster management authorities based on probabilistic information.
- Assess existing governance frameworks and investigate individual and institutional barriers to the implementation of multi-hazard and risk approaches.
- Disseminate multi-hazard and risk concepts to potential end-users and relevant members of the broader community, e.g. civil protection and research establishments.

Being natural hazards and their associated risks typically managed individually, ignoring possible interactions (e.g., cascading effects), MATRIX proposed innovative solutions as a step towards dealing comprehensively with multiple disasters and risk assessment.

The multi-hazard and multi-risk methodologies and approaches were tested in Germany, Italy, and the French West Indies, each test case covering different natural hazards and potential variations of events. In addition, a generic multi-risk framework, termed the 'virtual city', was developed for evaluating conditions not addressed at the three sites.

The hazards that were the primary concerns of MATRIX are those most likely to afflict Europe, e.g. earthquakes, landslides, volcanic eruptions, tsunamis, wildfires, winter storms, and both fluvial and coastal floods.

RISK – Risk Management via an Innovative System Based on Knowledge (2012 - 2014), funded by the EU General Humanitarian Aid & Civil Protection - ECHO

https://civil-protection-humanitarian-aid.ec.europa.eu/system/files/2016_03/2012_final_report_risk.pdf

RISK focused on the challenges of adapting to climate change and preparing for natural disasters facing diverse areas of the EU. The project intends to integrate these two plans as they widely overlap and complement each other. The general objectives of the project were:

- to assess the vulnerability of the project areas to the impact of climate change and natural disasters;
- to prepare adaptation action plans which if implemented would make such areas more resilient; and
- to engage stakeholders in related decision-making.

The purpose of RISK was to propose an integrated approach on community and local government level that can guide decision-makers to reduce and manage the risk of natural disasters. The specific objective was: to develop a methodology to systemize and harmonize the presentation of risk information from community level, (ii) to improve the capacity of decision-makers on local, regional, and national level to measure key elements of disaster risk and vulnerabilities towards risk of communities, (iii) to provide comparative parameters to monitor changes in disaster risk, as a measure of evaluation of effects of policies and investments in disaster management, and (iv) point at the major deficiencies in confronting natural disasters and thus indicate possible areas of intervention.

The RISK project stands out as one of the earliest European efforts tackling risk management related to Civil Protection. It brought together various separate experiences from different countries and local areas across Europe, showing clearly the need for creating networks that support constant information sharing and encourage cooperation between key players. Moreover, RISK built upon insights gained from international initiatives like USGS and FEMA, which, although not directly focused on Civil Protection, helped to widen the project's original scope.

RISK highlights the importance of cooperation among all parts of society, including public institutions, private companies, and research organizations—as a key factor for successful collaboration. For instance, many risks and interdependencies involve critical infrastructure, which is often controlled by private firms. The project emphasizes the need for civil protection platforms that operate across borders and sectors, such as the RMST online tool, to connect and build strong networks at local and regional levels. This approach aims to enhance information exchange, raise awareness, and deepen understanding of risk and disaster management throughout the EU.

STREST – Harmonized approach to stress tests for critical infrastructure against natural hazards (2013 - 2016), funded by the European Union's Seventh Framework Programme (FP7/2007-2013)

<http://www.strest-eu.org/>

The main objectives of the STREST project were:

- Establish a common and consistent taxonomy of critical infrastructures, their risk profiles and their interdependencies, with respect to the resilience to natural hazard events.

- Develop a rigorous common methodology and a consistent modelling approach to hazard, vulnerability, risk and resilience assessment of low-probability high-consequence events used to define stress tests.
- Design a stress test methodology and framework, including a grading system (A – pass to C – fail), and apply it to assess the vulnerability and resilience of individual critical infrastructures as well as to address the first level of interdependencies among critical infrastructures from local and regional perspectives.
- Work with key European critical infrastructures to apply and test the developed stress test framework and models to specific real infrastructures chosen to typify general classes of critical infrastructures.
- Develop standardised protocols and operational guidelines for stress tests, disseminate the findings of STREST, and facilitate their implementation in practice.

Six types of critical infrastructures were used for experimental applications. They are: ENI/Kuwait oil refinery and petrochemical plant, Milazzo, Italy (for earthquake and tsunami); large dams in the Valais region of Switzerland (earthquake, flood, internal erosion, outlet malfunction, hydropower system malfunction); Baku-Tbilisi-Ceyhan hydrocarbon pipelines, Turkey (earthquake); Gasunie national gas storage and distribution network, the Netherlands (earthquake-induced liquefaction); port infrastructures of Thessaloniki, Greece (earthquake, tsunami, earthquake-induced liquefaction); industrial district of the Tuscany Region, Italy (earthquake).

SNOWBALL - Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools (2014 - 2017), funded by the EU's Seventh Framework Programme for research, technological development and demonstration

<https://cordis.europa.eu/project/id/606742/reporting>

The SNOWBALL project was a 3-year European FP7 project with the overall objective to increase preparedness and response capacities of decision-makers, emergency planners, and first responders in respect to amplifying hazards in large disasters. SNOWBALL consisted in a deep analysis of cascading effects and development of methods to anticipate them; and in a Decision Support System able to display current crisis monitoring and results of simulated decisions integrating cascading effects. SNOWBALL innovates in its modular approach to crises, its modelling techniques, its agent-supported coupled grid simulations, its generic Events Log Database, and tools to follow public behavior.

MELOGIC – An Integrated Methodological framework for Emergency Logistics (2014 - 2016), funded by the European Civil Protection and Humanitarian Aid Operations

<https://civil-protection-humanitarian-aid.ec.europa.eu/funding-evaluations/financing-civil-protection/prevention-and-preparedness-projects-civil->

protection/overview-past-track-i-and-track-ii-projects/integrated-methodological-framework-emergency-logistics-melogic_en

MELOGIC partnership consisted of the European University of Cyprus (coordinator), University of Aegean, Regional (Rome) Italian Red Cross/Regional (Vicenza) Italian Red Cross, Provincial Responsible of CARITAS, and Humanitarian Logistics and Supply Chain Research Institute. The main project objectives were the following:

- Categorization of main emergency logistic problems from civil protection authorities' point of view
- Creation of an e-library (data repository) of best practices and lessons learnt in emergency logistics
- Modelling of specific emergency logistics problems and development of efficient methods to solve them
- Design and development of a toolbox that will improve preparedness levels against natural emergencies
- Theoretical and practical training of users and decision makers
- Communication Plan and activities for disseminating emergency logistics importance to stakeholders

MELOGIC helped highlight the significance of civil protection during emergencies in rural and mountainous regions, especially those with sparse populations. From the partnership's perspective, the tools developed through the project were not only tailored for these specific areas but could also be effectively applied in various parts of Europe, which added considerable value to the initiative. The project allowed for a comparison of different civil protection systems and emergency response methods across Europe. This experience served as a valuable learning opportunity, reflecting the shared "European value" emphasized in the project draft. Also, it highlighted the crucial role of emergency logistics in ensuring effective civil protection efforts. Whether during the preparedness stage or the actual emergency response, emergency logistics form the foundation for planning and operations.

ITERATE – Improved Tools for Disaster Risk Mitigation in Algeria (2017 - 2019), funded by the European Civil Protection and Humanitarian Aid Operations

www.iterate-eu.org/

The ITERATE project is an EU funded project, which aimed at disaster risk reduction in Algeria. Large scale seismic risk assessment outcomes have provided quantitative evidence that regions with a significant percentage of non-seismically designed buildings, such as Algeria, are particularly vulnerable to seismic events. To deal with this issue, the Algerian government implemented in recent years several regulations to prevent and manage this situation, demonstrating its political will to promote disaster risk reduction. However, limited resources and capacities, lack of cross-sectoral coordination and, mainly, awareness among several stakeholders have impeded the full implementation of the conceived policies and the current seismic risk is unknown. Based

on this, ITERATE aimed at disaster risk reduction in Algeria by successfully implementing an improved framework for seismic risk assessment that can be replicated to other natural hazards, making use of a geographical and scientific privileged combination of expertise in Algeria, Portugal and Italy. The project involved a collaboration between three main institutions: Istituto Universitario di Studi Superiori di Pavia (Italy) – Coordinator, Faculdade de Engenharia da Universidade do Porto (Portugal), Centre de Recherche en Astronomie Astrophysique et Géophysique (Algeria).

The project empowered Algeria's capacity to enforce seismic risk reduction measures through a dual objective: address the lack of state-of-the-art tools for the seismic risk assessment throughout the country and engage local authorities and increase the awareness of local population and practitioners. The main outcomes are summarized as follows:

- Improved the existing Algerian hazard model.
- Implemented in-built data collection mechanisms and developed an exposure model
- Provided training focused on prevention and risk mitigation strategies
- Developed a physical vulnerability model.
- Developed a social vulnerability model.
- Developed a web-based platform for risk assessment and mitigation planning

METIS – Methods and Tools Innovation for Seismic Risk Assessment (2020 - 2025),
funded by Euratom

www.iterate-eu.org/

GEM (Global Earthquake Model) will contribute to the task on seismic hazard assessment and on Probabilistic Safety Assessment (PSA) Tools and Methodology through this project. In the hazard task, GEM will implement OQ (Open Quake) Engine methods such as vector-valued probabilistic seismic hazard analysis (PSHA), cluster-based PSHA as well as new methods to propagate epistemic uncertainties. Research will also be carried out in the context of processing earthquake catalogues to remove aftershocks, foreshocks, and cascading effects, and on testing PSHA models. GEM's contribution to PSA Tools and Methodology will concentrate on testing risk results.

The objective of this project is to translate research into practice through rigorous and efficient methodologies and tools to assess seismic safety of NPP (Nuclear Power Plants). It also aims to innovate current practice by combining simulation with experimental data.

The research will develop methods to improve the ability to define safety limits for extremely rare events, which go beyond current design analyses. The refined PSA is expected to provide meaningful support in defining regulations for safe design of NPP as well as for assessing plant safety in real-time in case of temporary unavailability of relevant safety equipment or structures.

Subnational Risk INFORM Index (2021)

<https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Subnational-Risk>

In 2021, UNDRR Regional Office for Europe and Central Asia (UNDRR ROECA, 2021) in collaboration with DPPI-SEE Secretariat initiated a process that resulted with a subnational INFORM risk assessment for three pilot countries (Albania, Republic of North Macedonia, and Montenegro). The same exercise was repeated in 2022 with the same countries, including also Romania. INFORM identifies areas at high risk of humanitarian crisis that are more likely to require international assistance. The model itself is based on risk concepts published in scientific literature and envisages four dimensions of risk: Hazard and Exposure, Vulnerability and Lack of Coping Capacity. Figure 1 represents the overview of the INFORM risk results and the structure of the model.

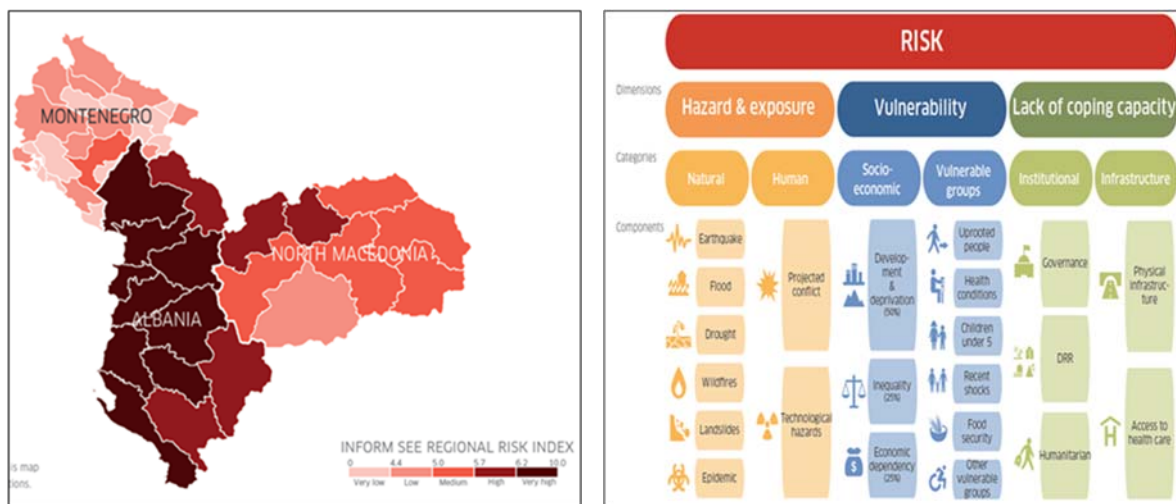


Figure 1. Subnational Risk Inform Index

BORIS – The Cross-border risk assessment for increased prevention and preparedness in Europe (2021 - 2022), funded by the Union Civil Protection Mechanism (UCPM)

<https://civil-protection-knowledge-network.europa.eu/projects/boris>

BORIS2 – Cross border risk assessment for increased prevention and preparedness in Europe: way forward (2024-2025), funded by the Union Civil Protection Mechanism (UCPM)

<https://www.borisproject.eu/>

BORIS and BORIS2 projects focus on the development of harmonized cross-border approaches for assessing and communicating the multiple risks posed by seismic and hydro-meteorological hazards in the eastern Alps region.

More in detail, during the BORIS project (completed), a shared methodology for single and multi-risk assessment in transboundary regions and a platform for single and multi-risk assessment and representation were implemented. BORIS methodology and platform, as well as multi-hazard risk assessment, were applied at two cross-border areas in this target region, allowing for evaluation of the data required, testing of procedures, effective cross-border seismic and flood risk assessment, as well as multi-risk comparison and ranking.

The multi-risk analysis methodology developed in BORIS, implemented at municipality scale, will be upgraded in BORIS2 (which is currently ongoing) for application at sub-municipal level (e.g., at census tract level or for square grid units) considering relevant multi-risk scenarios. Main goal of BORIS2 is to deliver a methodology and tool to support stakeholders to undertake strategic decisions to improve emergency planning. This will enable us to highlight urban areas that are most impacted by single and multiple risks for better planning of emergency phase. Moreover, critical infrastructures and their connections will be included for the evaluation.

MYRIAD-EU – Multi-hazard and systemic framework for enhancing risk-informed management and decision-making in the EU (2021- 2025), funded by the European Union’s Horizon 2020 research and innovation programme call H2020-LC-CLA-2018-2019-2020

<https://www.myriadproject.eu/>

This project is set to change the way disaster risks are managed. Through its systemic and forward-looking approach, the project (currently ongoing) aims at offering new ways to assess trade-offs and synergies between economic sectors, hazards, and their scales.

Through five different pilot studies in close collaboration with different stakeholders, MYRIAD-EU will try to develop solutions to real-world challenges. The pilots in the North Sea, on the Canary Islands, in Scandinavia, the Danube region, and in Italy’s Veneto region will serve as laboratories for systemic multi-hazard risk assessment and management. The considered hazards are biological hazard, drought, earthquake, extreme wind, fire, flood, heat, landslide, snow, storm, thunder and hail, tornado, tsunamis, and volcano.

MYRIAD-EU is developing a broad range of solutions and tools to enable decision-makers and practitioners to adopt a new approach to disaster risk management, including open-source software for multi-hazard/risk scenario generation.

MEDiate – Multi-hazard and risk informed system for enhanced local and regional disaster risk management (2022 - 2025), funded by HORIZON-CL3-2021-DRS-01

<https://mediate-project.eu/>

The project aims to develop a Decision Support System (DSS) for disaster risk management by considering multiple interacting natural hazards and cascading impacts

using a novel resilient-informed, service-oriented and people-centered approach that accounts for forecasted modification in the hazard and exposure. A Participatory Action Research (PAR) methodology is adopted to guide the co-design, co-development, and co-evaluation of the MEDiate DSS. This risk informed DSS is going to be delivered as a user-friendly IT system, allowing end-users to model and visualize potential disaster scenarios and understand how potential physical and social actions will influence the scenarios and their communities' resilience to current and future natural hazards. Objectives of MEDiate project (currently ongoing) are hereinafter illustrated:

- Improving multi-hazard assessments of natural hazards and highlighting potential trends due to climate change. The project will develop improved modelling of how the natural hazards interact and cascade at various scales and how these hazards will change with time due to the changing climate.
- Improving multi-hazard risk assessments accounting for interactions and trends in their components. The project will prioritize the improvements in the modelling of risk to the built environment and people given these interacting and increasing hazards and changes to both exposure and vulnerability/resilience.
- Advancing beyond the state-of-the art in multi-hazard hazard and risk approaches by developing dynamic and future-centric risk-framing tools that effectively address the decision-making needs of various stakeholders, including local government, businesses and citizens. These tools will be integrated into the computational engine of the MEDiate DSS, providing sufficient flexibility that will enable different decision makers to tailor the analyses and visualizations in line with their specific priorities.
- Providing decision makers with a means of visualizing the components of disaster risk and resilience, the stakeholders' preferences and the effect of different actions and alternate futures on possible scenarios for an area, considering the multiple hazards that are present and how these (and other risk components) may change with time.

MEDiate project focuses on four European testbeds, i.e. Oslo (Norway), Nice (France), Essex (UK), and Múlaping (Iceland). Hazards addressed in the project are hydrological (e.g., surface water, flash and fluvial floods), meteorological (e.g., storms and wind), climate (e.g., heatwaves, forest fires and droughts), and geophysical (e.g., landslides and earthquake).

FORCE – Forecasting and Communicating Earthquake Hazard and Risk (2022 - 2025), project supported by USAID Bureau for Humanitarian Assistance (BHA)

<https://www.globalquakemodel.org/proj/force>

The project aims to strengthen the capacities and to understand how to manage and respond to future earthquake risk. It aims to strengthen the capacities and understanding to manage and respond to future earthquake risk through the following objectives:

- Introducing future growth or change into national and global exposure models to enable the quantification of future disaster losses, including those associated with climate change.
- Developing communication and dissemination tools to maximize the uptake of disaster risk information in policy-making bodies.
- Improving the reliability of earthquake hazard and risk assessment, in particular in regions that lack information.

FIRMITAS – Multi-hazard assessment, control and retrofit of bridges for enhanced robustness using smart industrialized solutions (2022 - 2024), Italian Ministry of Education and Research

The FIRMITAS project focused on the preservation of serviceability and the extension of the service life of existing infrastructure, with particular emphasis on the Italian roadway system. Unlike the railway sector—largely centralized under RFI’s management—the road network in Italy spans over 837,000 km and is managed by a multitude of entities at national, regional, and local levels. This fragmented technical oversight has led to inconsistent design, construction, and maintenance practices, increasing the system’s vulnerability.

Considering recent bridge collapses, FIRMITAS aimed to develop and promote effective, sustainable intervention strategies to reduce the collapse risk of roadway bridges. Rather than relying on demolition and reconstruction, the project emphasized maintenance and rehabilitation based on smart, technically sound solutions.

A key goal was to support decision-making by proposing a multi-scale assessment of both individual bridges and the connectivity of entire bridge networks under multiple hazards. These include not only floods and scouring—main causes of past failures—but also environmental degradation, fire, traffic evolution, and cascading events like landslides triggered by earthquakes. Current standards often fail to account for these risks, despite the fact that many bridges have exceeded their original design life.

FIRMITAS adopted an integrated approach to assess the robustness of infrastructure systems under both natural and human-induced hazards. The project brought together interdisciplinary expertise – hydraulics, topography, geotechnics, innovative materials, and structural engineering, through the collaboration of five research institutions: Politecnico di Milano (PoliMI), University of Naples Federico II (UniNA), University of Parma (UniPR), IUSS Pavia, and Roma Tre University (UniRoma3).

COASTWAVE – Strengthening resilience of coastal communities against tsunamis and other coastal hazards (2022 - 2024), initiative under UNESCO’s Intergovernmental Oceanographic Commission (IOC)

<https://tsunami.ioc.unesco.org/en/articles/coastwave>

The COASTWAVE project was implemented in coastal communities of the project countries: Malta, Cyprus, Greece, Turkey, Egypt, Morocco, and Spain. In the framework

of this project the town of Samos (Samos Island, Northern Aegean Sea) became the first Tsunami Ready community in Greece. Project activities included tsunami awareness activities, hazard and evacuation mapping, developing local protocols and Standard Operational Procedures, and testing them through a local exercise (Kalligeris et al., 2025).

The aims, designed to enhance disaster risk reduction efforts, were to:

- **Raise Awareness:** Increase public understanding of tsunami risks and promote effective responses.
- **Strengthen Early Warning Systems:** Collaborate with local, national, and regional stakeholders to enhance real-time monitoring and alert mechanisms.
- **Build Resilient Communities:** Support coastal areas in adopting the Tsunami Ready program, ensuring they meet critical preparedness criteria.

Its key activities included Capacity Building, i.e. training workshops and simulation exercises to prepare community leaders and decision-makers against tsunami risks; Public Engagement, through disseminating educational materials to schools and the general public; and Partnerships, through engaging with international and local organizations to ensure a cohesive, multi-level response to coastal hazards.

ARISTOTLE – Multi-Hazard Expert Advice System for ERCC (2022 - 2028), funded by the European Civil Protection and Humanitarian Aid Operations

<https://www.globalquakemodel.org/proj/aristotle>

It aims to deliver world-leading multi-hazard capability to the Emergency Response Coordination Centre (ERCC). It is designed to offer a flexible and scalable system that can provide new hazard-related services to the ERCC and to create a pool of experts in the field of Meteorology and Geophysics of Europe that can support the ERCC with regard to situation assessments in crises.

The project objectives are:

- Designing a flexible multi-hazard, scalable early warning service.
- Comprehensive reporting of the available information gathered by the 24/7 operational centers.
- Providing expert analysis by an expert panel readily available upon request e.g. through teleconferencing.

The project's methodology is:

- 1) Establishment of a partnership among the participants and of a network of scientific and operational centers run by a governance body that will evaluate and agree on the adoption of common international standards for the delivery of monitoring reports.
- 2) Provide training to ensure preparedness and to achieve a common understanding of the services developed and their reporting activities.

The developed service shall be scalable to include additional hazards and 24/7 operational centers.

SERENE – Optimal seismic and energy retrofit of buildings considering economic and environmental impacts (2023 - 2025), Portuguese Foundation for Science and Technology

www.serene-project.pt/

The project has successfully addressed the pressing challenge of renovating Portugal's vulnerable building stock by developing and demonstrating an integrated framework for seismic and energy retrofitting of existing residential buildings. A significant portion of Portuguese buildings were constructed before the introduction of seismic design codes in the 1980s and were also found to be highly energy inefficient, posing considerable risks to both safety and sustainability.

The project filled a critical gap in existing practices, which typically addressed either seismic vulnerability or energy inefficiency in isolation. SERENE proposed a comprehensive approach that combines both dimensions through multi-criteria decision-making, grounded in life-cycle performance metrics. By integrating advanced hazard, exposure, and vulnerability models tailored to different structural typologies, SERENE identified optimal retrofitting solutions that minimize both economic and environmental impacts.

Rather than relying on demolition, which is costly, disruptive, and environmentally damaging, SERENE demonstrated that targeted retrofitting is the most sustainable path forward. This approach aligns with the EU's broader goals of reducing greenhouse gas emissions and construction waste, as the building sector is a major contributor to both.

The project assessed seismic risk and energy inefficiency of Portuguese buildings and incorporated environmental impact evaluation into the retrofit decision-making process. As a result, SERENE delivered tools and strategies to support sustainable renovation at scale, aligned with Portugal's 2030 Sustainable Development agenda. Finally, it contributed advanced seismic risk models integrated with energy renovation strategies and provided practical outputs for policymakers, engineers, and stakeholders. Beyond the technical community, the project also targeted broader societal benefits through the dissemination of its findings and the promotion of resilient, energy-efficient, and sustainable housing in Portugal. The main results are summarized as follows:

- Improved characterization of the seismic hazard in Portugal for multiple building configuration analysis, with advanced intensity measures;
- Simplified loss analysis approach for buildings to enable rapid loss estimates for seismic risk classification and identification of retrofit needs;
- Framework for life cycle based environmental emissions and environmental impact characterization, quantified in metrics that can be combined with seismic average annual losses.

Multi-criteria decision-making framework for identification of optimal combination of energy and seismic retrofit strategies, with economic and environmental impacts mitigation.

Prior-Built - Prioritization of Italian regions for seismic and energy performance upgrading of existing buildings (2023 - 2025), project funded by ReLUIS

The project is aimed at developing an integrated prioritization framework of the Italian regions based on primary metrics needed for regional assessment, estimated according to solid, state-of-the-art engineering-based research. Such metrics were the expected loss of life, expected economic loss, energy consumption, CO2 emission, socioeconomic development aspects, to name a few. Single and multi-sectoral indicators were defined; thus, the framework provides different prioritization patterns and different refinement scales, from province-level to regional/national-level. Three research-based pillar actions can summarize the main objectives of Prior-Built:

- quantification of different primary metrics (seismic risk, energy performance and socio-economic vulnerability) at national-level and proposing prioritisation partners of provinces/regions based on each independent primary metric;
- devise and propose an integrated research-based framework for the prioritisation of the Italian regions, allowing to identify (i) different integrated prioritisation patterns and refinement scales and (ii) regional/national-based financial strategies, supporting regulatory changes to current tax deduction measures and allowing the allocation of funds in regions with higher needs and/or according to their specific needs;
- development of an open-source platform and reports collecting the main outcomes of Prior-Built, supporting decision-makers in defining future financial planning for the nationwide strengthening/renovation process specifically based on all the primary metrics.

As such, Prior-Built allows to: (i) identify a strategy to make Italian cities safer and more resilient; (ii) enable the tax deduction process to become more impactful at the national scale; (iii) improve the seismic safety and energy performance of the existing Italian building stock in a more consistent and resilience manner.

MIRACA - Multi-hazard infrastructure risk assessment for climate adaptation (2023 - 2026), funded by HORIZON-MISS-2021-CLIMA

<https://cordis.europa.eu/project/id/101093854>

Fotopoulou et al., 2025

The mission of the ongoing EU-funded MIRACA project is to catalyze and empower the implementation of adaptation measures for critical infrastructure (CI) throughout Europe. CI in Europe is at risk of failure due to natural hazards and rapid climate change, which can lead to major physical and economic damage. Existing methods for climate

risk analysis are not tailored to the complexities of CI: they do not properly account for systems interdependencies, while also still containing key data gaps. Public authorities urgently need tools to pinpoint risk-prone areas and to develop affordable adaptation strategies to enhance CI resilience.

The MIRACA Consortium will develop an evidence-based decision-support toolkit, consisting of: (i) guidance on technical and economic appraisal of adaptation strategies, (ii) a technical decision-support workbench, and (iii) an online interactive viewer. These will be based on a multi-hazard climate risk assessment framework that employs advanced new methods of data acquisition, which will fill critical gaps in knowledge of the vulnerability and costs of CI. New model capabilities will be developed to fully appraise the benefits for people and businesses of climate-resilient infrastructure systems.

The uptake of MIRACA's research and innovation will be demonstrated, validated, and promoted through five use cases, which cover a variety of locations, infrastructure types, and natural hazards. To propel transformative change, all methodologies will be made available through open-access datasets, model codes, and online interactive visualizations. The toolkit will be implemented across Europe, most notably in regions and communities that are currently not well-prepared against future climate change and still confronted with data scarcity.

ICARIA – Improving climate resilience of critical assets (2023 – 2025), funded by HORIZON-MISS-2021-CLIMA

<https://www.icaria-project.eu/>

The EU-funded ongoing ICARIA project uses asset-level modelling to understand climate-related direct and indirect impacts provoked by complex, compound, and cascading disasters and the risk reduction that suitable, sustainable, and cost-effective adaptation solutions provide. ICARIA focuses on both critical assets and infrastructures, which were not designed to consider potential climate changes that can increase the unplanned outages and failures, and on housing, nature, and land areas. Cutting edge methods regarding climate scenario building, assets level coupled models, and multi-risk assessment approaches will be implemented and replicated in three EU regions. The aim is to understand how future climates might affect life-cycle costs of these investments in the coming decades and to help risk owners managing public and private infrastructures assess the costs and benefits of various adaptation solutions. Two of the three case studies, Barcelona Metropolitan Area and the archipelago of South Aegean region, are in the coastal area of the Mediterranean and are facing increasingly extreme weather events (storm surges, pluvial floods, heatwaves, drought, and forest fire) with critical socio-economic and environmental impacts. The third region is situated in Austria, representing an area that is highly affected by climate change with effects (glacier melt and heatwaves) that directly impact the prevailing energy production assets (extremely critical infrastructures) and other important sectors. Moreover, the other seven follower regions (third parties) will be the first candidates for replication beyond

the project. In this context, ICARIA also fosters several actions to maximize replication and outreaching of the main project outcomes.

Centre for Observation and Modelling of Earthquakes, Volcanoes and Tectonics (COMET) - Global Earthquake Model (GEM) (2020 - 2025)

<https://www.icaria-project.eu/>

This project is as a result of partnership between COMET and GEM, and its goal is to integrate the latest advancements in earthquake science into seismic hazard and risk modeling. Phase one (2020 - 2022) focused on building essential data sets such as an active fault database, a homogenized earthquake catalog, and a preliminary seismic hazard model for Central Asia. The ongoing second phase (2023 - 2025), supported by the Natural Environment Research Council-NERC, UK, expands these efforts by incorporating time-dependent hazard modeling, earthquake clustering analysis, and geodetic data processing. By bridging scientific research with practical applications, the collaboration ensures that hazard models remain at the forefront of earthquake risk assessment, strengthening preparedness efforts in Central Asian and beyond. Hazards of focus also include both seismic and volcanic risks. Objectives include:

- Enhancing seismic hazard models by refining databases, earthquake catalogs, and strain rate field to improve hazard predictions, and incorporating time-dependent earthquake occurrence models and earthquake clustering analysis to improve forecasting.
- Integrating advanced scientific techniques by utilizing InSAR-based deformation data and GNSS data sets to quantify seismic strain accumulation across Central Asia.
- Supporting disaster risk reduction by integrating hazard models into seismic risk assessments to estimate economic and human losses and engaging local communities and stakeholders in seismic hazard model development.
- Collaborative research and capacity building through workshops and training sessions to enhance global expertise in seismic hazard assessments as well as supporting research collaborations in the region and beyond.

Methodology:

- OpenQuake Engine - Utilized for hazard modeling, enabling the integration of various data sets and the execution of complex simulations.
- Remote sensing and InSAR - employed to monitor ground deformation, aiding in the detection of seismic and volcanic activities.
- GNSS and strain mapping - applied to measure and analyse strain accumulation along fault lines, providing insights into potential earthquake occurrences.

ADAM – World food program - advanced disaster analysis and mapping (2024 - 2025), funded by the World Food Programme Innovation Accelerator Programme

<https://www.globalquakemodel.org/proj/wfp-adam>

The ADAM project is an operational system for collecting, analyzing, and mapping geospatial and socio-economic information following sudden onset humanitarian emergencies. It is currently operational for floods, earthquakes, and tropical storms. ADAM issues alerts for preparedness and response dashboards aggregating relevant, evidence-based, near-real-time risk and impact information.

Project objective: integrating GEM's earthquake risk methodologies and data sets into humanitarian emergency preparedness and response efforts. The project seeks to enhance global access to reliable earthquake risk data and post-disaster impact assessments for humanitarian actors.

Methodology:

The above objective will be achieved by testing GEM's models within the WFP's ADAM tool (<https://storymaps.arcgis.com/stories/8f2396e762154841b16d264e5b3008be>), ensuring they align with humanitarian needs in earthquake-prone regions.

DPC-RELUIS – Assessment of integrated seismic and energy performance retrofitting schemes (2024 – 2026), Italian Department of Civil Protection

www.reluis.it/progetto-dpc-reluis-2024-2026

The project addresses the urgent need to integrate sustainability into the design, construction, and management of the built environment. Its primary objective is to promote the reduction of emissions and support the ecological transition (Green) through an extended concept of sustainability that incorporates life cycle thinking, eco-efficiency, structural safety, and resilience.

The project tackles a critical gap in the current approach to construction and infrastructure: the lack of a unified framework that considers the full life cycle of structures, from design to demolition, while also accounting for their environmental, social, and technical impacts. It also addresses the need for a shared language and cultural foundation across the construction sector to enable consistent and effective sustainability practices.

Furthermore, the project highlights the central role of structural engineering in achieving sustainable development and emphasizes the importance of a multi-scale perspective—spanning from individual buildings to urban systems. The goal is to ensure that sustainability strategies are not only technically sound but also adaptable to complex, real-world conditions and regulations. By promoting awareness and practical application of a life cycle approach, the project supports the transition toward more resilient, robust, and sustainable built environments.

EPOS ON – European Plate Observing System - Optimization and Evolution (2024 - 2027), funded by EC Horizon Europe

<https://www.globalquakemodel.org/proj/epos-on>

Based on the achievements of the previous EU projects on the design, implementation, and pre-operation of the EPOS Research Infrastructure (EPOS RI), this project will support the consolidation of the infrastructure and pave the way for its further evolution. It will enable the EPOS RI to meet long-term sustainability conditions for operation, relying on its ability to create value for the scientific and IT communities, and to produce new insights for contributing to societal challenges related to risk management and environmental impact reduction. Main objectives are:

- Ensure full exploitation of project results through a Consortium representative of the EPOS community.
- Cultivate multidisciplinary research as the next step needed to boost EPOS impact.
- Enhance and disseminate the EPOS societal value to increase its capacity to trigger socio-economic impact.
- Elaborate a user strategy able to capture user needs and evaluate their implementation.
- Reinforce the presence of EPOS in the European and global contexts through cooperation and networking with relevant organizations and initiatives.

Strengthen EPOS long-term sustainability by focusing on actual needs to steer EPOS optimization and evolution.

NEAM COMMITMENT – North-Eastern Atlantic and Mediterranean Tsunami Risk Management and Planning (2025 – 2027), funded by the Union Civil Protection Mechanism

<https://www.globalquakemodel.org/proj/neam-commitment>

The project aims to improve tsunami risk management and planning in the NEAM region (North-Eastern Atlantic and Mediterranean). It has two objectives:

- To develop national inundation maps in Cyprus, Greece, and Spain through the methodology applied to produce inundation maps for evacuation planning in Italy, aiming to achieve compatible tsunami inundation maps across the NEAM region.
- To address the need for a multi-hazard approach for effective tsunami evacuation management to complement existing tsunami evacuation management guidelines. The proposed new approach focuses on multi-hazard cascading effects concerning tsunami evacuation and emergency management. It will be piloted in local cities in Greece and Italy.

3.2 National level

3.2.1 Albania

This subsection presents a selection of national projects, strategies, and frameworks that contribute to the evolving landscape of multi-hazard risk assessment and needs planning in Albania. These include efforts at both central and municipal levels, many of which were supported by UNDP, the European Union, and other international donors.

RESEAL – Resilience strengthening in Albania (2020 - 2023), funded by UNDP, AKMC
<https://www.undp.org/albania/projects/resilience-strengthening-albania-reseal>

The United Nations Development Programme in Albania (UNDP) supports the country's attempts to improve the system and the capacities to manage disaster risks, both at the central and local level. In the framework of capacity building for DRR (Disaster Risk Reduction), this sector was previously supported by UNDP's RESEAL project (Resilience Strengthening in Albania), which began operations on July 16, 2020, by a bilateral cooperation of by the Ministry of Defense and UNDP. The RESEAL project was developed as a comprehensive response to the needs for strengthening the DRM (Disaster Risk Management) systems at all levels in the country. The overall objective of the project is to strengthen, Albania's DRM system and support country's efforts in becoming a fully-fledged member of the EU Civil Protection Mechanism. The project also promotes the implementation of Sendai Framework for Disaster Risk Reduction (SFDRR). It has two major interlinked pillars: *strengthening the DRM strategic and operational framework and capacities at central level* and *supporting the development of local (municipal) DRR framework and local response capacities in harmonization with the national DRR system and legal framework in place*.

Law no. 45/2019 'On Civil Protection' in Albania aims to minimize disaster risks and ensure civil protection. The law regulated the functioning of the civil protection system by defining the responsibilities of institutions and structures, international cooperation, as well as rights and obligations of different actors. Civil protection aims to create conditions for a society capable of reducing the risks of disasters, to prevent, prepare, cope with disasters and to recover, through an integrated and efficient civil defense system in the Republic of Albania.

To support national authorities' efforts to develop and finalize the National Risk Assessment, National DRR Strategy, and National Civil Emergency Plan, a wide working group with participation of relevant national authorities was set up and was finalized with a set of approved documents as follows:

DCM no. 168 "On the approval of the disaster risk assessment (DRA) at the central level"; DCM no. 94 "On the approval of the national strategy for disaster risk reduction 2023–2030 and action plan"; DCM no. 807 "On the approval of the national plan for civil emergencies". The approved documents have considered the risk of a wide range of natural hazards: earthquakes, wildfire, floods, landslides, technological, and biological.

A qualitative multi-hazard risk assessment is proposed as a summary of DRA combining the results of each assessed risk. A lot of data was lacking in performing a quantitative integrated multi-hazard risk assessment. A qualitative risk assessment, besides being an approximate approach lacking a lot of specific risk data related to the cascade consequences, followed by a strong interpretation of all risk experts involved in multi-hazard risk assessment.

The following project was finalized to develop the local and regional DRR framework, which includes the drafting of DRA and DRR Strategy in Municipality and Regional level for all six Municipality of Fier region. This project was finalized by approving DRA, VCA (Vulnerability & Capacity Assessment), and DRR Strategy for all Fier municipalities. The Civil Emergency Plan is prepared as well. Within the project “Developing the Regional Disaster Risk Reduction in Fier Region”, the working group work with the municipalities and region experts to carry out each of the components of the risk assessment, under the guidance and coordination of UNDP, the National Agency for Civil Protection.

Through this project, the aim is to draft the documents focused on disaster risk assessment for the municipalities and Fier region. The documents prepared at the national level (risk assessment, disaster risk reduction strategy and the national civil emergencies plan) have been the main references and serve as guidance throughout the implementation of this assignment. The process and the products have been guided by the national processes as well as the experiences and lessons learned from previous UNDP’s projects.

Additionally, the work was focused on assessing coping capacities and risk assessment for six main risks: earthquakes, floods, fire, landslides, pandemic (biologic) and technological risk.

More specifically:

- Evaluate the human capacities of each municipality to cope with the various disaster risks;
- Draft the risk assessment document;
- Provide professional support in the establishment and operation of Civil Defense Commissions;
- Train the Civil Defense Commissions;
- Train and prepare Training for Trainers who will share their knowledge with the staff of the prefecture in the future.

At the end of the project, the achievements can be summarized as follows:

- Region and relevant civil protection commissions have been equipped with a framework and knowledge to contribute to the reduction of disaster risks and with improved capacities to cope with possible disasters in the future. Results are also expected in the mid- and-long terms to increase the local ability to recover through the use of a fruitful and integrated civil defense system.

- The structures of the civil protection commissions efficiently used the findings of the Project in terms of reducing the risk of disasters and increasing the coping ability.

The process is ongoing to finalize the same documents for Tirana Municipality.

3.2.2 Greece

In Greece, no multi-hazard risk assessment has been conducted at national level. however, some relevant initiatives have been taking place in the last years in the framework of national and European research projects, focusing on selected regions in Greece. These initiatives are described in the following.

SNOWBALL - Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools (2014 - 2017), funded by EU's Seventh Framework Programme for research, technological development and demonstration
<https://cordis.europa.eu/project/id/606742/reporting>

One of the first European projects that tackled multi-hazard risk assessment in a region in Greece was the SNOWBALL project, where the island of Santorini was used as a case study to validate a procedure to assess the possible multiple cascading effects caused by volcanic unrest and tectonic earthquakes (Zuccaro et al. 2018; Forte et al., 2019). Assuming the worst-case scenario of a sub-Plinian eruption, the most critical areas (hot spots) for slope stability were identified. In addition, the decision algorithm that was developed to support decision makers to better deal with cascading effects in disasters in pre-crisis phase was applied at the pilot site of Santorini to compare two evacuation strategies in the scenario where a volcanic reactivation is followed by two earthquakes.

More details for this project are given also in Section 3.1 European and worldwide level.

CRISIS – Multi-Hazard Risk Assessment of Basic Services and Transport Infrastructure (2020 - 2022), cross-border cooperation programme funded by The European Civil Protection and Humanitarian Aid Operations
<https://civil-protection-knowledge-network.europa.eu/projects/crisis>

CRISIS project focused on the educational facilities, health facilities, and bridges located at the cross-border region (CBR) of Greece, North Macedonia, and Albania. A risk assessment for seismic hazard and/or earthquake-induced landslides was performed, while a web-based platform (WBP) was also developed intended to support disaster and emergency management authorities. The CRISIS WBP contains, organises, and enables the visualisation of the hazard (earthquake and landslides) for the target CBR. Rapid information is also available on the level of damage that hospitals, schools, and bridges in the reference area could suffer in the event of an earthquake. Specifically, the platform allows displaying damage scenarios calculated for selected historical events that occurred in the project CBR but also to calculate real-time scenarios using a proper tool implemented in it. Furthermore, it is possible to identify which areas of the CBR are most

susceptible to landslides and, consequently, which assets are most at risk in the event of seismic-induced landslides. A routing tool is also provided, which is to identify alternative routes to be followed by the rescue teams if the main ones are unusable due to damaged road infrastructure (Sheshov et al., 2022, Di Meo et al., 2023).

BEYOND (2021 - 2024), funded by the Region of Attica

<http://beyond-eocenter.eu/index.php/news-events/375-ypografi-trimeris-programmatikis-symvasis-me-tin-periferia-attikis>

In the framework of BEYOND research project, earthquake, fire, and flood risk assessment was conducted in selected and most vulnerable areas in the Region of Attica, Greece, the most highly dense region in Greece which hosts Athens - its capital. Attica constitutes a region with significant characteristics, such as long coastline, large inland area and nine islands, various geoenvironmental units, high population density (3.792.469 residents, 36,4% of the country's population according to the Hellenic Statistical Authority (2021)), crucial infrastructures and social economic activities. A holistic multi-parameter risk assessment methodology was developed and implemented at selected municipalities of Attica at high spatial resolution (building block level). The applied approach included the collection of all available data, detailed field visits, hazard assessment, vulnerability and exposure modelling, and risk assessment for the different hazards considered. Moreover, high-risk critical points were identified and, finally, refuge areas and escape routes were proposed for the worst-case scenarios. All collected and produced data, including risk maps, critical points, and escape routes, were made available to the Region of Attica through a user-friendly web GIS platform, to support the relevant authorities in the effective crisis management for the protection of the population, the properties and the infrastructures. In addition, training sessions were organized for all the relevant stakeholders and the competent authorities who are directly or indirectly involved in civil protection, including co-design and support for the organization and implementation of civil protection exercises at both local and regional scale. The general outcomes of the study were also disseminated to the public to raise awareness and contribute to the preparedness of the general population.

INFRARES – Towards resilient transportation infrastructure in a multi-hazard environment (2022 - 2025), funded by the Hellenic Foundation for Research and Innovation (HFRI) under the 2nd Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers

<https://www.infrares.gr/>

In the project framework, a comprehensive methodology and a relevant software for the risk and resilience assessment of critical transportation infrastructure components (i.e., bridges and tunnels) in a multi-hazard environment have been proposed (Stefanidou et al., 2022; Karatzetzou et al., 2022). To this end, new fragility functions for various typologies of bridges and tunnels for a range of critical components of transportation infrastructure were developed considering single and combined hazards, case- and data-specific damage states were defined to fill the relevant knowledge gap, and a

resilience index for roadway network assets was finally calculated. The index is appropriately modified so that to be applicable for multi-hazard assessment purposes. INFRARES tool for multi-hazard risk assessment of transportation systems helps towards: (i) identifying vulnerabilities within transportation systems exposed to floods and earthquakes, (ii) mitigating risk and thus enhancing resilience and ensuring that transportation systems can withstand and recover from various threats more effectively, (iii) resource allocation by focusing on the most critical areas needing attention in terms of safety measures, maintenance, and emergency response planning.

MIRACA - Multi-hazard infrastructure risk assessment for climate adaptation
(2023 - 2026), funded by HORIZON-MISS-2021-CLIMA

<https://cordis.europa.eu/project/id/101093854>

Fotopoulou et al., 2025

Within the ongoing European project MIRACA (<https://miraca-project.eu/>), one of the considered Use Cases (UC4) refers to Climate Adaptation for Healthcare and Educational Infrastructure in Greece. The developed methodology for asset-level risk assessment involves creating loss maps for different return periods and scenarios using the collected hazard data and vulnerability functions. Different risk metrics are considered to account for economic and human losses. The use case includes risk calculations for both single and multi-hazards, focusing on educational and healthcare facilities for Central Macedonia, Greece. Both single hazards (earthquake, flood, landslide) and combinations of hazards (such as earthquake and flood, or earthquake and landslide) are considered. The systemic risk to hospitals is also assessed by examining interdependencies with other critical infrastructure, such as the road network. This is important considering e.g., that damage to roads can impede access to healthcare facilities during emergencies, exacerbating the impact of the disaster.

ICARIA – IME - Climate hazards and extreme weather: A call for urgent action,
funded by the European Union’s Horizon Europe research and innovation programme

<https://www.icaria-project.eu/about-icaria/>

Within the ongoing European project ICARIA, the South Aegean Archipelago in Greece is selected as case study due to the more pronounced climate change effects it faces compared to continental Greece and Europe. The region’s distinct geographical characteristics, including 52 inhabited islands, pose challenges in meeting local population needs such as water, food supplies, electricity, and healthcare. Seasonal population changes due to tourism further strain infrastructure and resources. Vulnerable infrastructure like ports and power plants are directly and indirectly affected by climate change, making disaster risk reduction and resilience crucial. ICARIA analyses climate-related compound events and their cascading effects on services in the South Aegean, focusing on Syros, Rhodes, Kos, and Naxos islands. Considered climate hazards include forest fire, drought, extreme winds, heat wave, as well as compound events (consecutive and coincident).

3.2.3 North Macedonia

In the following sections selected initiatives and projects, presented in Chapter 2, involving risk assessment, multi hazard & needs planning for emergency management, which have been conducted at national and regional level in N. Macedonia are described.

Technical support for the development of climate – resistant projects, guidelines for the public enterprise for state roads of the Republic of North Macedonia (2019), World Bank

(<https://roads.org.mk/wp-content/uploads/2023/03/PartB-CLIMATE-RESILIENCE-DESIGN-Guidelines.pdf>)

This Guide and the accompanying methodology have been prepared for Public Enterprise for State Roads of N. Macedonia PESR to enable a better understanding of the impact of climate events (more specific floods and landslides hazards on the road network in the Republic of North Macedonia), the appropriate intervention options available, and investment priorities. The Guide is prepared as a series of linked documents, each of which is intended for a different user within PESR and organizations in the transport sector in the Republic of North Macedonia.

EU Project COMMAND d – Commanding and operations mechanism for Multisector Analysis of Nexus disaster Data from Union Civil Protection Mechanism (2020 - 2022), Funded by the European Civil Protection and Humanitarian Aid Operations

https://civil-protection-humanitarian-aid.ec.europa.eu/funding-evaluations/financing-civil-protection/prevention-and-preparedness-projects-civil-protection/overview-past-track-i-and-track-ii-projects/commanding-and-operations-mechanism-multisector-analysis-nexus-disaster-data-command-d_en

The project gives information about the protection and rescue system in N. Macedonia. The system is regulated by Protection and Rescue Law. The law states that responsibilities are shared among participants in protection and rescue activities, including the state, local authorities, private companies, public enterprises, facilities and services. Based on the Protection and Rescue Law, rescue organizations are obliged to participate in protection and rescue activities in the event of disasters and major accidents.

The Law on Crisis Management regulates all risk management approaches from local to national level in crisis management. The crisis management system in North Macedonia was established due to the need for continuous monitoring and assessment of security risks and dangers. The Protection and Rescue Department performs work in the field of protection and rescue, crisis management, defense and firefighting in accordance with the law and coordinates its work with other departments within the administration of the City of Skopje.

Protection and rescue of people, environment, material goods, natural resources, animal and plant life, and cultural heritage from natural disasters and other accidents in peace, state of emergency or war in North Macedonia are regulated by the Law on Protection and Rescue.

The Structure of the COMMAND Data system in the City of Skopje implemented a comprehensive data collection approach during the preparatory phase through three interconnected segments. First, it established an overview of technical facilities that included a detailed catalog of operating costs to ensure financial transparency and resource management. Second, it developed a methodology for risk assessment that incorporated an atlas of risks, providing spatial visualization of potential hazards throughout the city. Third, it created an online archive of planning documentation, enabling efficient access to critical information for decision-makers and stakeholders involved in disaster prevention and response activities. This integrated data system framework supported the city's ability to prepare for, respond to, and mitigate various disaster scenarios.

CRISIS – Multi-Hazard Risk Assessment of Basic Services and Transport Infrastructure (2020 - 2022), cross-border cooperation programme funded by The European Civil Protection and Humanitarian Aid Operations

Sheshov et al., 2023

Details for this project are given in the section for Greece.

The R2R Diagnostic Report – Ready 2 Respond Emergency Preparedness and Response Assessment diagnostic for North Macedonia (2021), The report is a product of the staff of The World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR)

Ready2Respond Diagnostic Report for North Macedonia, 2021

In 2020, the World Bank engaged Prepared International (PPI) to assess emergency preparedness and response (EP&R) capacities in five Western Balkan countries, including North Macedonia, using the Ready2Respond (R2R) diagnostic methodology. The R2R diagnostic in North Macedonia used a blended approach of desk research and structured interviews with key actors from national and municipal emergency management bodies. Although the number of respondents wasn't specified, participants included officials from ministries, local emergency units, and planning departments.

The assessment aimed to evaluate the country's disaster preparedness and response across five key areas: legal frameworks, institutional coordination, information systems, emergency facilities, and personnel. Using the Ready2Respond framework, national systems were benchmarked against international standards.

Analysis combined qualitative coding of interviews with a review of institutional documents and emergency plans. The results demonstrated a significant capacity for

national-level coordination and identified critical weaknesses in municipal-level preparedness, gaps in resource availability, and insufficient integration of risk reduction strategies into national development planning. The report recommended prioritizing the strengthening of core EP&R components, including investments in equipment, capacity-building, legal modernization, and a unified disaster risk management framework. It emphasized the need for a strategic, long-term approach to enhance resilience, with clear roadmaps for capacity building, legal improvements, and infrastructure investments to address both current and emerging risks.

L2BR – Learn to be Resilient Project (2021 - 2022), project financed by the Union Civil Protection Mechanism UCPM-2020-KN-AG

<https://civil-protection-knowledge-network.europa.eu/projects/l2br>

Apostolska et. al, 2024

The L2BR project aimed to improve earthquake prevention, preparedness, and response in the context of pandemic crises through fostering intersectoral cooperation across various stakeholders. The study used a unified model to collect and interpret data, focusing on two case studies: the 2020 earthquake in Zagreb and the 2019 earthquake in Tirana. The model utilized three urban risk indicators, i.e. the Urban Disaster Risk Index (UDRI), the Risk Management Index (RMI), and the Disaster Resilience Index (DRI), to evaluate gaps in resilience systems.

Stakeholders from national and local governments, universities, public health institutions, and civil protection authorities were involved, ensuring a comprehensive approach to data collection and validation. These stakeholders contributed insights at local, national, and international levels, combining scientific research and practical exercises to support disaster risk management and the sharing of knowledge. Data analysis involved the calculation of the three indices for both cities, providing a structured comparison of resilience gaps.

The results indicated that urban resilience in both cities was relatively low, underscoring the need for both immediate and long-term strategic actions. These actions included enhancing awareness, improving physical vulnerability mitigation, retrofitting infrastructure, and establishing more robust disaster recovery systems. The findings led to specific recommendations aimed at improving operational procedures and disaster management systems, particularly in the context of pandemic challenges. This methodology and its outcomes contribute to better disaster planning and informed decision-making in earthquake-prone regions, highlighting the importance of multi-hazard risk assessments in enhancing resilience.

NRAMK – National Risk Assessment in North Macedonia (2023 - 2025), project under the Union Civil Protection Mechanism (UCPM)

<https://civil-protection-knowledge-network.europa.eu/projects/nra-mk>

The project NRAMK developed a comprehensive methodology for national risk assessment of natural disasters in North Macedonia. The Disaster Risk Assessment contained crucial information and data encompassing various types of risks threatening

citizens, material and cultural goods, as well as the environment. It presented different scenarios about the occurrence of each risk individually, alongside detailed risk matrices and maps illustrating geographical vulnerability. Furthermore, the assessment determined the degree of threat posed by the identified risks through systematic analysis. A critical component was the thorough analysis of available resources at the disposal of participants within North Macedonia's rescue and protection system, ensuring preparedness and response capabilities were accurately evaluated.

The EU-funded project “National Risk Assessment in North Macedonia (NRA MK)” is currently in its no-cost extension phase. Following a formal request submitted starting from 10 January 2023, the Contracting Authority granted an additional six months to complete the remaining project activities without additional funding.

The final phase of the project focuses on the completion of lectures and the translation into the Albanian language of the risk analyses developed for the following eight thematic chapters: 1. Geological Risks (1.1 Earthquakes, 1.2 Landslides), 2. Climate Change (2.1 Storms, 2.2 Droughts, 2.3 Avalanches and Cold Waves), 3. Floods (3.1 Floods in the Vardar River Basin, 3.2 Floods in the Crna River Basin), 4. Forest and Open Space Fires (4.1 Fires in National Parks, 4.2 Fires in Agricultural Areas), 5. Epidemics and Communicable Diseases, 6. Animal and Plant Diseases, 7. Technological and Industrial Accidents, 8. Radiological and Nuclear Accidents.

In line with the revised implementation schedule, the risk analysis component is nearing completion. The final remaining activity is the organization of a study visit, which will provide an opportunity for practical learning, knowledge exchange, and the consolidation of outcomes achieved during the project.

Multi-Hazard Vulnerability Assessment in Makedonska Kamenica Municipality (2024), Academic article

Aleksova et al., 2024

The study presents a comprehensive GIS and remote sensing-based analysis for assessing multi-hazard susceptibility to natural hazards in the Makedonska Kamenica municipality in North Macedonia. This includes erosion, landslides, flash floods, and forest fires. The research did not involve human respondents but relied on spatial data, environmental indicators, and expert validation to model risk areas.

The main purpose of the study was to identify zones of hazard exposure in order to support informed needs planning and disaster risk mitigation. A range of established methods for the different hazards were used to contribute to this objective. The outputs from the individual hazard models were integrated into a comprehensive multi-hazard framework that accounts for cumulative and cascading risks, enabling the identification of high-vulnerability zones. The framework is based on GIS software (QGIS and SAGA GIS) and allows for spatial identification of overlapping risk zones.

The identification of multi-hazard zones underscores the critical need for targeted preventive measures and robust land management strategies to mitigate potential

disasters and safeguard both human infrastructure and natural ecosystems. Recommendations include the implementation of enhanced monitoring systems, validation methodologies, and community engagement initiatives to bolster hazard preparedness and response capabilities effectively.

MCR2030 – Making Cities Resilient 2030 (2023 – 2030), funded by UNDRR

Nedeljković, 2024

Through the MCR2030 initiative, municipalities across North Macedonia, i.e. Ohrid, Gazi Baba and Gyorche Petrov, voluntarily took part in a structured self-assessment process to evaluate their resilience to various hazards. Key respondents in the process included local officials, technical personnel, and urban planners, though the number of participants differed by city. The main objective of the initiative was to support cities in shaping resilience strategies and embedding disaster risk reduction into everyday local governance and planning. To achieve this, municipalities used the provided tools to assess their institutional, infrastructure, and social preparedness.

The assessment process was based on the “Ten Essentials for Making Cities Resilient”, a framework first drawn up in the Hyogo Framework for Action and adapted to the Sendai Framework for Disaster Risk Reduction 2015-2030. During the workshops, local officials and relevant services filled out a scorecard, allowing them to evaluate their disaster risk management practices and identify areas for improvement.

The assessment results were analyzed by compiling resilience scores and reviewing local policies and planning documents. This was further supported by qualitative input gathered through consultations and interviews.

The findings revealed several key areas needing improvement, such as emergency coordination, risk-sensitive urban development, and public awareness. Based on the assessment results, participating cities developed tailored action plans and set measurable goals that align with national and global disaster risk reduction frameworks.

National Platform for Disaster Risk Reduction, Government of North Macedonia

Latest versions 2009, 2019

The implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 in North Macedonia has been supported through multiple initiatives, with the development of national policies and strategies playing a crucial role. One of the most significant achievements in this regard has been the creation of North Macedonia’s National Platform for Disaster Risk Reduction, which followed a broad consultation process involving stakeholders from various national institutions, including civil protection authorities and public administration bodies. Its primary goal was to formalize disaster risk coordination across different sectors.

The process included reviewing existing legislation, emergency plans, and policy frameworks through a combination of gap analysis and forward-looking strategy

development. As a result, the platform introduced a more integrated approach to disaster governance, improved coordination among institutions, and laid the groundwork for structured early warning systems and long-term resilience planning across multiple sectors.

These developments align with the Sendai Framework's Priority 2: Strengthening Disaster Risk Governance to Manage Disaster Risk by reinforcing the importance of coherence across policies and institutional mechanisms. They also support Priority 1: Understanding Disaster Risk through the establishment of systems that promote knowledge sharing, multi-sectoral collaboration, and improved data collection.

4. Concluding remarks

In this report, a review of current projects, practices, and available methodologies on national, regional, European, and international level for risk assessment and emergency planning in general is given. Projects compiled in this report reflect comprehensive and multi-disciplinary efforts in strengthening disaster risk management and resilience across different contexts, from local, national, European, and international. Each initiative addresses distinct yet interconnected challenges ranging from multi-hazard risk assessment and critical infrastructure taxonomy to decision-making support systems, sustainable strategies, and regional prioritization frameworks. By accounting for hazard inter-dependencies, cascading impacts, and evolving exposure patterns, the projects contribute to more accurate and actionable risk assessments. The development of a consistent categorization of critical infrastructures (such as transport, education, and health) and the emphasis on participatory methodologies ensure that tools and solutions are not only technically sound but also inclusive and grounded in real-world needs.

This report incorporates both natural and human-induced hazards, such as earthquakes, fire, floods, infrastructure-related risks, volcanic eruptions, landslides, etc. Advancements in seismic risk analysis and environmental impact evaluation, alongside initiatives to integrate sustainability and eco-efficiency into the built environment, highlight the importance of aligning safety with long-term environmental goals. Efforts to define prioritization metrics for regional planning, for example in Italy, and to catalyze adaptation measures across Europe contribute to a more strategic and scalable approach to building resilience.

It is important to note that, although gaps remain, such as the absence of national-scale multi-hazard assessments e.g., in Greece, the ongoing regional projects provide a strong foundation for future developments. They represent an important step towards integrated, evidence-based, and forward-looking disaster risk management that supports both short-term preparedness and long-term sustainability.

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