Union Civil Protection Mechanism (UCPM)

Progress Report

Version 1.0
30 June 2026

IMPORTANT NOTICE

What is a progress report?

Progress reports are deliverables which are sometimes requested at mid-term (or other crucial points in the project) if there is a long time-span without reporting.

The report (+ annexes) must be prepared (by all beneficiaries together) and uploaded on the Funding & Tenders Portal Grant Management System Continuous Reporting Deliverables screen.

⚠ Progress reports should NOT be confused with periodic reports. Periodic reports are linked to payments, progress reports are not.

COVER PAGE

PROJECT	
Project number:	101193586
Project acronym:	EMERGE
Project name:	Rapid Multi-Risk Needs Evaluation and Planning Platform
Project starting date:	01.02.2025
Project duration:	24

PERIOD COVERED ⚠ *Please note that this is only a progress report. The information in this report must also be included in the next periodic report/final report.*	
Period covered *(from last periodic report):*	from 01.11.2025 to 30.06.2026

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1. MILESTONES, DELIVERABLES AND CRITICAL RISKS

Deliverables and milestones (outputs/outcomes)	YES/NO
We confirm that we updated the following Continuous Reporting screens: • Deliverables • Milestones	YES

Critical risks	YES/NO
We confirm that we have reviewed and updated, as relevant, the following Continuous Reporting screen: • Critical risks	YES

2. OVERVIEW OF THE PROGRESS AND ACTIVITIES

Overview of the progress and activities
Please summarise progress in the implementation of the activities explaining how these will contribute to achieving the project objectives. *Elaborate on any emerging issue that may affect the implementation of the project and/or the achievement of its objectives.*

The progress of the EMERGE project during the second progress-reporting period, from 01 November 2025 to 30 June 2026, has advanced in line with the Grant Agreement and the updated Continuous Reporting screens. Activities continued to directly support the overall objective of the project: the development of a rapid Multi-Risk needs evaluation and planning platform to support evidence-based civil protection decision-making in cross-border contexts.

During this reporting period, substantial progress was achieved in the consolidation of exposure, vulnerability, resources and capacity-related outputs under WP3, the completion of strong-motion and near-real-time ShakeMap-related outputs under WP4, and the continued technical development of the EMERGE Web-Based Platform under WP2. Project management, quality assurance, dissemination and coordination activities continued throughout the period.

All deliverables due within the reporting period, except the present deliverable D1.5 Second Project Progress Report, have been successfully submitted and approved. The present report is prepared for submission as part of this reporting exercise. This confirms that project implementation is progressing according to the planned timetable and that the main technical outputs required for the next stages of platform integration, testing, training and sustainability planning are now available.

During the reporting period, the following deliverables were submitted and approved:

- **D1.3** First Project Progress Report – approved on 17 November 2025
- **D2.3** EMERGE WBP Architecture – approved on 20 November 2025
- **D3.1** Socio-Economic Vulnerability Assessment – approved on 17 November 2025
- **D3.2** Residential, Commercial and Industrial Buildings Vulnerability Assessment and Prioritization of Interventions – approved on 19 December 2025
- **D3.3** Basic Services and Transport Infrastructure Vulnerability Assessment and Prioritization of Interventions – approved on 19 December 2025
- **D3.4** Evaluation of Civil Protection Resources, Capacities and Capabilities – approved on 05 February 2026
- **D3.5** Executive Summary of Civil Protection Resources, Capacities and Capabilities – approved on 05 February 2026
- **D4.1** Evaluation of CBR Strong Motion Capacities and ORFEUS-EIDA Integration – approved on 31 March 2026
- **D4.2** CBR NRT ShakeMap Module – approved on 22 June 2026
- **D4.3** ShakeMap Manual – approved on 22 June 2026
- **D4.4** Executive Summary of Near-real-time Shake Map Module – approved on 22 June 2026
- **D5.2** Potential Synergies with Other UCPM Projects – approved on 28 May 2026

As of 30 June 2026, all deliverables due within the reporting period have been completed, submitted and approved, with the exception of the present D1.5 Second Project Progress Report, which is being submitted as the current progress-reporting deliverable.

During the same period, all milestones due within the reporting period were also successfully achieved. In particular, MS6 – Final exposure assets was achieved on 12 November 2025, following the previously reported minor rescheduling; MS7 – Integration with ORFEUS-EIDA was achieved on 20 November 2025; MS2 – Second coordination meeting was successfully held on 05 February 2026; and MS5 – Successful reply from the GSM-EMERGE service was achieved on 31 May 2026.

Together with the milestones already achieved in the previous reporting period — MS1 Kick-off Meeting, MS4 Selection of Rapid Needs Assessment Methodology, and MS8 Completion of the Dissemination and Exploitation Plan — a total of 7 out of 9 project milestones have been achieved as of 30 June 2026. The remaining two milestones, MS9 – Completion of Sustainability Plan and MS3 – Final Meeting, are not yet due, with planned due dates of 30 November 2026 and 31 January 2027, respectively. No milestone-related delays affecting the overall project implementation or the achievement of objectives are reported for the current period.

In terms of work package progress, project management activities under WP1 continued throughout the reporting period through regular coordination, monitoring of deliverables and milestones, quality assurance and continuous reporting. The First Project Progress Report was approved during the reporting period, and the Second Project Progress Report has been prepared in line with the required UCPM progress report format. Regular communication among partners was maintained to ensure timely delivery of outputs, coordination between work packages and consistency of the technical approach. The Second EMERGE Coordination Meeting was successfully held on 05 February 2026 (https://civil-protection-knowledge-network.europa.eu/news/emerge-project-holds-2nd-coordination-meeting), contributing to the alignment of the consortium regarding completed activities, ongoing technical development and upcoming tasks. Supporting materials related to the meeting are included in Annex A.

Under WP2 – Comprehensive Multi-Risk Assessment Platform for Needs Prioritization and Planning, the EMERGE WBP Architecture was approved during the reporting period and provides the technical basis for further development of the web-based platform. Work continued on the EMERGE WBP beta version, including preparation for the integration of exposure, vulnerability, resources and capacity datasets developed under WP3, as well as the near-real-time ShakeMap outputs developed under WP4. This work remains central for transforming the methodological and technical outputs of the project into an operational platform supporting rapid needs evaluation and planning in the cross-border region.

Significant progress was achieved under WP3 – CBR Exposure, Resources and Capacity Portfolio. All WP3 deliverables due in this reporting period were completed, submitted and approved. These outputs cover socio-economic vulnerability, residential, commercial and industrial buildings, basic services and transport infrastructure, and civil protection resources, capacities and capabilities. The approved WP3 deliverables provide essential input for the rapid needs assessment and prioritisation process within the EMERGE platform. They also support the harmonization of cross-border exposure and capacity information, which is one of the key preconditions for effective Multi-Risk needs evaluation and emergency planning.

Under WP4 – CBR Ground Shaking Map and Near-Real-Time ShakeMap Module, all deliverables due within the reporting period were completed, submitted and approved. This includes the evaluation of strong-motion capacities and ORFEUS-EIDA integration, the CBR NRT ShakeMap Module, the

ShakeMap Manual and the executive summary of the near-real-time ShakeMap module. These outputs represent an important technical achievement of the project, providing the basis for near-real-time assessment following seismic events. The integration of strong-motion capacities and the development of the ShakeMap module directly support the rapid estimation of earthquake impact and subsequent needs assessment in the cross-border region.

Dissemination and exploitation activities under WP5 – Dissemination, Exploitation, Training and Sustainability continued throughout the reporting period. The deliverable on potential synergies with other UCPM projects was submitted and approved, supporting the positioning of EMERGE within the broader UCPM and civil protection community. Project visibility continued through the UCPKN project webpage, social media channels, institutional communication activities and participation in relevant professional and scientific events.

Beyond the scheduled coordination meetings, several additional online working meetings were held to strengthen technical collaboration, facilitate the timely exchange of inputs, and ensure consistency across work packages. These meetings supported the coordination of technical activities related to exposure and vulnerability datasets, the near-real-time ShakeMap module, and the further development of the EMERGE Web-Based Platform.

The project has also been actively promoted and represented through media visibility, international scientific events and professional networks, enhancing outreach and fostering exchange with other EU-funded initiatives and expert communities. During the reporting period, the following dissemination and visibility activities were carried out:

- *ПОРТА3 (Newspaper PORTA3)* (13 May 2026) (Annex B)
  Article: "ИЗИИС носител на проектот EMERGE: Како до побрз и попаментен одговор по земјотреси (IZIIS leads the EMERGE project: Towards a faster and smarter response after earthquakes)"

- *4th International Conference on Resilience, Multi-Risk Assessment and Monitoring, Florence, Italy* (16-19 June 2026) (Annex C)
  Accepted paper and delivered oral presentation: "Rapid Multi-Risk Needs Evaluation as a Basis for Cross-Border Emergency Planning" (Salic Makreska et al.)

- *18th European Conference on Earthquake Engineering, Berlin, Germany* (14-18 September 2026) (Annex D)
  3 Submitted papers: "Near Real-Time Shaking Information to Resource Prioritisation in Cross-Border Regions" (Salic Makreska et al.); "EMERGE: A Web-Based Platform for Multi-Hazard Assessment and Early Crisis Response in the Cross-Border Region of North Macedonia, Albania and Greece" (Borzi et al.); and "Assessing Social Vulnerability to Natural Hazards in Cross-Border Regions: The EMERGE Project" (Amendola et al.).

- *7th World Landslide Forum, Faridabad, India* (23-27 November 2026) (Annex E)
  Submitted Abstract: "Near Real-Time (NRT) earthquake induced landslide hazard and risk assessment" (Bojadjieva et al.)

The **project website** (civil-protection-knowledge-network.europa.eu/projects/emerge) and official project **social media channels** have been regularly updated to enhance outreach and visibility:

- Facebook: [EMERGE Project]()

- LinkedIn: EMERGE – Rapid Multi-Risk Needs Evaluation and Planning Platform

No critical risks have materialized during the reporting period. The project continues to be implemented in accordance with the Grant Agreement, and no issues have been identified that would negatively affect the achievement of the project objectives.

Overall, EMERGE is progressing steadily toward its technical and strategic objectives. The successful submission and approval of all deliverables due in the reporting period, together with the achievement of all milestones due during the same period, confirms that the project remains on track. The main inputs for exposure, vulnerability, resources and capacity assessment, as well as near-real-time ground-shaking integration, are now available for the next stages of WBP integration, testing, training and sustainability planning.

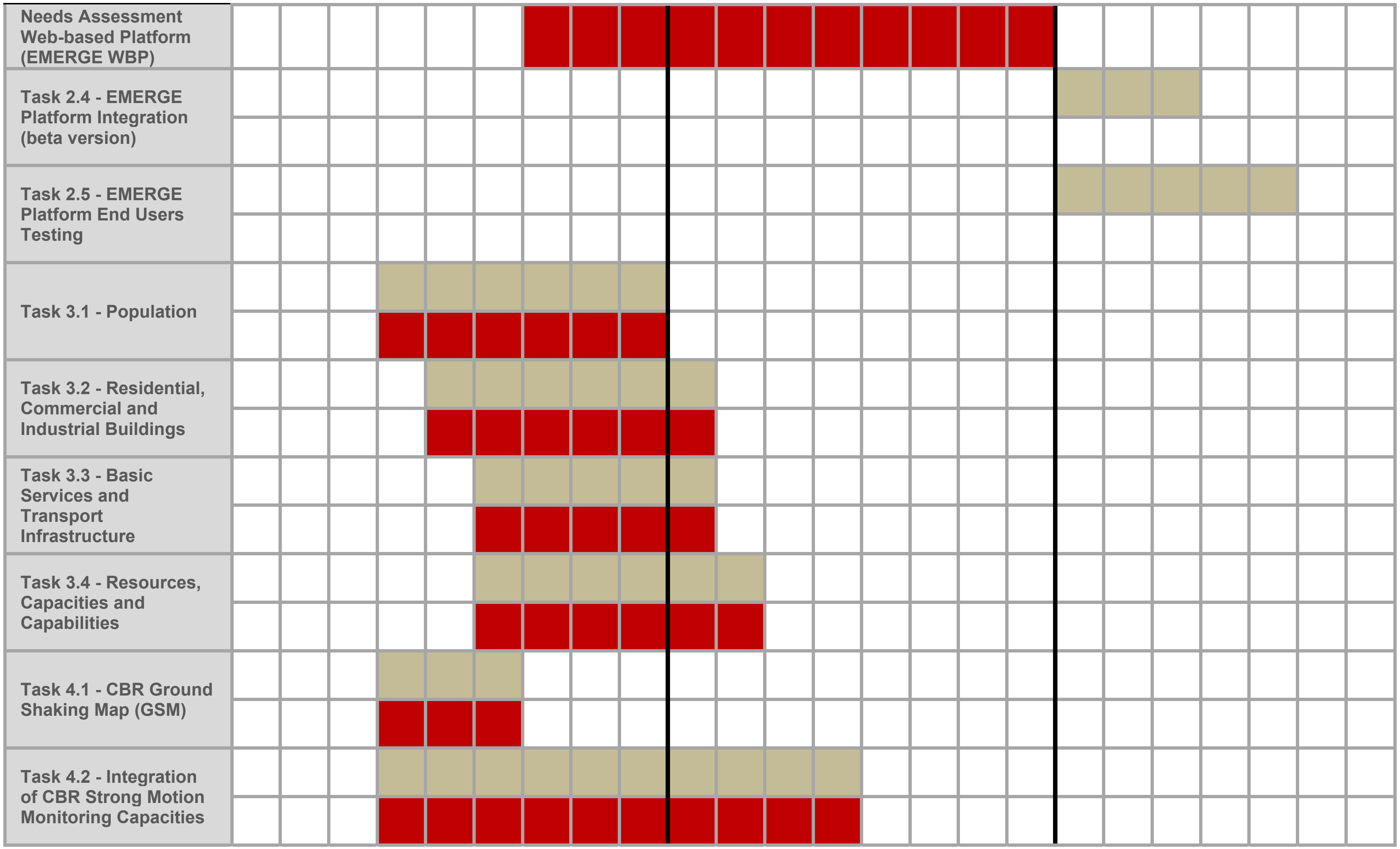
All approved deliverables classified as *public* are accessible and can be downloaded via the UCPKN project webpage at the following link: https://civil-protection-knowledge-network.europa.eu/projects/emerge#inpage-section-outputs-results

Timetable

Timetable (projects up to 2 years)

Fill in the planned implementation in beige and the deviations in red. Repeat lines/columns as necessary.

ACTIVITY									OCT-2025			MONTHS					JUNE-2026							
	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12	M 13	M 14	M 15	M 16	M 17	M 18	M 19	M 20	M 21	M 22	M 23	M 24
Task 1.1 - Overall project management																								
Task 1.2 - Communication strategy																								
Task 1.3 - Quality assurance (QA) and Quality control (QC)																								
Task 1.4 - Intellectual Property Rights (IPR) management and data privacy																								
Task 2.1 - Best EU and CBR Practices for Multi Risk Assessment and Needs Planning																								
Task 2.2 - Implementation of Need Assessment for early crisis/emergency management																								
Task 2.3 - Development of Rapid																								


Needs Assessment Web-based Platform (EMERGE WBP)
Task 2.4 - EMERGE Platform Integration (beta version)
Task 2.5 - EMERGE Platform End Users Testing
Task 3.1 - Population
Task 3.2 - Residential, Commercial and Industrial Buildings
Task 3.3 - Basic Services and Transport Infrastructure
Task 3.4 - Resources, Capacities and Capabilities
Task 4.1 - CBR Ground Shaking Map (GSM)
Task 4.2 - Integration of CBR Strong Motion Monitoring Capacities

Task 4.3 - CBR Ground Shaking Module																								
Task 5.1 - Dissemination, Exploitation, and Sustainability																								
Task 5.2 - Training and workshops																								
Task 5.3 - Open access journal publications and conferences																								

Delays

If there are delays, identify them, explain the reasons why and how you plan to manage those delays (catch-up with / avoid further delays, impact on timetable, etc.).

Overall, project implementation is progressing according to plan. All deliverables due within the reporting period, except the present D1.5 Second Project Progress Report, have been submitted and approved, and all milestones due within the reporting period have been achieved.

A minor schedule adjustment has been introduced for D2.4 EMERGE WBP Beta Version, for which the due date has been shifted from 31 July 2026 to 31 August 2026. The adjustment is justified by the need to ensure additional technical alignment, integration of WP3 and WP4 outputs, and sufficient internal testing before delivery of the beta version.

This delay is limited in scope and does not affect the overall project timetable or the achievement of project objectives. The Coordinator and the responsible partners are managing the adjustment through regular technical coordination and follow-up meetings to ensure timely completion of the beta version and smooth continuation of the subsequent testing, training and dissemination activities.

No other delays affecting the project implementation are reported for the current period.

3. BUDGET IMPLEMENTATION

Budget implementation — Use of resources
Provide information on whether the budget consumption is in line with the advancement of the activities. Identify and justify any divergences.
Budget implementation is consistent with the advancement of project activities during the reporting period. The main resources were used for personnel effort related to project coordination, data collection and harmonisation, exposure and vulnerability assessment, evaluation of civil protection resources and capacities, development and verification of the near-real-time ShakeMap module, WBP development, dissemination and reporting activities. No significant divergences from the planned budget are reported at this stage. During the reporting period, one partner (AUTH) requested a limited internal reallocation of approximately EUR 4,500 from the budget category Other Costs to Personnel Costs, due to additional personnel effort required for the implementation of project activities. The Coordinator reviewed the request in relation to the Grant Agreement and confirmed that such a transfer can be accepted under Article 5.5 – Budget flexibility, which allows transfers between budget categories without a formal amendment, provided that they do not imply any substantial or important change to the Description of the Action in Annex 1. The Grant Agreement also confirms that budget flexibility is allowed and that no flexibility cap applies. The requested reallocation is limited in scope, remains within the existing approved budget structure, and does not affect the planned implementation of the action. The additional personnel costs must be directly linked to the EMERGE project activities, justified by the extra work performed, and supported by the required records and documentation for reporting and possible audit purposes. The concerned partner has also been reminded to ensure compliance with the general eligibility rules under Article 6.1 and the specific eligibility rules for personnel costs under Article 6.2 of the Grant Agreement. The minor schedule adjustment related to D2.4 EMERGE WBP Beta Version is being managed within the existing work plan and budget structure. No budget amendment is required for the current reporting period. At this stage, no major budgetary deviations have been identified by the Coordinator based on the information available. The Coordinator will continue to monitor budget implementation at consortium level and will remind all beneficiaries that they remain responsible for ensuring the eligibility, justification and proper documentation of their declared costs in accordance with the Grant Agreement. Detailed financial reporting will be provided by each beneficiary in the periodic/final report, as required.

ANNEXES

LIST OF ANNEXES

Annex A – 2nd Coordination Meeting Status Report (Thessaloniki, Greece), 5 February 2026

Annex B – Article in PORTA3, 13 May 2026

Annex C – 4th International Conference on Resilience, Multi-Risk Assessment and Monitoring, Florence, Italy; 16-19 June 2026, (Accepted paper)

Annex D – 18th European Conference on Earthquake Engineering, Berlin, Germany, 14-18 September 2026, (Submitted Papers)

Annex E – 7th World Landslide Forum, Faridabad, India, 23-27 November 2026, (Submitted Abstract)

HISTORY OF CHANGES		
VERSION	PUBLICATION DATE	CHANGE
1.0	23.02.2021	Initial version (new MFF).

Annex A

2nd Coordination Meeting Status Report

(Thessaloniki, Greece)

5 February 2026

Rapid Multi-Risk Needs Evaluation and Planning Platform

101193586 - EMERGE - UCPM-2024-KAPP-PV

Project Management
2nd Coordination Meeting

Work package:	01
Milestone:	MS2
Lead Beneficiary:	IZIIS
Coordinator:	IZIIS
Contributing Beneficiaries:	IZIIS, UPT, AUTH, EUCENTRE, IUSS, NOA, CMC, PRD, AKMC, PPI, INFRATECH
Dissemination Level:	Consortium
Version:	01
Due Date:	February 28, 2026
Submission Date:	February 10, 2026

Rapid Multi-Risk Needs Evaluation and Planning Platform

101193586 - EMERGE - UCPM-2024-KAPP-PV

Project Management

2nd Coordination Meeting

WP-01 | MS2

February 10, 2026

Executive summary

The EMERGE 2nd Coordination Meeting (MS2) was held in Thessaloniki at AUTH (KEDEA) with 36 participants. In line with the Grant Agreement objective, the consortium reviewed the financial and administrative status and discussed implementation issues affecting successful delivery. The meeting confirmed overall mid-term progress and highlighted key priorities for the next period: ensuring stronger partner proactivity, strengthening engagement of national civil protection authorities, and resolving cross-cutting constraints related to sensitive data access/sharing/handling. Technical updates across WP1–WP5 confirmed steady advancement of the EMERGE web-based platform, exposure and vulnerability layers, and near-real-time shaking products, while identifying urgent items requiring consortium follow-up (e.g., fragility model gaps and boundary inconsistencies). The meeting concluded with agreed next steps toward integration, end-user readiness, and planned dissemination/training activities.

Date & venue: 05 February 2026, KEDEA (AUTH), Thessaloniki (hybrid).

MS2 objective: Presentation of the financial and administrative status of the project and discussion of potential issues affecting successful project implementation.

Meeting Chair: *Dr. Evi Riga*

AGENDA-BASED MEETING STATUS REPORT AND SUMMARY

Welcome & Opening Remarks

Speakers: *D. Pitilakis (AUTH), R. Salic Makreska (IZIIS)*

Participants were welcomed and the MS2 purpose and flow were confirmed. The Coordinator emphasized early identification of implementation risks, with particular attention to engagement of national civil protection authorities (NCPAs) and to sensitive-data constraints.

Part 1. General overview and status of project activities

Administrative & Financial Aspects

Speaker: *R. Salic Makreska (IZIIS)*

EMERGE aims to deliver a rapid multi-risk assessment and needs planning web platform supporting disaster response. The overall budget and co-funding structure were presented (EU contribution and institutional contribution). The mid-term status overview covered deliverables and milestones.

Key administrative challenges and risks highlighted:

- Need for stronger proactivity by some WP/Task/Deliverable leads to avoid slippage.
- Stronger engagement of NCPAs to ensure the platform meets operational needs.
- Sensitive data as a cross-cutting constraint affecting access, sharing and handling.

Financial reminders included maintaining signed timesheets throughout the project and retaining documentation proving institutional contribution. It was reiterated that the remaining payment is released after completion and approval of the final report (post-project evaluation period).

Group photo & Lunch

Informal partner networking and bilateral coordination discussions.

Part 2. Work Packages & Technical Implementation

WP1 – Project Management

Speaker: *R. Salic Makreska (IZIIS)*

WP1 presented the project management framework: governance structure (Project Management Board, Coordinator, WP Leads/Task Leads), and quality assurance arrangements (Internal Review Panel and Quality Procedures Manual). The presentation emphasized disciplined internal communication, timely partner inputs, and consistent implementation of procedures—especially regarding sensitive-data handling and documentation.

WP2 – Comprehensive Multi Risk Assessment Platform for Needs Prioritization and Planning

Speaker: *B. Borzi (EUCENTRE)*

WP2 presented progress on the EMERGE Web-Based Platform (WBP) as an intuitive, modular and expandable online tool supporting early response through near-real-time seismic and landslide risk evaluation and needs planning.

Key enhancements compared to CRISIS:

- Exposure upgrade: addition of population and residential, commercial and industrial buildings (beyond schools, hospitals and bridges).
- Hazard upgrade: integration of near-real-time ShakeMaps produced in WP4.
- Updated vulnerability models aligned with the expanded exposure.
- Support to rapid response within 72 hours (building on CRISIS routing logic).

WP2 highlighted three open and urgent issues requiring consortium action:

1) Fragility models for structural typologies beyond RC frame and masonry (e.g., RC shear-wall, steel, wood, precast).
2) Inconsistency in the area of interest due to discrepancies in Albania boundaries between CRISIS and EMERGE layers.
3) Need for a code/tool to compute a near-real-time landslide scenario to be included in the platform.

The landslide topic was framed as a defined development need (near-real-time scenario tooling) rather than a finalized module.

WP3 – CBR Exposure, Resources and Capacity Portfolio

Speaker: *C. Amendola (AUTH)*

WP3 presented objectives and progress on: population distribution and socio-economic vulnerability, exposure models for buildings/basic services/bridges, vulnerability assessment and prioritization, and evaluation of NCPA resources/capacities/capabilities.

Social Vulnerability (SoVI): implemented at municipality level for Albania, Greece and North Macedonia using seven thematic groups (population, education, economy, health, infrastructure, habitat, governance/institutional capacity). Two weighting scenarios were applied to address data heterogeneity. Health was highlighted as the most critical and uniformly high-vulnerability dimension across the CBR.

Exposure portfolios were presented for residential/commercial/industrial buildings and for schools, healthcare facilities and bridges. Resources/capacities data collection progress and challenges were discussed, including variable response rates from municipalities.

WP4 – CBR Ground Shaking Map

Speaker: *I. Gjorgjiev (IZIIS)*

WP4 presented progress toward a Near Real-Time ground shaking module, including evaluation of strong-motion capacities, integration of networks with ORFEUS–EIDA, and generation of ShakeMaps for use in WP2 needs assessment. SeisComP was presented as the backbone for real-time processing, with ShakeMap-based methodology for near-real-time shaking/intensity mapping.

An end-to-end workflow was presented: event detection and processing at IZIIS → ShakeMap generation → outputs (GeoJSON) exposed via REST API → ingestion by WP2 platform.

WP5 – Dissemination

Speakers: *M. Baballëku (UPT)*

WP5 reviewed dissemination, communication and exploitation activities, deliverables and timeline. The strategy emphasizes visibility of EU support, stakeholder engagement, synergies with other UCPM projects, and promotion of adoption of the WBP. Monitoring indicators (newsletters, UCPKN visits, social media engagement, stakeholder events, downloads, mentions/citations) were presented for mid-term tracking. Planned scientific dissemination through conferences and papers was reviewed.

Next Steps & Final Comments

Speaker: *R. Salic Makreska (IZIIS)*

The Coordinator summarized priorities: improve proactivity of some WP/Task/DL leads; strengthen NCPA engagement and resolve sensitive-data constraints; advance planned visibility and scientific dissemination; and prepare the training workshop in Bitola (September 2026) to present the beta platform and collect stakeholder feedback.

Consolidated action points

Action	Responsible partner(s)	Due / timeframe	Status
Sensitive data handling / governance	IZIIS (Coordinator/WP1) + NCPAs (AL/GR/MK) + EUCENTRE (WP2) + AUTH (WP3)	Next coordination checkpoint (≈4–6 weeks)	Open
WP2 fragility gap solution (non-RC-frame / non-masonry typologies)	EUCENTRE (WP2) + AUTH (WP3) + IZIIS (support as needed)	Before next platform integration sprint	Open
Albania boundary inconsistency (CRISIS vs EMERGE AOI)	EUCENTRE (WP2) + UPT (Albania partner)	Before next platform data freeze / integration sprint	Open
Near-real-time landslide scenario tooling in WBP	EUCENTRE (WP2) + IZIIS (WP4) + AUTH (WP3) + relevant NCPAs (requirements)	Before end-to-end beta testing	Open
WP4 → WP2 integration finalization (ShakeMap products, format, metadata, QC)	IZIIS (WP4) + EUCENTRE (WP2)	Before end-to-end workflow testing	Ongoing
Resources/capacities database completion and harmonization	AUTH (WP3) + NCPAs/municipal focal points (AL/GR/MK)	Continuous; next update within 1–2 months	Ongoing
Dissemination/training alignment (incl. Bitola beta workshop)	UPT (WP5) + IZIIS (Coordinator) + all partners	Before workshop planning finalization	Ongoing

Annex 1: Meeting Agenda

Agenda

2nd Coordination Meeting

101193586 — EMERGE — UCPM-2024-KAPP

Date: Thursday, February 05, 2026

Venue: Aristotle University Research Dissemination Center (KEDEA)
https://maps.app.goo.gl/YLe269oHCNbM6mnc8

Virtual Meeting Link (alternatively):
https://authgr.zoom.us/j/98084430018?pwd=SkEZ0pHiGuz2JZDqf9MVeVciPOcHBV.1

12:00 – 12:10 **Welcome & Opening Remarks**

Dimitris Pitilakis (AUTH)

Radmila Salic Makreska (IZIIS)

Part 1. General overview and the status of the project activities

12:10 – 12:25 **Administrative & Financial Aspects**
Radmila Salic Makreska (IZIIS)

Introduction
Objectives of the Second Coordination Meeting
Project status and timeline
Administrative challenges and potential risks
Reporting and communication with PO
Discussion

12:25 – 13:25 **Group photo & Lunch**

Part 2. Work Packages & Technical Implementation

13:30 – 13:50 **WP-1: Project Management**
Radmila Salic Makreska (IZIIS)

13:50 – 14:10 **WP-2: Comprehensive Multi Risk Assessment Platform for Needs Prioritization and Planning**
Barbara Borzi (EUCENTRE)

14:10 – 14:30 **WP-3: CBR Exposure, Resources and Capacity Portfolio**
Chiara Amendola (AUTH)

14:30 – 14:50 **WP-4: CBR Ground Shaking Map**

	Igor Gjorgjiev (IZIIS)	
14:50 – 16:10	**WP-5: Dissemination** *Markel Baballëku (UPT)*	
		WP objectives, deliverables & timelines Current activities Challenges and potential risks Discussion
16:10 – 16:20	**Next Steps and Final Comments** *Radmila Salic Makreska (IZIIS)*	
		Key tasks and deadlines for the next months Open discussion and final comments
16:20 – 16:30	**Coffee Break**	
16:30 – 17:30	**AUTH Lab visit**	
20:00 – 22:00	**Common Dinner**	

Annex 2: Attendance List

WP-01 | MS2 101193586-EMERGE-UCPM-2024-KAPP-PV

Emerge

Funded by European Union Humanitarian Aid

2nd Coordination Meeting

101193586 — EMERGE — UCPM-2024-KAPP

Date: Thursday, February 05, 2026

Venue: AUTH, Thessaloniki, Greece

List of participants

No.	Name	Title	Institution	Attendance	Signature
1	Fatjona Xhaferi	Mrs.	AKMC	On-site	
2	Kleant Sulce	Mr.	AKMC	On-site	
3	Dimitris Pitilakis	Prof.	AUTH	On-site	
4	Evi Riga	Dr.	AUTH	On-site	
5	Chiara Amendola	Dr.	AUTH	On-site	
6	Sara Baruti	Mrs.	CMC	On-site	
7	Merhije Rustemi	Mrs.	CMC	On-site	
8	Stevko Stefanoski	Dr.	CMC	**virtual**	
9	Barbara Borzi	Dr.	EUCENTRE	On-site	
10	Davide Quaroni	Mr.	EUCENTRE	On-site	
11	Antonella Di Meo	Mrs.	EUCENTRE	**virtual**	

WP-01 | MS2 101193586-EMERGE-UCPM-2024-KAPP-PV

Emerge

Funded by European Union Humanitarian Aid

No.	Name	Title	Institution	Attendance	Signature
12	Francesca Bozzoni	Mrs.	EUCENTRE	**virtual**	
13	Rezeart Zgjanjolli	Mr.	INFRATECH	On-site	
14	~~Ina Daiu~~ Juliana Gjoka	Mrs.	INFRATECH	On-site	
15	Ricardo Monteiro	Prof. Dr.	IUSS	On-site	
16	Gianrocco Mucedero	Dr.	IUSS	On-site	
17	Mattia Calò	Dr.	IUSS	On-site	
18	Radmila Salic Makreska	Prof. Dr.	IZIIS	On-site	
19	Igor Gjorgjiev	Prof. Dr.	IZIIS	On-site	
20	Julijana Bojadjieva	Prof. Dr.	IZIIS	On-site	
21	Roberta Apostolska	Prof. Dr.	IZIIS	On-site	
22	Theo van Wijk	Mr.	JBI	**virtual**	
23	Jan Pol	Mr.	JBI	**virtual**	
24	Olga Ktenidou	Dr	NOA	On-site	
25	Vlatko Jovanovski	Mr.	PPI	On-site	
26	Dejan Spasevski	Mr.	PRD	On-site	
27	Aleksandar Mihov	Mr.	PRD	On-site	

WP-01 | MS2 101193586-EMERGE-UCPM-2024-KAPP-PV

Emerge share, prepare, respond

Funded by European Union Humanitarian Aid

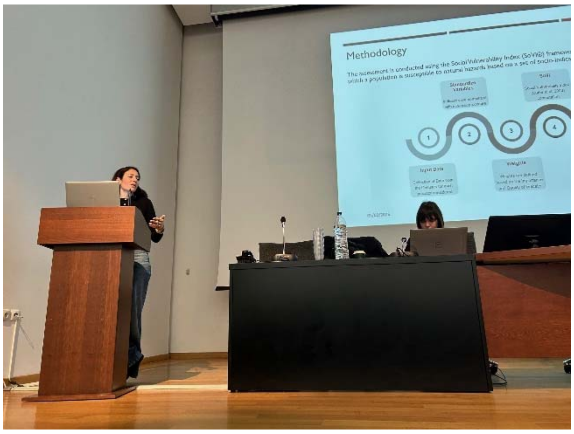
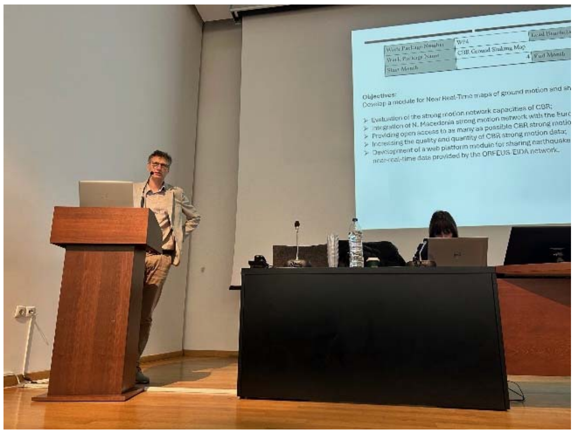
No.	Name	Title	Institution	Attendance	Signature
28	Markel Baballëku	Prof. Asoc	UPT	On-site	
29	Rikard Luka	Dr.	UPT	On-site	
30	Edmond Dushi	Prof. Asoc	UPT	On-site	
31	Genti Qirjazi	Dr.	UPT	On-site	
32	Georgia Kroupi	PhD student	AUTH	On-site	
33	Paraskevi Tsoumani	PhD student	AUTH	On-site	
34	Eleni Filoglou	PhD Student	AUTH	on-site	
35	Φίλιππος Τασιάλης	-//-	-//-	-//-	
36	Lingyue Xu	`	`	`	

Annex 3: Meeting Photos


Eflampia-Efterpl...
Antonella Di Me...


Presentation of financial and administrative status of the project and discussion about any potential issues on the successful project implementation.
MS1
WP1


2nd Coordination Meeting


Methodology


The main focus
The objectives




MTS


Annex B

Article in PORTA3

13 May 2026

Автор: Порта3 Категорија: Вести, Градежништво, Порта3 13/05/2026 0

ИЗИИС носител на проектот EMERGE: Како до побрз и попаметен одговор по земјотреси

ИЗИИС е носител и го координира меѓународниот европски проект EMERGE, кој развива современа платформа за брза проценка на потреби, подобра координација и јакнење на капацитетите за одговор на земјотреси и свлечишта.

Кога ќе се случи силен земјотрес, времето е еден од најкритичните фактори. Во првите часови по настанот, институциите мора брзо да одговорат на низа прашања: колку луѓе се погодени, каде е најголемата штета, кои објекти и услуги се загрозени, дали локалните капацитети се доволни и дали е потребна дополнителна, па и прекугранична помош. Одговорот на овие прашања не смее да зависи само од проценката „на терен“, туку и од навремени, сигурни и систематизирани податоци.

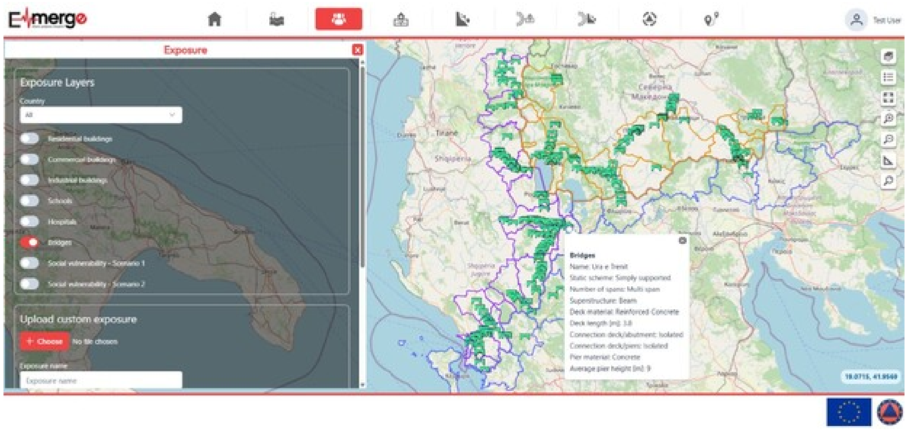
Од последните поголеми земјотреси во регионот (Албанија, 2019)

Токму во таа насока е насочен европскиот проект EMERGE со целосен назив Rapid Multi-Risk Needs Evaluation and Planning Platform, чиј координатор е Институтот за земјотресно инженерство и инженерска сеизмологија (ИЗИИС) при Универзитетот „Св. Кирил и Методиј“ во Скопје. Проектот е финансиран од Европската Унија преку Union Civil Protection Mechanism (UCPM), во рамки на повикот UCPM-2024-KAPP, а се реализира во периодот од 1 февруари 2025 до 31 јануари 2027 година.

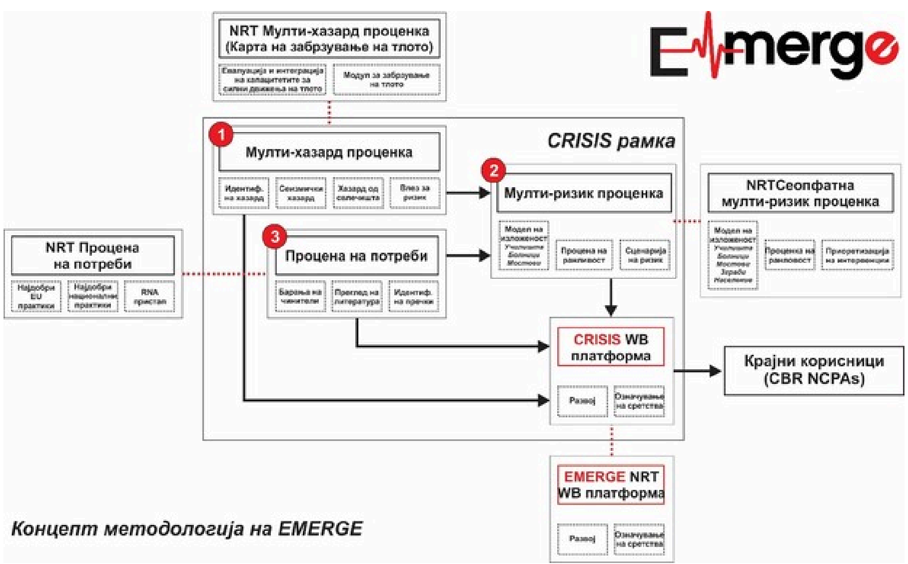
Проектот EMERGE има јасна и практична цел: да развие отворена, модуларна веб-платформа која ќе овозможи брза мултиризик проценка и планирање на потребите во раната фаза по катастрофа, особено по земјотреси и земјотресно-предизвикани свлечишта. Фокусот е ставен на пилот-регионот, прекуграничниот регион меѓу Северна Македонија, Албанија и Грција, простор што историски е изложен на силни сеизмички влијанија, а воедно бара и високо ниво на координација меѓу соседните држави. Во проектот се работи токму на тоа: науката, податоците, институциите и оперативните служби да се поврзат во една функционална целина што ќе помогне во побрзо и поефикасно донесување одлуки.

Она што го прави овој проект особено вреден е што тој не останува само во рамките на научна анализа или теоретско моделирање. Напротив, проектот е замислен како алатка што треба директно да им помогне на институциите надлежни за координација и заштита и спасување. Наместо да се застане само на прашањето, односно на одговорот „каква е опасноста“, EMERGE оди чекор понатаму и дава одговор на прашањата: што значи таа опасност во реалноста, колкави може да бидат последиците, кои потреби ќе се појават веднаш по настанот и дали постојните ресурси и капацитети се доволни за да се одговори навремено.

Во суштина, платформата треба да ја поврзе логиката опасност → штети → потреби → ресурси. Тоа значи дека земјотресот не се разгледува само како природна појава, туку како настан што може да предизвика жртви и повредени, оштетувања на објекти, прекин на витални услуги, проблеми со пристапност, дополнителен притисок врз болничките капацитети, потреба од привремено сместување и итни интервенции. Потоа, овие проценети последици се споредуваат со расположливите човечки, технички и институционални капацитети, за да се утврди каде постојат празнини и каде евентуално е потребна помош од соседните земји.



Проектот се надоврзува на претходниот европски проект CRISIS, исто така предводен од ИЗИИС, но значително истиот го надградува. Додека CRISIS воспостави основа за прекугранична проценка на сеизмички ризик кај одредени категории на инфраструктура, EMERGE ја проширува оваа рамка кон пооперативен и покомплетен систем. Новиот пристап опфаќа не само училишта, болници и мостови, туку и станбени, комерцијални и индустриски објекти, како и население од социоекономска ранливост. Дополнително, се воспоставува и база на податоци за ресурси, капацитети и способности на институциите за цивилна заштита, што ја прави проценката многу поблиску до реалните потреби на терен.

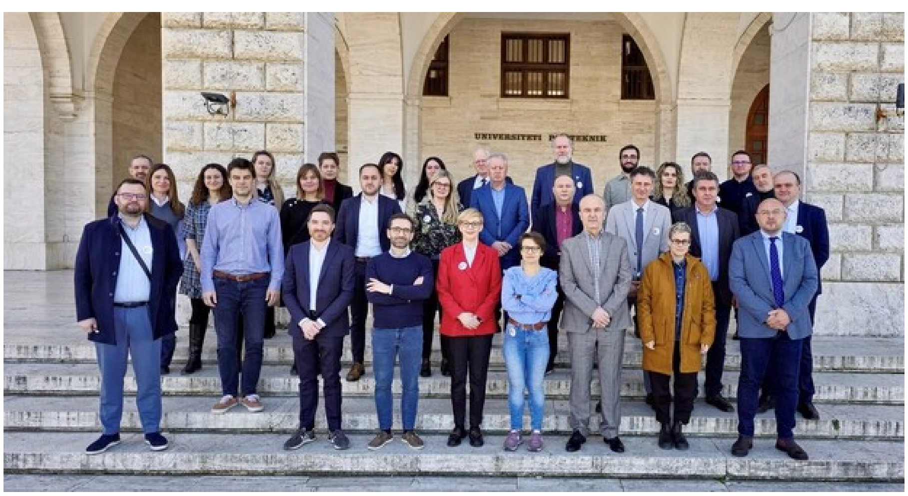


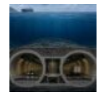
Концепт методологија на EMERGE

Особено е важно што во EMERGE силно се препознава македонскиот придонес, не само формално, туку и суштински. ИЗИИС е координатор на проектот и има централна улога во неговото концептуално обликување, методолошкиот развој, координацијата на партнерите и поврзувањето на научните резултати со потребите на крајните корисници. Покрај ИЗИИС, од Република Македонија во проектот активно учествуваат и Дирекцијата за заштита и спасување (ДЗС) и Центарот за управување со кризи (ЦУК), што му дава на проектот силна национална и институционална подлога. Ова е особено значајно затоа што покажува како научноистражувачка установа и национални институции можат заеднички да работат на решенија што имаат директна примена во управувањето со ризици и кризни состојби.

Покрај партнерите од Македонија, конзорциумот вклучува и реномирани институции од повеќе европски земји. Во проектот учествуваат: EUCENTRE – European Centre for Training and Research in Earthquake Engineering, Италија; AUTH – Aristotle University of Thessaloniki, Грција; UPT-FCE – Polytechnic University of Tirana, Faculty of Civil Engineering, Албанија; IUSS – University School for Advanced Studies Pavia, Италија; NOA – National Observatory of Athens, Грција; AKMC – National Civil Protection Agency of Albania, Албанија; PPI – Prepared International, Германија; JBI – Janson Bridging International BV, Холандија; и INFRATECH, Албанија. Ваквата структура на партнерството покажува дека EMERGE има силна научна, институционална и практична основа, а воедно и јасна европска димензија.

Посебна вредност на проектот е и јакнењето на капацитетите. EMERGE не се сведува само на изработка на платформа, туку претставува и процес на учење, координација и институционално поврзување. Преку работилници, технички состаноци, размена на искуства и заеднички активности, партнерите работат на развој на заеднички пристапи и подобра интероперабилност. Тоа е особено важно во прекуграничен контекст, каде што различните системи, бази на податоци и административни практики често претставуваат пречка за брза и усогласена реакција. EMERGE придонесува токму тука, во создавање заедничка основа за разбирање, комуникација и делување.



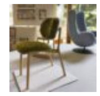

Африка и Европа размислуваат за изградба на подводни тунели вредни милијарди евра


Изборно и Свечено собрание на ДГКМ по повод Златниот јубилеј

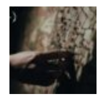

Половните електрични автомобили стануваат се почест избор на купувачите во Европа


Денес во Битола граѓански форум за уредување на плоштадот „Гоце Делчев“


Распишан е регионален студентски конкурс „Екотон 26“ со награден фонд од 30.000 евра


На Факултетот за дизајн и технологии на мебел и ентериер во Скопје годишна изложба на студентите


Предупредување, децата ќе престанат да размислуваат под влијание на ВИ – ќе веруваат дека 2×2=5


Премиера во Шангај на филмот „Руини“ на Елена Чемерска за реставрацијата на Споменикот на слободата во Кочани


Изложба „Меѓу нас“ – визуелна приказна за емпатија, надеж и колективна грижа

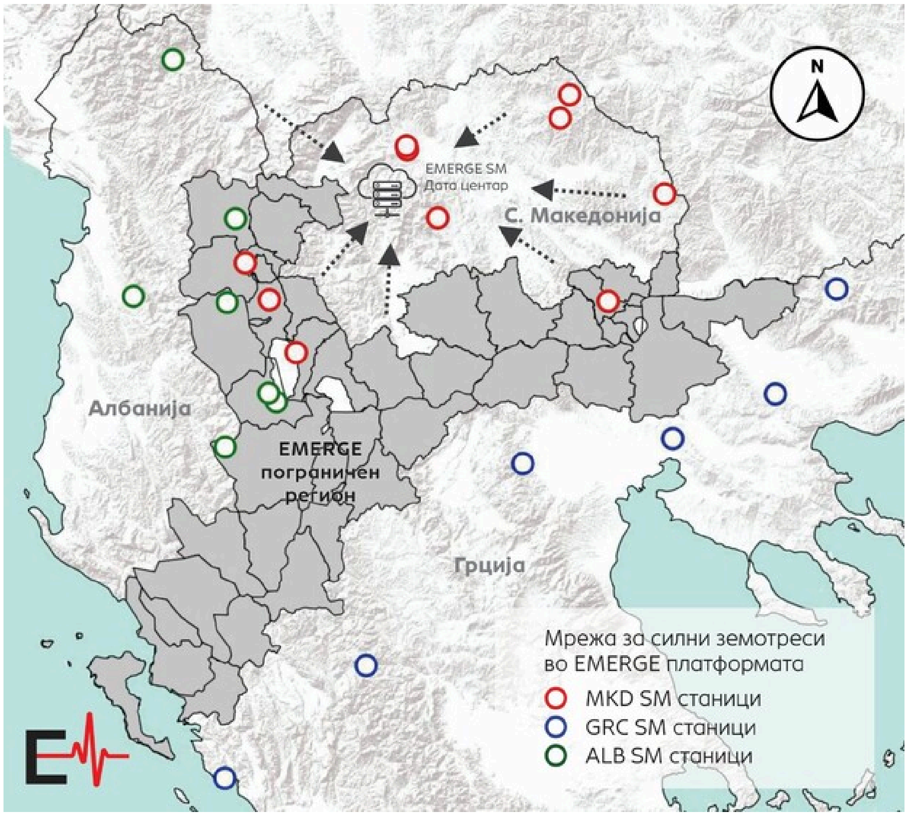
КОРИСНИ ЛИНКОВИ

- Светски саеми за градежништво
- Светски саеми за мебел
- Светски саеми за хортикултура

Прва работилница во Тирана, Албанија (7.3.2025)

Втора работилница во Солун, Грција (5.2.2026)

Во тој контекст, многу значаен е и сегментот поврзан со мрежите за силни земјотреси и размената на податоци во речиси реално време. Проектот вклучува активности за подобра интеграција на регионалните капацитети и нивно поврзување со ORFEUS-EIDA, европската инфраструктура за сеизмолошки податоци. Ова не е само технички чекор, туку суштинска придобивка за целиот регион: подобри и побрзи податоци за движењето на тлото, значат подобра проценка на последиците, а тоа директно влијае врз квалитетот и брзината на одговорот. За Република Македонија, ова претставува и значајно меѓународно позиционирање на националните капацитети во поширок европски контекст.



Проектот EMERGE истовремено покажува и нешто многу важно: подготвеноста не почнува по катастрофата, туку пред неа. Затоа проектот има и силна превентивна и планерска димензија. Освен за брза реакција по земјотресен настан, платформата ќе може да се користи и за подготвителни сценарија, вежби, симулации и подобро планирање на мерките за намалување на ризикот. На тој начин, EMERGE не е само алатка за кризни состојби, туку и инструмент за долгорочно унапредување на отпорноста на регионот.

За читателите на ПОРТА 3, ова е важна порака, современото справување со катастрофи веќе не се базира само на искуство и добра волја, туку сè повеќе на паметно користење на податоци, научни модели, дигитални алатки и прекугранична соработка. Во една таква слика, лидерската улога на ИЗИИС во проект како EMERGE има особено значење. Таа покажува дека македонското знаење, експертиза и институционално искуство не се само дел од регионалните процеси, туку и нивен двигател.

Проектот EMERGE всушност е пример како една научна идеја може да прерасне во практично решение со директна општествена вредност. Со поврзување на истражувањето, технологијата и институциите, проектот придонесува за побрз, поусогласен и поинформиран одговор во моменти кога тоа е најпотребно. А тоа е вредност што ја надминува рамката на еден проект и станува инвестиција во безбедноста, подготвеноста и отпорноста на целиот регион.

Автор: проф. д-р Радмила ШАЛИЌ-МАКРЕСКА, координатор на EMERGE-проектот

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Претходно:
Денес во Комората презентација на Алуконигштал Schüco: „Одржливост кај старите и новите градби, со новата генерација системи за обвивка на зградата“

Следно:
Стан во Рим кој ги истакнува трагите од претходниот живот

СЛИЧНИ СТАТИИ

IEA: Судирот на Блискиот исток ги менува приоритетите при изборот на енергетски проекти и партнери

08/06/2026

IEA: Судирот на Блискиот исток ги менува приоритетите при изборот на енергетски проекти и партнери

08/06/2026

Избрана е најубавата плажа во Европа за 2026 година

08/06/2026

ИСПРАТИ КОМЕНТАР

Име

Зачувај го моето име, е-маил и веб страна во овој пребарувач за следниот пат кога ќе коментирам.

Испрати коментар

ПОРТА 3

- За Нас
- Импресум
- Претплата
- Маркетинг
- Контакт
- Архива
- Упатство за дописници
- КЛУБ НА ПРИЈАТЕЛИ

КАТЕГОРИИ

- Насловна
- Вести
- Градежништво
- Архитектура Ентериери
- Урбанизам Сообраќај
- Екологија Енергетска Ефикасност
- Хортикултура
- Арт и дизајн
- Став
- Фото/Видео Репортажа

КОРИСНИ ЛИНКОВИ

- Светски саеми за градежништво
- Светски саеми за мебел
- Светски саеми за хортикултура

Annex C

4th International Conference on Resilience, Multi-Risk Assessment and Monitoring, Florence, Italy

16-19 June 2026

(Accepted paper)

Rapid Multi-Risk Needs Evaluation as a Basis for Cross-Border Emergency Planning

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[5] University School for Advanced Studies Pavia, Italy (IUSS)
[6] National Observatory of Athens, Greece (NOA)
[7] Crisis Management Centre, Government of Republic of N. Macedonia (CMC)
[8] Protection and Rescue Directorate, Government of Republic of N. Macedonia (PRD)
[9] Nacional Civil Protection Agency of Albania (AKMC)
[10] Prepared International, Samerberg, Germany (PPI)
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[12] Infratech sh.p.k. Tirana, Albania (INFRATECH)

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RADMILA SALIC MAKRESKA

Abstract. EMERGE, the Rapid Multi-Risk Needs Evaluation and Planning Platform, upgrades the CRISIS Web-Based Platform into a system for rapid multi-risk assessment and needs planning supporting early crisis response in the cross-border region of North Macedonia, Greece and Albania. The platform focuses on earthquakes and earthquake-triggered landslides and combines scenario-based analysis with near real-time impact assessment. Compared with CRISIS, EMERGE expands the exposure model from schools, hospitals and bridges to include residential, commercial and industrial buildings, as well as population, and introduces a Rapid Needs Assessment methodology tailored to cross-border emergency management. The workflow includes pre-event preparation of harmonised hazard, exposure and vulnerability layers, and post-event use of near real-time shaking information to estimate impacts and translate them into urgent needs. These are compared with available resources and capacities to identify response gaps and possible cross-border assistance requirements within the first 72 hours after an event. Overall, EMERGE aims to strengthen cross-border disaster management through faster, coordinated and evidence-based response planning.

Keywords: Earthquake, Landslide, Multi-risk, Needs assessment, Disaster management

1 Introduction, Geographic Focus and European Added Value

Europe has faced numerous damaging natural hazards, with major disasters often exceeding the response capacity of a single country and therefore requiring cross-border approaches [1]. In the wider Balkan region, earthquakes and related hazards, notably landslides, remain among the most significant threats, as shown by recent events in Albania (2019) and Croatia (2020). Common risk drivers, such as unplanned urbanization, poor land management and weak regulatory enforcement, further increase potential impacts.

Against this backdrop, the EMERGE project [2] aims to support rapid multi-risk assessment and needs planning for early crisis response through near real-time seismic and landslide risk evaluation [3]. Building on the CRISIS platform [4,5], EMERGE extends the previous scenario-based approach towards a workflow that also supports near real-time post-event impact estimation and rapid needs planning.

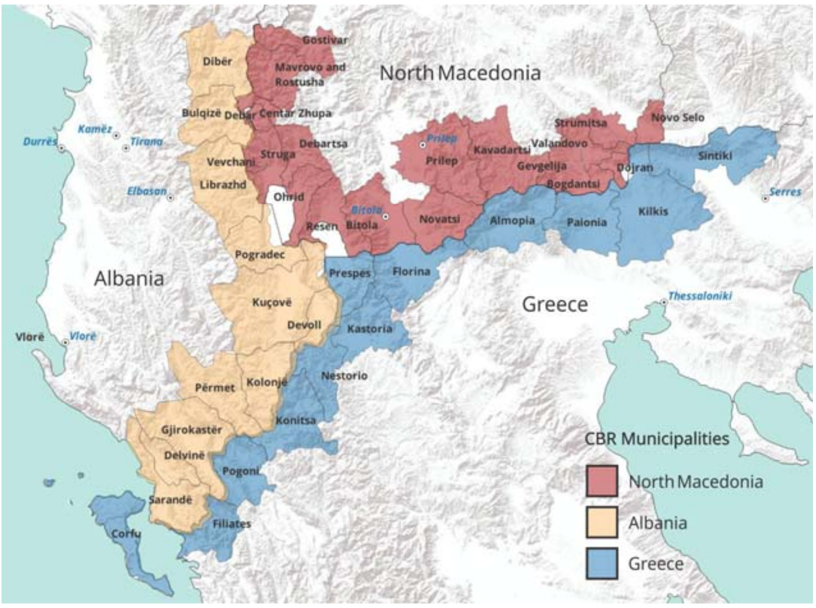

Fig. 1. EMERGE pilot region: N. Macedonia-Albania-Greece cross-border region

The pilot region covers the cross-border area of North Macedonia, Albania and Greece (Fig. 1), including 18 municipalities in North Macedonia, 17 districts in Albania and 14 municipalities in Greece. The region is exposed to strong earthquakes generated by active cross-border seismic sources [6,7] and is also susceptible to landslides triggered by seismic shaking [8,9].

EMERGE brings European added value through its cross-border scope, active involvement of civil protection authorities, and integration of strong-motion stations into the European Integrated Data Archive (EIDA) network, strengthening near real-time seismic data sharing in South-eastern Europe. The project contributes to the EU's disaster resilience goals [10] and supports improved use of disaster risk information for preparedness and response [11].

2 Conceptual Framework for Multi-Risk Needs Assessment

The EMERGE conceptual framework (Fig. 2) supports near real-time situational awareness and rapid prioritisation of response actions in the cross-border region. Building on the CRISIS platform, EMERGE extends the approach into a comprehensive tool for rapid multi-risk assessment and needs planning by linking hazard, exposure, expected impacts and available response capacities within a unified web-based environment. The objective is to provide timely information on immediate needs, available resources and coping capacity, supporting evidence-based early crisis management and prioritisation.

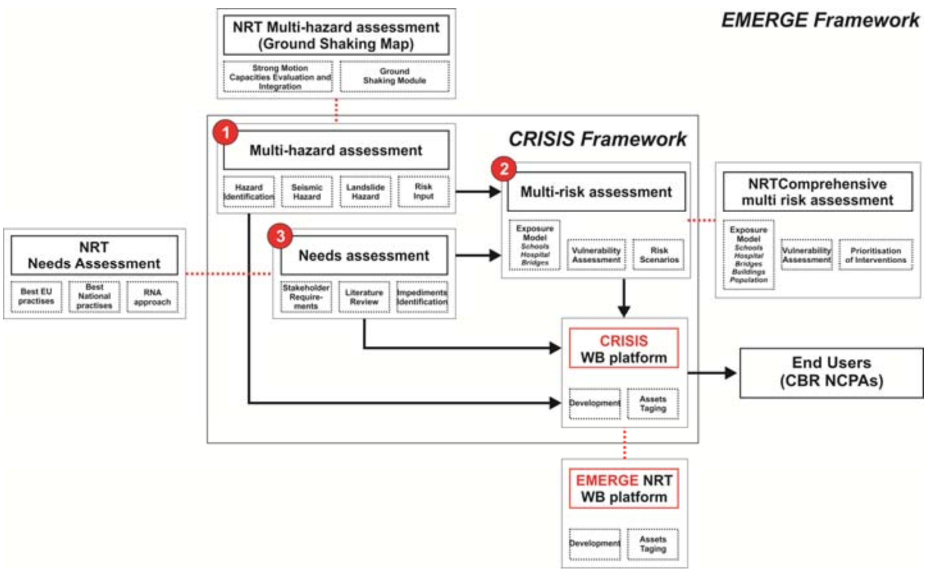

Fig. 2. EMERGE conceptual framework (source: Salic et al., 2025 [3])

2.1 Core modules and information flow

EMERGE integrates three interlinked modules (Fig. 2): (1) multi-hazard assessment, focusing on earthquakes and earthquake-induced landslides; (2) multi-risk assessment, combining hazard, exposure and vulnerability to estimate impacts; and (3) needs assessment, translating impact estimates into priority needs for crisis management and cross-border coordination. The modules are linked through a single workflow in which hazard information feeds impact estimation, and impact estimation feeds operational needs assessment.

To support rapid decision-making within the first 72 hours after an event [12], the workflow is structured into pre-event and post-event components (Fig. 3). The pre-event component prepares harmonised hazard, exposure, vulnerability and capacity datasets for the cross-border region. The post-event component activates these datasets using near real-time shaking information, producing rapid estimates of damages, casualties and service disruption.

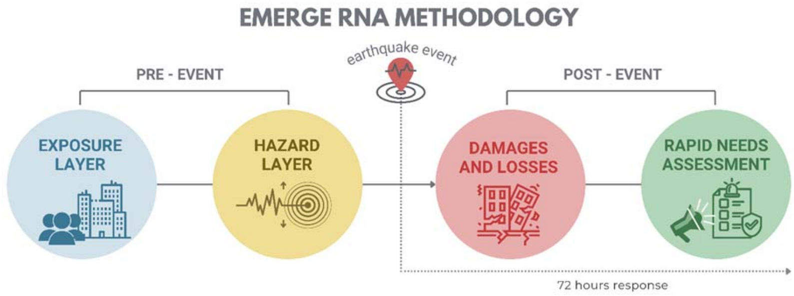

Fig. 3. Conceptual framework of the EMERGE Rapid Needs Assessment integrating hazard, exposure, impact estimation and emergency prioritization (source: EMERGE Deliverable D2.2 [12])

Within this framework, the multi-hazard module combines the harmonised earthquake and landslide hazard basis with near real-time strong-motion observations and shaking information, supported by integration of strong-motion instruments into EIDA. The resulting shaking field is propagated through the vulnerability models of exposed assets, enabling event-based impact estimation.

The multi-risk module synthesizes impacts across buildings, basic services, transport infrastructure and population. These outputs form the direct input to the Rapid Needs Assessment module, which compares estimated consequences, such as casualties, building damage, reduced hospital functionality, sheltering demand and accessibility constraints, with available resources, capacities and capabilities across the cross-border region. This enables identification of shortages in critical response functions and helps indicate where cross-border assistance may be required [13].

2.2 EMERGE enhancements beyond CRISIS

EMERGE upgrades the CRISIS approach by transforming deterministic/probabilistic hazard components into near real-time multi-hazard assessment, strengthening needs assessment into rapid post-disaster needs assessment, and expanding risk assessment beyond basic services and transport infrastructure to include population and the broader building stock. The web-based platform (Fig. 4) is designed as a directly usable tool for civil protection authorities during emergencies, following a modular architecture that supports interoperability through widely adopted GIS standards and web services and enables future extensions to additional hazards, assets and spatial coverage.

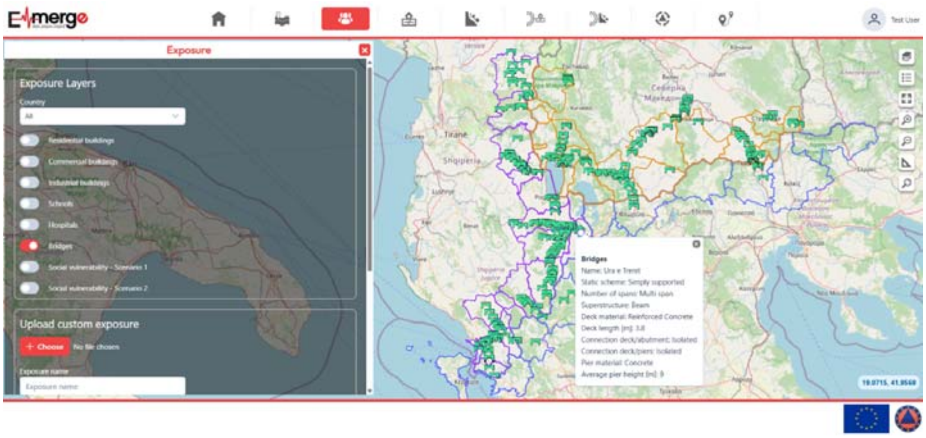

Fig. 4. Example of the EMERGE web-platform environment for layered visualisation and rapid interpretation of event-related information – in development (source: Borzi et al. 2026 [23]

3 Cross-Border Exposure and Vulnerability Portfolio

A robust multi-risk needs assessment requires a harmonised exposure and vulnerability portfolio across the cross-border region. In EMERGE, this portfolio includes: (1) socio-economic vulnerability of the population [14]; (2) exposure and structural vulnerability of the building stock [16]; (3) exposure and fragility of basic services and transport infrastructure [21]; and (4) civil protection resources, capacities and capabilities [13]. Together, these components provide the basis for moving from hazard information to impact estimation and from impact estimation to needs prioritisation within the Web-Based Platform.

3.1 Socio-Economic Vulnerability of the CBR

EMERGE establishes a harmonised Population–Socio-Economic Vulnerability Database for Albania, Greece and North Macedonia [14]. The assessment follows the Social Vulnerability Index framework [15] and aggregates 35 indicators into seven dimensions: Population, Education, Economy, Health, Infrastructure, Habitat, and Governance and Institutional Capacity. Two weighting scenarios were applied to address cross-country differences in data availability and relevance: Scenario S1 uses common indicator-importance weights with country-specific data-quality weights, while Scenario S2 applies country-specific weights for both importance and data quality. Results indicate generally higher social vulnerability levels in Albanian municipalities and greater sensitivity to weighting assumptions in North Macedonia, with the Health dimension consistently emerging as critical. These vulnerability layers are used in EMERGE not only to describe pre-existing territorial differences across the cross-border region, but also to support the interpretation and prioritisation of post-event impacts, especially where similar physical damage levels may lead to different emergency needs because of different social conditions and coping capacity.

3.2 Residential, Commercial and Industrial Buildings

A harmonised cross-border exposure model for residential, commercial and industrial buildings was developed using available national datasets (statistical office records and census data), European sources including the European Seismic Risk Model [17], and other publicly available documentation at municipality level, without field investigations [16]. The inventory includes 399,022 residential buildings (148,392 in North Macedonia; 135,755 in Greece; 114,875 in Albania), 18,237 commercial buildings (9,929 in North Macedonia; 8,201 in Greece; 107 in Albania), and 5,666 industrial buildings (4,324 in North Macedonia; 1,242 in Greece; 100 in Albania). Seismic fragility models for these building classes are cross-border harmonised and follow the CRISIS methodology [18] together with the updated SP-BELA fragility curves [19,20].

3.3 Basic Services and Transport Infrastructure

EMERGE refines and harmonizes the exposure and vulnerability model for basic services and transport infrastructure, focusing on schools, hospitals/health-care structures and road bridges [21]. Exposure harmonization for schools and hospitals is performed using the GEM Building Taxonomy [22], while bridges are classified consistently according to reinforced concrete bridge structural system and number of spans. The inventory prioritizes assets located in or near larger cities, serving significant user populations and therefore critical for emergency response and service continuity. In total, 787 school buildings (58 in North Macedonia; 63 in Greece; 666 in Albania), 56 health-care structures (16 in North Macedonia; 9 in Greece; 31 in Albania), and 334 bridges (128 in North Macedonia; 16 in Greece; 190 in Albania) are mapped. Fragility models for basic-service buildings are harmonised following the CRISIS framework and updated SP-BELA curves [19,20], while bridge fragility modelling remains consistent with the CRISIS approach [18].

Within the EMERGE workflow, these exposure and fragility datasets support rapid estimation of damage patterns and service disruption immediately after an event, thus providing essential input to the needs assessment phase.

3.4 Civil Protection Resources, Capacities and Capabilities

EMERGE addresses the operational response dimension through assessment of civil protection resources, capacities and capabilities across the cross-border region [13]. Resources include personnel, equipment, facilities, knowledge and funding; capacities reflect institutional ability to mobilise and coordinate resources; and capabilities represent the ability to perform key response functions such as search and rescue, medical aid, evacuation and damage assessment. A dedicated database structured around twelve key attributes mapped to the Rapid Needs Assessment metrics was developed using project data, national civil protection authorities and publicly available sources. The database includes, for example, the distribution of schools, hospitals and shelters, hospital bed capacity, medical staff and first-aid vehicles, and temporary sheltering capacity. Its function within the EMERGE framework is not limited to inventorying available assets. Rather, it provides the operational reference layer against which modelled impacts are evaluated. This enables direct comparison between estimated needs derived from impact modelling and available response capacity, sup-porting identification of response gaps and potential requirements for cross-border assistance within the first 72 hours after an event. Accordingly, if the post-event impact estimation indicates concentrations of injured population, severe service disruption or increased sheltering demand in specific municipalities, these outputs can be compared with the local and regional availability of medical, sheltering and emergency support resources. This supports prioritisation of response actions and highlights where reinforcement from neighbouring areas or cross-border mechanisms may be needed.

4 Discussion and Conclusions

This paper presented the EMERGE conceptual framework for near real-time multi-risk assessment and rapid needs planning in the cross-border region of North Macedonia, Greece and Albania. By expanding the CRISIS platform with additional exposure categories (residential, commercial and industrial buildings, and population), harmonised socio-economic vulnerability layers, and a structured portfolio of civil protection resources, capacities and capabilities, EMERGE advances towards an operational Rapid Needs Assessment workflow supporting early response coordination.

A central contribution of the proposed framework is the explicit connection between the three modules of the platform and their organisation into pre-event and post-event components. In the pre-event component, EMERGE develops harmonised hazard, exposure, vulnerability and capacity layers for the cross-border region. In the post-event component, near real-time shaking information is used to estimate impacts, which are then translated into urgent needs and compared with available response capacity. This workflow clarifies how the platform moves from hazard assessment to impact estimation and from impact estimation to operational prioritisation.

A key added value of EMERGE is the explicit linkage between expected impacts and available response capacity, enabling prioritisation of affected areas while also identifying potential resource gaps and requirements for cross-border assistance within the first 72 hours after an event. Integration of strong-motion stations into the European Integrated Data Archive network further supports near real-time hazard information exchange and improves interoperability of seismic monitoring in South-eastern Europe.

The work also highlights typical constraints of cross-border applications, including heterogeneous national datasets, differences in administrative structures and asset inventories, and variable data completeness. Since the approach is designed for rapid decision support, it prioritizes consistency and operational usability over highly detailed local-scale modelling; these limitations are addressed through the modular design of the Web-Based Platform, allowing progressive updates of datasets and models.

Overall, EMERGE extends the CRISIS platform into a comprehensive framework for near real-time multi-risk assessment and rapid post-disaster needs planning. Its key contributions are: (i) a harmonised cross-border portfolio integrating socio-economic vulnerability, population distribution, buildings, basic services and transport infrastructure, and civil protection resources; (ii) a Rapid Needs Assessment workflow supporting prioritisation of urgent needs and identification of response gaps within the first 72 hours; and (iii) implementation within a modular and interoperable platform designed for replication and scaling.

At the time of writing, EMERGE remains in the implementation phase, with 12 of 24 months completed; next steps therefore focus on full platform integration, pilot testing and validation with end-users, and refinement of the workflow to strengthen operational uptake and cross-border emergency preparedness.

Acknowledgement

This contribution is part of the EMERGE project (Grant Agreement No. 101193586), financed by the European Union Civil Protection Mechanism under the UCPM-2024-KAPP call. The authors acknowledge the contributions and support of all project partners in the preparation and implementation of the project.

Emerge share, prepare, respond

Funded by the European Union

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Annex D

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(Submitted Papers)

Near Real-Time Shaking Information to Resource Prioritisation in Cross-Border Regions

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Abstract

Rapid emergency decision-making often suffers from a gap between hazard information, impact estimation, and actionable planning, especially in cross-border regions where coordination, data availability, and response capacities differ. This contribution presents a web-based approach, developed within the EU project EMERGE, that couples earthquake and earthquake-triggered landslide hazard information with rapid impact and needs planning for a cross-border region spanning North Macedonia, Greece, and Albania. Building on an earlier platform concept developed within the EU project CRISIS, the exposure representation is expanded from a limited set of assets to a broader portfolio covering seven exposure categories (schools, hospitals, bridges, residential, commercial, industrial buildings, and population). A rapid needs assessment workflow is introduced to translate estimated impacts into operational outputs, supported by: (i) socio-economic vulnerability profiling and population distribution mapping, (ii) a structured inventory and evaluation of civil protection resources, capacities, and capabilities, and (iii) a prioritisation rationale that supports intervention planning and decision-making. These elements are integrated within a needs-assessment web platform that leverages near-real-time ShakeMap information, linked to regional strong-motion instrumentation of the ORFEUS-EIDA network. In addition to improving the consistency of cross-border situational awareness, the approach is designed to support faster interpretation of event consequences in the critical early response phase and to facilitate comparison between expected needs and available response capacities. It therefore strengthens the connection between scientific risk information and the practical requirements of emergency coordination and resource prioritisation. The proposed workflow supports faster, more comparable cross-border situational awareness and enables coordinated response planning, while offering a replicable model adaptable to other multi-risk regions.

Keywords: earthquake, landslide, near-real-time, rapid needs assessment, cross-border planning

1- INTRODUCTION

Europe continues to face disasters whose impacts often exceed the administrative and operational capacity of a single country. This is particularly evident where strong natural hazards interact with dense exposure, vulnerable communities, and uneven response capacities across neighbouring territories. In such settings, effective emergency management depends not only on understanding hazard and risk, but also on translating this knowledge rapidly into operational priorities. This challenge is especially relevant in the Balkan region, where earthquakes and associated collateral hazards, notably landslides, have caused severe losses over time and where levels of prevention, preparedness, and interoperability still vary across countries [1,2].

The cross-border area shared by North Macedonia, Albania, and Greece is a representative example of this problem. Active tectonic structures affect the region across national boundaries, while mountainous terrain, settlement patterns, and infrastructure networks create conditions in which earthquake impacts may be amplified by slope instability, accessibility disruption, and stress on civil protection systems. This is particularly important in the studied regional setting, where strong earthquakes may be accompanied by earthquake-induced landslides, requiring hazard and risk information that explicitly incorporates both effects within a harmonised cross-border framework [2,3].

Earlier work under the CRISIS project established a harmonised cross-border methodology for multi-hazard risk assessment of basic services and transport infrastructure, together with a WebGIS environment for regional integration of hazard, exposure, vulnerability, and needs-related information [4,5]. EMERGE builds directly on this foundation, while extending it towards a more operational framework for rapid post-event needs assessment, prioritisation of interventions, and support to cross-border emergency planning. In parallel, the project retains continuity with related UCPM efforts such as INFRA-NAT and ISRA, thereby combining infrastructure-risk logic, cross-border platform development, and stakeholder-oriented disaster-risk communication [2,14] (Figure 1).

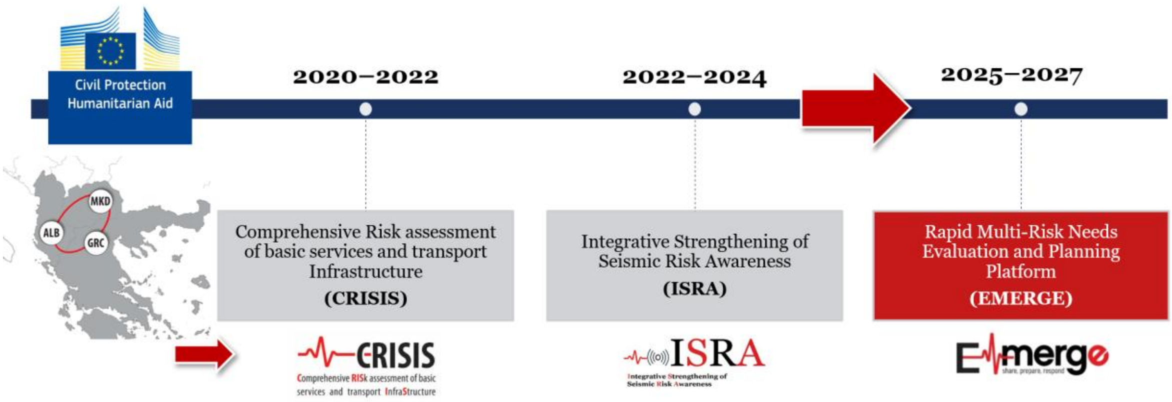

Figure 1. Storyline of recent related UCPM efforts and the positioning of EMERGE as an operational advancement of earlier project results [2]

A central premise of EMERGE is that early emergency decision-making requires reliable and timely information that can connect hazard, impact, and coping capacity. For this reason, the framework combines harmonised hazard and exposure data with additional layers describing population distribution, social vulnerability, and civil protection resources, capacities, and capabilities [6–12]. It further strengthens the near-real-time dimension through the integration of strong-motion capacities in the cross-border region and their linkage to ORFEUS-EIDA, improving the basis for event-specific shaking information and post-event interpretation [2,13].

The geographical focus of the framework is the cross-border region of North Macedonia, Albania, and Greece, illustrated in Figure 2, which provides the spatial context for the methodological and operational developments presented in this paper. The figure highlights the regional scope of the study and underlines the transboundary nature of the targeted hazard and response environment.

The development of EMERGE should also be understood within a broader progression of related UCPM-supported efforts in the region. As illustrated in Figure 1, earlier initiatives addressed complementary dimensions of resilience, including infrastructure-focused vulnerability and prioritisation, harmonised cross-border seismic and landslide risk assessment, and seismic risk awareness and communication. EMERGE builds on this accumulated experience while moving one step further towards near-real-time impact interpretation, rapid needs assessment, and prioritisation of response resources in the early post-event phase [2,14].

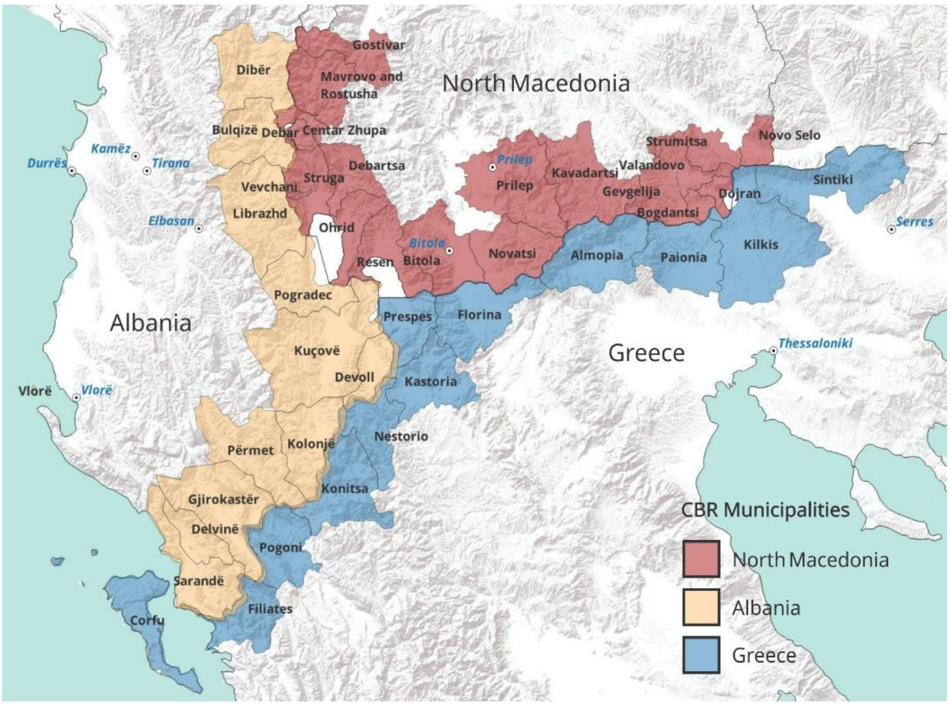

Figure 2. EMERGE pilot region: N. Macedonia-Albania-Greece cross-border region

2- EMERGE FRAMEWORK FOR RAPID CROSS-BORDER NEEDS ASSESSMENT

The methodological backbone of EMERGE is a rapid needs assessment approach organised as a sequence explicitly connecting hazard information, exposure and vulnerability data, damage and loss estimation, and rapid needs assessment [6]. This logic reflects a key principle of the framework: timely and reliable information is a prerequisite for prioritising measures and allocating available resources during the earliest post-event period [2,6]. Rather than treating hazard, impact estimation, and emergency planning as separate analytical exercises, EMERGE combines them within a single operational workflow.

In its pre-event component, the framework prepares the layers required for rapid activation after an earthquake. These include: (i) hazard layers for earthquakes and earthquake-induced landslides, (ii) exposure layers for buildings, basic services, transport infrastructure, and population, (iii) vulnerability characterisation for the exposed assets, (iv) social vulnerability information describing demographic and socio-economic sensitivity, and (v) structured information on available resources, capacities, and capabilities of civil protection authorities [6–12]. Once an event occurs and near-real-time shaking information becomes available, the post-event component is activated. Damage and loss estimates are then translated into urgent needs and assessed against available response capacities within the critical 72-hour response window [6].

The overall methodological chain adopted in EMERGE is summarised in Figure 3. As shown in the figure, the framework is organised as a connected sequence in which pre-event data preparation supports post-event activation, thereby linking hazard input, exposure and vulnerability characterisation, damage and loss estimation, and rapid needs evaluation into a single operational structure.

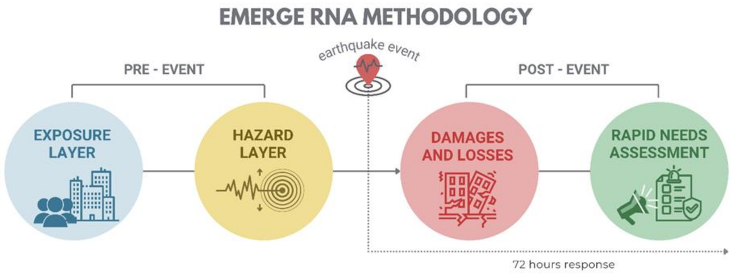

Figure 3- Methodological workflow of the EMERGE framework for rapid cross-border needs assessment [6]

This stepwise structure also clarifies the main upgrade relative to CRISIS. The earlier framework established the regional multi-hazard and multi-risk basis for schools, hospitals, bridges, and viaducts in the North Macedonia–Albania–Greece cross-border region [4,5]. EMERGE extends this logic in three main directions (Figure 4): first, by moving towards near-real-time multi-hazard activation; second, by upgrading needs assessment into a rapid post-disaster decision-support process; and third, by broadening the exposure and response-information base to reflect the wider built environment, the affected population, and the coping capacities of civil protection systems [2,4–7].

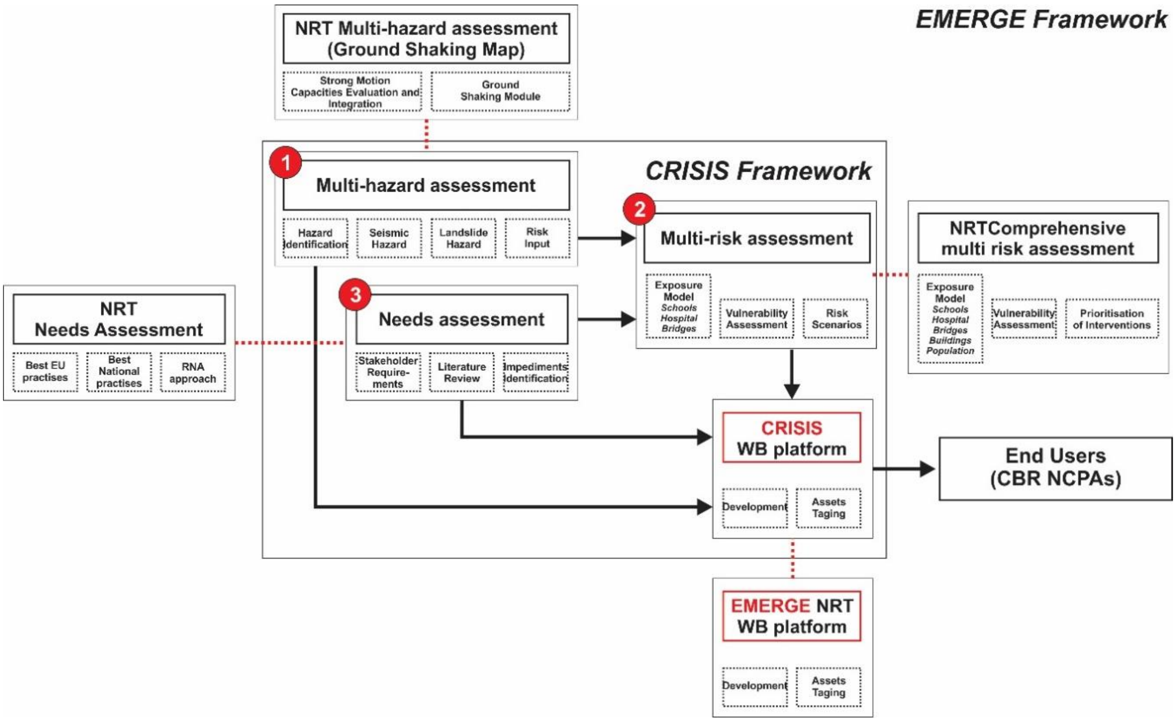

Figure 4 - Main upgrades from the CRISIS framework to the EMERGE rapid needs assessment platform

From a methodological perspective, the platform is therefore conceived not as a simple repository of scenarios or maps, but as a chain of interoperable modules. Hazard information feeds event-specific impact estimation; impact estimation feeds rapid needs identification; and identified needs are evaluated against available resources and capacities in order to support prioritisation, gap identification, and, where necessary, cross-border assistance [6,11,12]. This progression is central to the EMERGE concept and gives the framework its operational relevance for both preparedness planning and early crisis management [2,6].

The basis of hazard itself follows a harmonised cross-border logic that combines earthquake and earthquake-induced landslide information, drawing on recent methodological developments for regional-scale landslide hazard and risk integration [3]. This is important because, in the studied area, the operational consequences of an earthquake may depend not only on direct shaking impacts but also on terrain instability, accessibility problems, and the cascading effects of disrupted connectivity.

3- CROSS-BORDER DATA BASIS FOR THE EMERGE PLATFORM

A major share of the EMERGE added value lies in the extent and harmonisation of its cross-border data basis. The framework is not constructed around a single inventory or a single hazard layer, but around several interdependent datasets that together support a more realistic representation of post-event conditions. This broader structure reflects one of the core ideas of the framework: rapid needs planning becomes meaningful only when exposure, vulnerability, social conditions, and available response capacities are considered together rather than alone [2,8–12].

The integrated EMERGE portfolio extends well beyond the critical-facility scope of the earlier CRISIS framework and includes both the broader building stock and the main basic-services and transport-infrastructure assets. The scale of the current cross-border portfolio is summarised in Table 1, which describes the country-by-country distribution of the principal exposed asset classes currently incorporated in the framework [8,9].

Table 1. Main components and indicative scale of the EMERGE cross-border asset portfolio

Asset category	North Macedonia	Greece	Albania	Total	Main purpose in EMERGE
Residential buildings	148,392	135,755	114,875	399,022	Broader built-environment exposure and impact estimation
Commercial buildings	9,929	8,201	107	18,237	Representation of economic activity and service disruption
Industrial buildings	4,324	1,242	100	5,666	Representation of production-related exposure and disruption
Schools	58	63	666	787	Assessment of basic-service vulnerability and emergency needs
Hospitals / health-care structures	16	9	31	56	Assessment of critical service continuity and medical-response pressure
Bridges / viaducts	128	16	190	334	Accessibility, connectivity, and transport disruption

As shown in Table 1, the largest component of the portfolio is the general building stock, comprising 399,022 residential, 18,237 commercial, and 5,666 industrial buildings across the three-country cross-border region, while the basic-services and transport-infrastructure branch includes 787 schools, 56 health-care structures, and 334 bridges/viaducts [8,9]. This scale is important because it demonstrates that EMERGE moves beyond a narrow critical-infrastructure screening logic towards a broader and more operationally relevant representation of the affected territory.

The first major part of this data basis concerns the exposure and vulnerability model. In addition to the asset categories already addressed in CRISIS, EMERGE develops a broader portfolio by incorporating residential, commercial, and industrial buildings across the cross-border region [8]. This extension allows the framework to move beyond critical facilities alone and to reflect the wider built environment affected by strong earthquakes. At the same time, the exposure basis for schools, hospitals, bridges, and viaducts is updated and refined, ensuring continuity with the earlier framework while improving consistency and regional comparability [9]. These two exposure branches together provide the physical basis for estimating direct impacts on buildings, services, and transport infrastructure.

A second key layer is the social vulnerability component developed through the Social Vulnerability Index (SoVI) framework [10,15]. In EMERGE, the SoVI approach is adapted to the cross-border region and built from 35 indicators grouped into seven thematic dimensions: Population, Education, Economy, Health, Infrastructure, Habitat, and Governance and Institutional Capacity [10]. This layer is essential because similar levels of physical hazard and structural impact may produce different human and operational consequences depending on demographic structure, socio-economic conditions, institutional performance, and service availability.

The third major data branch concerns resources, capacities, and capabilities for disaster and emergency response. EMERGE develops a structured cross-border database to support comparison between urgent needs and available means of response [11,12]. In this context, resources refer to personnel, equipment, facilities, and other tangible assets; capacities refer to the ability of institutions and systems to organise, mobilise, and sustain those resources; and capabilities refer to the demonstrated ability to perform critical response functions such as search and rescue, evacuation, medical support, or damage assessment under real disaster conditions [11,12]. The database is intended to support gap identification and possible cross-border assistance requirements.

Taken together, these layers provide a broader and more realistic analytical base for rapid needs planning than the earlier CRISIS environment. Physical exposure and fragility indicate where damage is likely to occur; social vulnerability indicators help explain how similar physical impacts may translate into different levels of human consequence; and the resources-capacities-capabilities inventory provides the basis for understanding whether or not the estimated needs can be met within the cross-border system [8–12]. In this sense, the EMERGE data basis is not simply larger than before; it is qualitatively closer to the information structure required for operational prioritisation.

The nature of this transition from CRISIS to EMERGE is also consistent with the project progression illustrated in Figure 1, which highlights the conceptual and operational shift from earlier cross-border risk-assessment efforts towards a framework more explicitly oriented to rapid post-event decision support [2,14].

4- CBR STRONG-MOTION NETWORK INTEGRATION AND NEAR-REAL-TIME SHAKING INPUT

Given that the title and purpose of this paper emphasise near-real-time shaking information, the strong-motion component deserves dedicated treatment. Accurate and timely data are a prerequisite for effective early crisis management [2], and the EMERGE framework translates that principle into a concrete regional integration effort focused on strong-motion capacities across the cross-border region [13]. The role of this component is not only technical; it underpins the credibility of the post-event activation chain by improving the event-specific basis on which damage, losses, and urgent needs are inferred.

The current strong-motion basis of the framework builds on the documentation and evaluation of monitoring capacities in Greece, North Macedonia, and Albania and on the identification of how these capacities can support the cross-border needs-assessment chain [13]. In Greece, the framework draws on the broader accelerometric environment available through EIDA@NOA. In North Macedonia, it builds on the long-established UKIM-IZIIS strong-motion network, whose capacity has been strengthened over time through previous regional and international initiatives. In Albania, it incorporates the national strong-motion network and evaluates candidate stations with respect to the cross-border region [13]. This documentation step is important because the reliability of near-real-time shaking input depends on actual station performance, accessibility, and interoperability rather than on conceptual assumptions alone.

The regional integration achieved through this effort is shown in Figure 5, which presents the integrated strong-motion monitoring capacities relevant to the EMERGE framework. The figure visually supports the transition from national monitoring capacities to a more connected cross-border basis for event-specific shaking input and operational use.

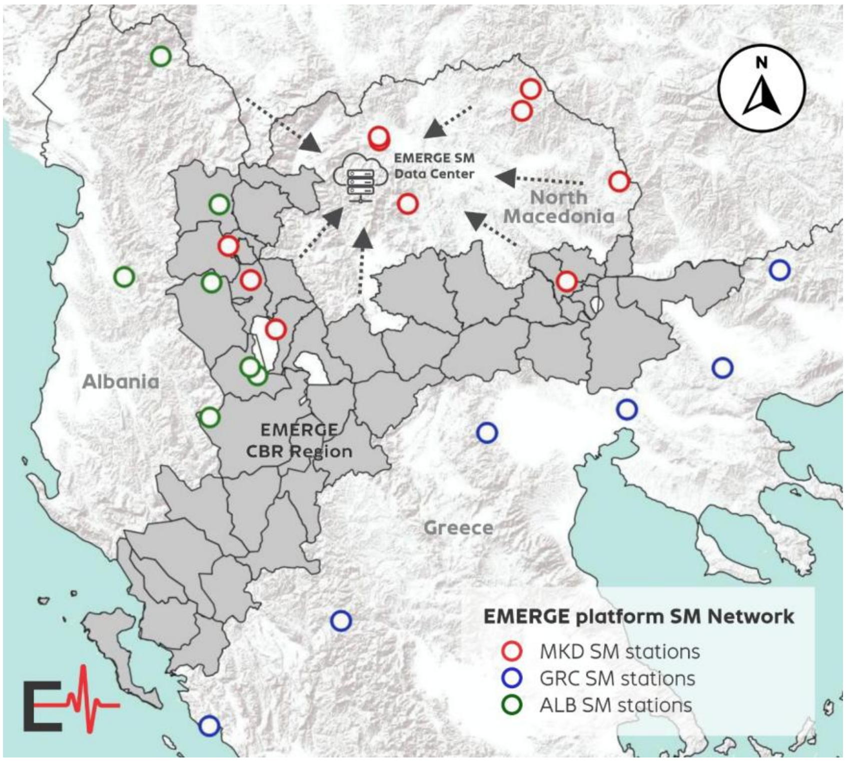

Figure 5- Integrated strong-motion monitoring capacities in the cross-border region supporting near-real-time shaking input for EMERGE [13]

The main advancement, however, is the integration of North Macedonian stations into the ORFEUS-EIDA framework through NOA's regional node, together with real-time data-sharing arrangements for selected stations in the broader cross-border setting [13, 14]. This development adds a direct European dimension to the framework and corresponds closely to the added value: strengthening regional seismic-data interoperability while improving the availability of information needed for rapid response support [2,13]. In the EMERGE workflow, such integration is essential because it improves the basis for near-real-time shaking input that can trigger and update the rapid needs-assessment process.

For the purposes of the present paper, the strong-motion component should therefore be understood as an enabling layer of the wider needs-assessment framework. Its significance lies less in the seismological description of the networks themselves than in its operational effect: it makes the transition from pre-defined scenarios to near-real-time activation more credible, more regionally interoperable, and more useful for post-earthquake decision support [13].

5- WEB-BASED IMPLEMENTATION AND OPERATIONAL RELEVANCE

The EMERGE Web-Based Platform provides the operational environment through which the integrated results of the framework can be accessed, visualised, and interpreted in support of preparedness and early post-event decision-making [7]. Its main added value lies not simply in web-based accessibility, but in the ability to organise cross-border information within a common interface that supports rapid situational awareness and more comparable interpretation across countries and institutions.

From a technical perspective, the platform is designed as a modular web-based environment combining browser-based accessibility with the capabilities of geographic databases and standards-based web services. This architecture supports layered geographic visualisation, structured updating of spatial datasets, and interoperability between frontend and backend components, thereby enabling the integration of hazard, exposure, and needs-related information within a common operational interface [7].

From an operational perspective, one of the key innovations of the platform is the demand-capacity matching logic embedded in its workflow. The objective is not limited to visualising hazard or damage patterns, but extends to identifying priority needs, highlighting potential shortages, and indicating whether available local or national capacities are likely to be sufficient during the first response period [6,11,12]. This is a critical distinction, because emergency decisions depend not only on the severity of physical impacts, but on how those impacts translate into concrete response requirements.

An example of the EMERGE web-platform environment is shown in Figure 6. The figure illustrates the layered visualisation logic of the platform, in which hazard-related outputs, exposure information, and needs-oriented datasets can be interpreted together within a common operational interface. In this way, the platform supports a transition from raw event information toward structured situational awareness and rapid interpretation for emergency decision-making [7,11–13].

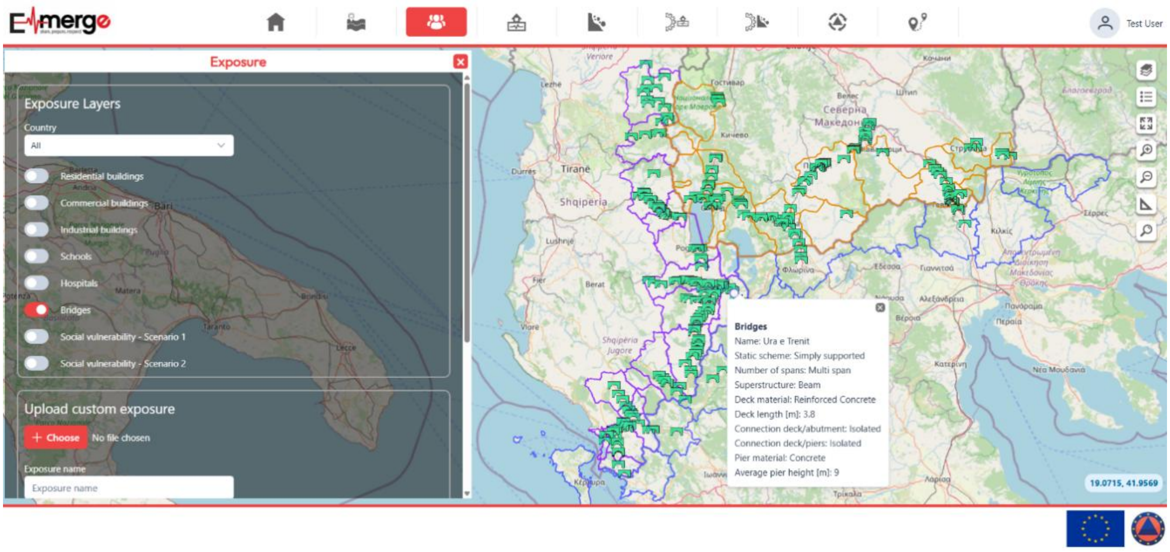

Figure 6- Example of the EMERGE web-platform environment for layered visualisation and rapid interpretation of event-related information

The operational significance of this approach becomes clearer when viewed in relation to the earlier CRISIS framework. While CRISIS demonstrated the feasibility of harmonised cross-border GIS-based risk assessment for selected infrastructure classes [4,5], EMERGE advances this basis towards a more decision-support-oriented structure by incorporating broader exposure categories, social-vulnerability information, civil protection resource inventories, and near-real-time activation through strong-motion integration [2,6–13]. As already illustrated by the project storyline in Figure 1, this progression positions EMERGE as a targeted operational advancement within a broader continuity of UCPM-supported work [2,14].

This development has broader relevance within the UCPM context. EMERGE shows how scientific risk information can be translated into more operationally meaningful support for civil protection authorities when datasets, methodologies, and response-oriented logic are brought together within a common cross-border environment [1,2,6]. In this sense, the platform addresses not only the technical challenge of integrating heterogeneous datasets, but also the institutional challenge of improving comparability, coordination, and timely interpretation across national systems [11,12,14].

At the same time, the practical value of the platform depends on the long-term maintenance and updating of its underlying datasets. Its usefulness in operational conditions will rely on data completeness, regular revision, and sustained institutional ownership, particularly for the resource and capacity layers managed by the responsible authorities in the cross-border region [11,12]. This underlines that effective rapid needs planning is not only a modelling issue, but also an organisational one, requiring robust procedures for data sharing, validation, and coordinated use in emergency contexts [6,11,12].

6- CONCLUSIONS

This paper presented the EMERGE framework as an integrated chain linking near-real-time shaking information, cross-border hazard and exposure layers, rapid needs assessment, and resource prioritisation in the North Macedonia–Albania–Greece cross-border region [6,7].

The first main conclusion is that EMERGE substantially broadens the analytical basis of cross-border post-earthquake decision support by combining physical hazard and impact layers with an expanded exposure model, a SoVI-based representation of social vulnerability, and a structured inventory of resources, capacities, and capabilities [8–12]. This makes the framework better aligned with the real information requirements of early crisis management with respect to a conventional risk platform limited to damage metrics alone.

The second main conclusion is that strong-motion network integration is a core enabler of the framework rather than a parallel technical activity. By improving regional data sharing and linking North Macedonian capacities with ORFEUS-EIDA, EMERGE strengthens the basis for event-specific shaking input and thereby supports the transition from scenario-based analysis toward more credible near-real-time activation of the rapid needs-assessment chain [2,13].

The third main conclusion is that the web-based implementation logic is essential to the operational value of the framework. The platform acts as the environment in which heterogeneous cross-border datasets are transformed into usable outputs for prioritisation, gap identification, and response support [6,7,11,12]. Its significance lies not only in visualisation, but in making the relationship between hazard, impact, and coping capacity explicit and operationally interpretable.

Overall, EMERGE shows how harmonised geospatial structures, shared methodological assumptions, and operationally oriented data integration can support more coordinated civil protection planning in transboundary seismic-risk environments. The framework is directly relevant to the Balkan cross-border case study, but its underlying logic is transferable to other regions where effective early response depends on connecting monitoring, impact estimation, and needs-based prioritisation within a common decision-support environment [1–3,6,7,13].

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Emerge share, prepare, respond

Funded by the European Union

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EMERGE: a Web-Based Platform for Multi-Hazard Assessment and Early Crisis Response in the Cross-Border Region of North Macedonia, Albania and Greece

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Abstract

Developed within an ongoing project funded by the European Civil Protection Mechanism, the EMERGE Web-Based Platform (WBP) provides advanced capabilities for multi-hazard analysis and operational decision support for seismic and landslide risks across the cross-border region (CBR) of North Macedonia, Greece, and Albania. Building on the WBP originally developed within the CRISIS project (2020-2022), EMERGE extends this framework into an integrated Near Real-Time (NRT) environment for multi-hazard impact assessment and rapid needs evaluation. The platform enables emergency managers and civil protection authorities to rapidly analyse potential damage scenarios and support informed decision-making immediately following seismic events. Several substantial enhancements have been introduced. Hazard modelling has been refined through the integration of NRT ShakeMaps, enabling dynamic estimation of ground-shaking intensity following earthquake events. Exposure and vulnerability models have also been significantly expanded. In addition to critical facilities such as schools and hospitals and key transport infrastructure including bridges and viaducts - already included in CRISIS - the EMERGE platform now incorporates residential, commercial, and industrial building stocks, providing a more comprehensive representation of the built environment within the CBR. Furthermore, the platform integrates spatial population distribution datasets, allowing the assessment of socio-economic exposure and facilitating the prioritisation of emergency actions based on population vulnerability. By combining hazard information with exposure, vulnerability, and response capacity data, the system supports rapid damage estimation, emergency needs assessment, and resource allocation planning. Through these advancements, the EMERGE WBP significantly strengthens situational awareness and facilitates coordinated decision-making among civil protection agencies and disaster management stakeholders. Furthermore, by enabling NRT damage scenario analysis to prioritise emergency interventions and optimise resource deployment through quantitative demand-capacity comparisons, the platform strengthens preparedness and resilience across the considered cross-border area.

Keywords: Multi-hazard Assessment, Needs Planning, Earthquake, Seismic Landslides.

1- Introduction

Several European regions are affected by seismic sources whose impacts extend across national borders, requiring harmonized transboundary risk assessment frameworks. The Balkan area represents a paradigmatic case, where active tectonic systems simultaneously influence North Macedonia, Greece, and Albania. In this context, hazard processes and exposed assets are spatially continuous, while emergency management structures remain administratively fragmented. This structural mismatch underscores the need for interoperable cross-border tools capable of ensuring consistent hazard characterization, exposure modelling, and impact estimation.

At continental scale, the European Seismic Risk Model (ESRM20) [1] has provided a harmonized framework for exposure, vulnerability, and loss assessment across Europe. While ESRM20 establishes coherent large-scale risk metrics, operational civil protection applications require regional refinement and platform-based implementation tailored to specific cross-border settings. Significant differences in building taxonomies, construction practices, and data availability across neighbouring countries often limit direct comparability and coordinated response planning.

European research has progressively addressed these challenges. Within the BORIS project, Polese et al. [2] developed a harmonized methodology for cross-border risk evaluation, emphasizing shared exposure datasets, aligned vulnerability models, and interoperable GIS-based environments. Their work conclusively demonstrated that the main challenges of transboundary platforms lie not only in hazard modelling but equally in exposure harmonization and in the translation of damage metrics into coordinated emergency indicators.

Building on these principles, the CRISIS project implemented one of the first operational cross-border seismic risk platforms in the Balkan region. As described by Di Meo et al. [3], CRISIS developed a GIS-based framework enabling harmonized scenario-based seismic risk assessment across North Macedonia, Albania, and Greece. The platform integrated shared exposure taxonomies and vulnerability models to estimate damage to essential facilities (schools and hospitals) and transport infrastructure (bridges and viaducts) within a unified computational structure, demonstrating the feasibility of coordinated cross-border impact evaluation.

CRISIS also pioneered the integration of earthquake-induced landslides into regional risk modelling. In mountainous areas of South-Eastern Europe, seismic shaking frequently triggers slope instabilities that amplify damage and disrupt connectivity. Bojadjieva et al. [4] developed a harmonized cross-border methodology for assessing earthquake-triggered landslide hazard and risk at regional scale, combining seismic inputs and susceptibility modelling within a consistent computational framework. This work established the scientific basis for multi-hazard integration in the Balkan context.

Despite these achievements, CRISIS remained scenario-based and did not operate within a fully Near Real-Time (NRT) environment. Moreover, its exposure model focused primarily on critical facilities and transport infrastructure, without encompassing the broader building stock and population distribution required for comprehensive emergency prioritization within the first critical hour's post-event.

EMERGE builds directly upon the CRISIS framework and represents a conceptual and operational leap toward an integrated NRT multi-hazard risk assessment platform. The transition from predefined scenarios to shakemap-driven hazard inputs is supported by the integration of regional seismic stations within the ORFEUS-EIDA (European Integrated Data Archive; https://www.orfeus-eu.org/data/eida/) framework [5][6], ensuring harmonized access to waveform data and rapid ground-motion products across the cross-border region. The integration of NRT shakemaps ensures consistent spatial distribution of intensity measures across administrative boundaries and enables rapid damage estimation within minutes of event detection.

Beyond hazard refinement, EMERGE substantially expands the exposure and vulnerability framework. In addition to essential facilities and transport infrastructure, the platform incorporates residential, commercial, and industrial buildings, providing a detailed representation of the built environment across the cross-border region. A harmonized population distribution dataset is integrated to quantify socio-economic exposure and support the assessment of social vulnerability. This inclusion marks a decisive shift toward holistic risk evaluation: while structural damage metrics quantify physical impact, demographic and socio-economic conditions strongly influence response capacity and recovery potential. By combining physical vulnerability functions with population and social indicators, the platform enables evidence-based prioritization of emergency actions.

Furthermore, EMERGE introduces rapid needs assessment modules that translate damage outputs into quantitative operational indicators for emergency planning and resource allocation. By embedding hazard, exposure, vulnerability, and population datasets within a modular Web-Based Platform (WBP), the system enables automated NRT damage scenario analysis and coordinated decision support across national borders, strengthening situational awareness and optimizing response strategies during early response phases.

This paper presents the architecture and functionalities of the EMERGE WBP, detailing the NRT mapping of seismic and earthquake-induced landslide hazards, the harmonized exposure, and vulnerability modelling approach - including social vulnerability components - and the integrated workflow for multi-hazard risk computation and rapid needs assessment, before concluding with key findings and perspectives.

2- THE EMERGE WEB-BASED PLATFORM AND ITS FUNCTIONALITIES

The EMERGE WBP represents a significant advancement of the tool originally developed within the CRISIS project. Building on the deterministic and probabilistic multi-risk analyses implemented in CRISIS, EMERGE adds NRT multi-risk assessment capabilities for seismic and landslide scenarios. This advancement enables rapid and operational evaluation of post-disaster needs, ensuring that decision-critical information reaches civil protection authorities within minutes in the immediate aftermath of an event.

Designed as a user-friendly tool, the EMERGE WBP is structured into several tabs. Upon logging in, users are directed to the **Home** tab, which provides a brief overview of the project, introduces the tool, and highlights the area of interest. Figure 1 shows the EMERGE WBP homepage, with the tabs organised by the pre- and post-event phases.

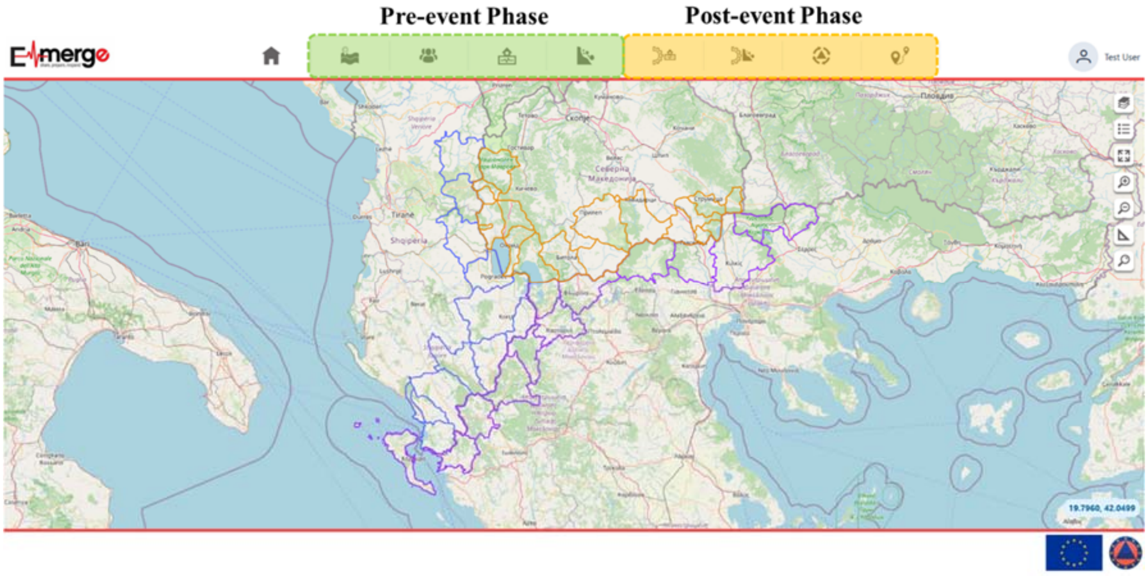


Figure 1- The EMERGE WBP homepage, highlighting the platform's tabs for the pre- and post-event phases.

Following the **Home** tab, the platform features four tabs corresponding to the pre-event phase, briefly outlined below to highlight their purpose and the functionalities they offer to users.

• **Base Layer** includes background and reference layers that do not fit into other sections. This tab is a new addition compared to CRISIS.

• **Exposure** contains the exposure datasets identified within the project better defined in the section 2-2. Compared to CRISIS, this tab also includes the social vulnerability layer calculated as part of the project, and a tool that allows users to upload their own exposure data for buildings and bridges via a predefined csv template.

• **Seismic Hazard** presents seismic hazard maps derived from the 2020 update of the European Seismic Hazard Model (ESHM 2020, [1]) for return periods of 102, 475, and 975 years, and includes a tool to retrieve shakemaps produced immediately after an earthquake.

• **Landslide Hazard** shows Peak Ground Displacement (PGD) based landslide hazard maps for return periods of 475 and 975 years, derived from the ESHM 2020 [7] and following the methodology proposed by [8].

As shown in Figure 1, the post-event phase is organized into four additional tabs, each designed to provide detailed, actionable information immediately following a disaster. These tabs focus on different aspects of impact assessment and response planning, enabling users to visualize damage scenarios, assess landslide risks, identify urgent needs, and plan safe emergency routes. The following is a brief description of the post-events phase tabs.

• **Earthquake Scenario** presents the damage scenarios calculated for eleven historical events that affected the CBR and the real-time damage scenarios generated from source parameters (e.g., epicenter and magnitude) using deterministic hazard maps - as previously implemented in CRISIS. Additionally, the platform now also enables the creation of NRT damage scenarios based on selected shakemaps.

• **Landslide Scenario** consists of layers of landslide risk maps. The risk for buildings is assessed using a semi-quantitative GIS-based method [9]. For bridges, landslide risk is evaluated by considering seismic events that could trigger landslides with return periods of 475 and 975 years, as well as NRT shakemap scenarios, and applying fragility curves for ground failure as proposed by HAZUS [10]. The landslide risk has not been calculated for all the bridges in the exposure database but for a part of them, selected based on their position and importance in terms of cross-border connection.

• **Post Disaster Needs** displays results in a visual format to help guide prompt and informed decisions. Areas of highest concern are categorized into five levels according to the number of casualties, injuries, and building damage. The platform also compares the availability of shelters and hospital capacity with estimated demand, helping to define priority areas for intervention. This feature represents a significant enhancement over the CRISIS platform.

• **Routing** enables users to define optimal emergency routes, avoiding potentially unusable damaged bridges.

Due to its intuitive structure and NRT multi-risk assessment capabilities, the EMERGE WBP significantly strengthens crisis and emergency management within the CBR. By rapidly processing and delivering impact-related information following major seismic or seismic induced landslide events, it enables authorities to make informed operational decisions, optimize resource allocation, and establish clear priorities during the critical early response phase.

2-1- MAPPING SEISMIC AND EARTHQUAKE-INDUCED LANDSLIDE HAZARD

The hazard component of the EMERGE WBP extends the scenario-based framework developed within CRISIS into a dynamically updated multi-hazard mapping environment for the cross-border region (CBR) of North Macedonia, Greece, and Albania. In CRISIS, seismic hazard characterization relied primarily on deterministic and probabilistic earthquake scenarios used to support preparedness-oriented simulations. EMERGE upgrades this configuration through the implementation of a dedicated module for real-time generation of ground-motion and shaking intensity maps, enabling spatially consistent representation of seismic demand across national boundaries.

Following earthquake detection and rapid source parameter estimation, ground-motion fields are computed using available instrumental recordings combined with appropriate ground-motion prediction equations. Spatial interpolation techniques are applied to derive continuous raster layers of key intensity measures, including Peak Ground Acceleration (PGA) and spectral accelerations at selected periods. These intensity measures are discretized on a regular grid and implemented within a harmonized GIS framework covering the entire CBR. Particular attention is given to ensuring consistency in spatial resolution, coordinate reference systems, and data structures across the three countries, thus avoiding discontinuities at administrative borders.

The integration of strong-motion stations from the CBR into the European ORFEUS-EIDA network (https://eida.gein.noa.gr/) strengthens the reliability and timeliness of ground-motion data acquisition. This integration enhances regional seismic monitoring capacity and supports the generation of updated shaking intensity fields based on shared European data infrastructures.

In addition to ground shaking, earthquake-induced landslides represent a critical hazard component in mountainous sectors of the CBR. The landslide module implemented in EMERGE builds upon the harmonized cross-border methodology previously developed within CRISIS and subsequently refined for regional application. The approach combines spatially distributed seismic intensity measures with landslide susceptibility layers derived from lithological, geomorphological, slope-gradient, and land-cover datasets. Susceptibility classes are defined consistently across the CBR, ensuring methodological homogeneity in the treatment of terrain instability.

Within this framework, ground-motion intensity values derived from the shakemap act as triggering parameters for slope failure. For each spatial unit, seismic demand is coupled with pre-defined susceptibility conditions to estimate the spatial probability of earthquake-induced landsliding under the given shaking scenario. The resulting output is a georeferenced landslide hazard layer that is fully aligned with the seismic shaking raster in terms of resolution and spatial reference.

By integrating seismic and landslide components within a unified GIS architecture, EMERGE produces a coherent multi-hazard representation at regional scale. This harmonized mapping approach ensures cross-border consistency, supports both scenario-based analyses and dynamically updated hazard estimation, and establishes the spatial foundation for the subsequent assessment modules described in the following sections.

2-2- Exposure Model And Assessment Of Physical and Social Vulnerability

The project aims to support the assessment of multi-hazard vulnerability (seismic and earthquake-induced landslide) and to strengthen emergency planning in the CBR of North Macedonia, Greece, and Albania. To this end, a systematic exposure mapping was developed for residential, commercial, and industrial buildings, also incorporating basic services (schools and hospitals) and transport infrastructure (bridges and viaducts) previously assessed in the CRISIS project, with their data updated and integrated within EMERGE. For basic services and transport infrastructure, only structures located in major urban centers or their immediate surroundings were considered, as they serve a significant number of users.

The building inventory was constructed exclusively based on available national datasets - including census and statistical office data, the ESRM20 [1] relevant studies and projects, technical documentation, and other public sources - with processing at the municipal level and without any on-site field surveys.

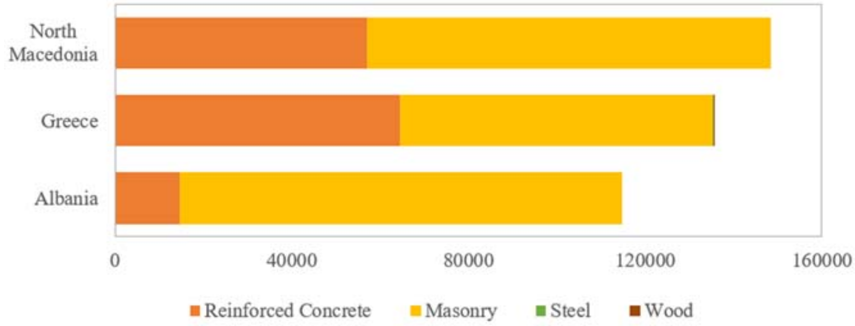
In North Macedonia, the residential building stock consists of approximately 60% masonry structures - with an almost even distribution among high, medium, and low vulnerability, and a slight predominance of high vulnerability - and the remaining portion in reinforced concrete, mostly seismically designed. In the commercial and industrial sectors, alongside the prevalence of reinforced concrete and masonry buildings, there is a residual presence of steel and prefabricated structures. In the commercial sector, reinforced concrete buildings are mostly seismically designed, whereas in the industrial sector, non-seismically designed reinforced concrete is more frequent. Masonry buildings in both sectors are distributed between high and medium vulnerability classes, with a prevalence of the latter. Schools are mainly seismically designed reinforced concrete, followed by masonry buildings (both low and high vulnerability) and mixed masonry-reinforced concrete structures. Hospitals are predominantly seismically designed reinforced concrete, with a limited share of high-vulnerability masonry and mixed masonry-reinforced concrete structures. Bridges are almost entirely reinforced concrete, mostly simply supported or monolithic/frame type.

In Greece, the majority of residential buildings are made of masonry or reinforced concrete, the latter of which is mostly seismically designed. A similar pattern is observed in the commercial and industrial sectors, with a residual presence of steel and timber buildings. Schools are predominantly seismically designed reinforced concrete, while about one-third consists of high-vulnerability masonry and a small portion of precast structures. Hospitals include reinforced concrete structures, both seismically designed and not, and one mixed masonry-reinforced concrete facility. Transport infrastructures are reinforced concrete with monolithic/frame structural typology.

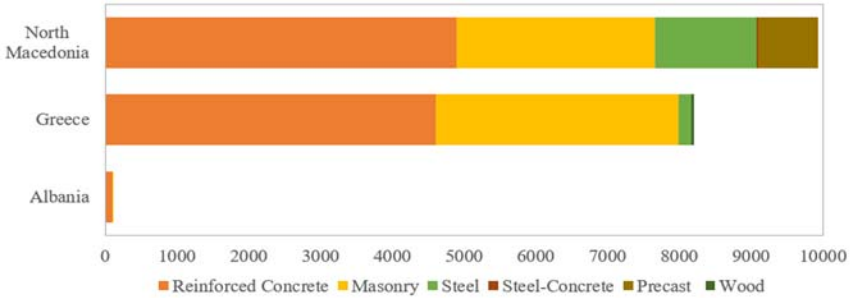
In Albania, residential buildings are mainly medium-vulnerability masonry, accompanied by a smaller share of reinforced concrete structures, mostly seismically designed. The commercial sector is dominated by seismically designed reinforced concrete buildings, while the industrial sector shows a more balanced distribution between medium-vulnerability masonry and seismically designed reinforced concrete. Schools are mostly medium-vulnerability masonry, with a smaller share of seismically designed reinforced concrete; hospitals are mixed masonry-reinforced concrete structures. Transport infrastructures are predominantly simply-supported reinforced concrete viaducts. In Table 1 the building inventory is classified accordingly. Figure 2 illustrates the estimated exposure in the project CBR in terms of structural types aggregated at municipal level from harmonized datasets and ESRM20 inventories.

Table 1- Comparative Building Typologies Across CBR Countries

Asset Class	North Macedonia	Greece	Albania
Residential	60% masonry (high/medium/low vuln., high predominant), 40% RC (seismic design)	Masonry + RC (mostly seismic design)	Medium-vuln. masonry (dominant), RC (seismic design)
Commercial	RC (seismic), masonry (medium vuln.), steel/prefab residual	RC (seismic dominant), masonry, steel/timber	RC (seismic dominant)
Industrial	RC (non-seismic frequent), masonry (medium vuln.)	RC (seismic), masonry, steel/timber	Masonry (medium) + RC (seismic) balanced
Schools	RC seismic (main), masonry (high/low), masonry-RC	RC seismic (dominant), 33% masonry high-vuln., precast	Masonry medium-vuln., RC seismic
Hospitals	RC seismic (dominant), masonry/masonry-RC (limited)	RC (seismic + non-seismic), 1× masonry-RC	Masonry-RC mixed
Bridges	RC simply-supported/monolithic	RC monolithic/frame	RC simply-supported viaducts



(a)



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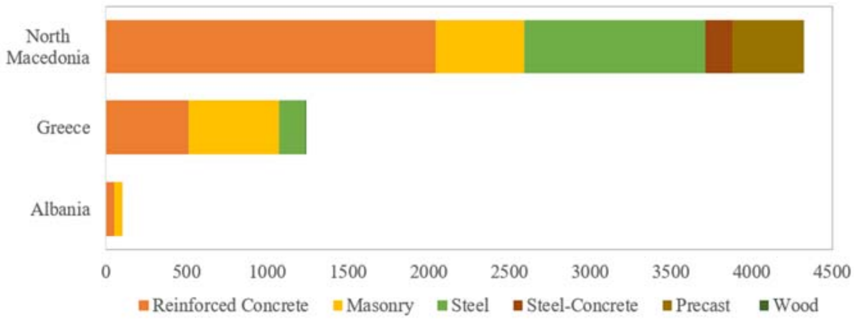

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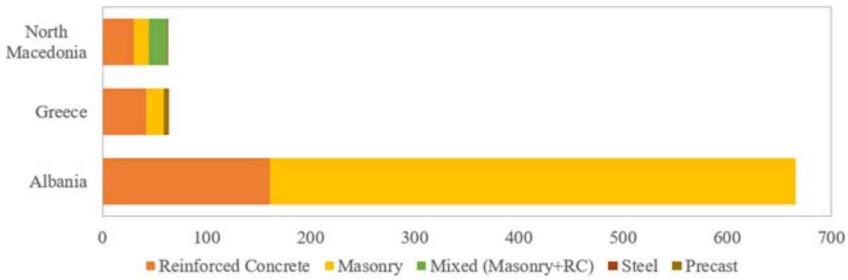

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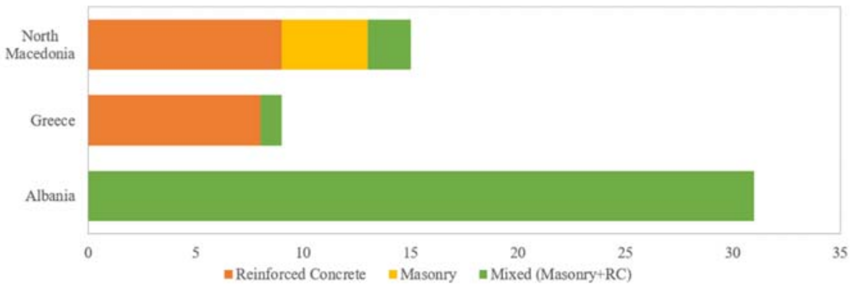

(e)

Figure 2- Distribution of the different structural typologies in the exposure of the project cross-border region for: (a) residential buildings; (b) commercial buildings; (c) industrial buildings; (d) schools, and (e) hospitals.

Figure 3 shows the **Exposure** tab functionality in EMERGE WBP with the *Bridges* layer activated. This allows users to view the spatial distribution of bridges in the CBR. In each tab, users can view information about an item by activating the corresponding layer and clicking on it, as illustrated in Figure 3. This feature allows interactive exploration of the data on screen.

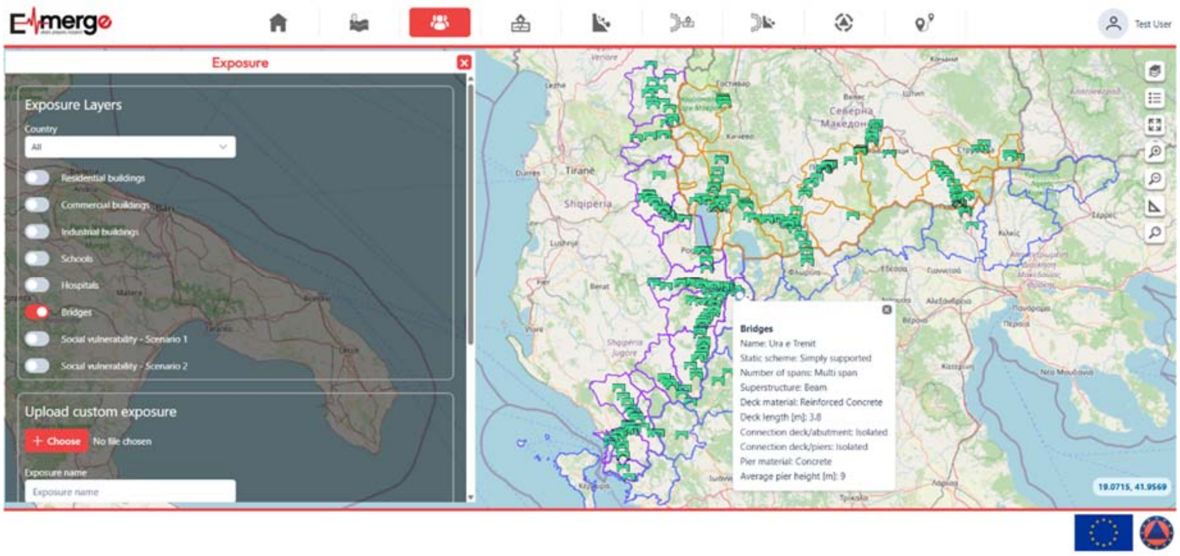

Figure 3- Exposure tab in the EMERGE WBP showing the transport infrastructure layer, highlighting the distribution of bridges and viaducts in the project cross-border region.

Once the exposure has been defined, the seismic scenario analysis requires selecting an appropriate method to estimate seismic vulnerability. In this study, we adopt SP-BELA (Simplified Pushover-Based Earthquake Loss Assessment), which evaluates the vulnerability of reinforced concrete and masonry buildings through fragility curves derived from a simplified mechanical approach [11]. These curves are applied directly to these building types; for other structural typologies, they are extended through an equivalence criterion based on the vulnerability classes defined in the European Macroseismic Scale (EMS-98; [12]). This methodology ensures that the expected structural behaviour during an earthquake is represented consistently and that the exposure database is treated uniformly.

For bridges, we used the fragility curves defined in [13].

In parallel with the physical exposure analysis, the EMERGE project also has developed a socio-economic vulnerability assessment for the entire CBR, aiming to create a harmonised and comparable municipal-level dataset. The analysis is based on the Social Vulnerability Index (SoVI; [14]) framework and integrates thirty-five indicators grouped into seven thematic dimensions - population, education, economy, health, infrastructure, habitat, governance, and institutional capacity - to describe socio-demographic and economic conditions and quantify relative social vulnerability. This approach captures the factors influencing communities' ability to prepare for, respond to, and recover from extreme events, providing an integrated framework to support risk reduction strategies.

The assessment has been conducted through two scenarios. The first scenario applies a uniform "importance" weight across the entire area, as well as country-specific "quality" weights to account for differences in data availability and resolution at the municipal level. The second scenario uses country-specific weights for both "importance" and "quality", reflecting expert judgement on the relative relevance of each indicator within its thematic group and the level of detail of the data source. This allows for greater adaptation to national contexts. Both scenarios are available on the platform under the **Exposure** tab, along with their respective legends.

2-3- Holistic Approach To Near-Real-Time Multi-Hazard And Rapid Needs Assessment

The EMERGE WBP adopts a holistic framework in which multi-hazard mapping, exposure and vulnerability modelling, and operational capacity evaluation are integrated within a unified computational environment. This architecture enables the seamless transition from hazard characterization to impact estimation and, subsequently, to rapid needs assessment across the cross-border region.

The system is structured around three tightly interconnected components: (i) multi-hazard assessment (NRT seismic + landslide hazard layers), (ii) impact estimation (Physical/human disruption via SP-BELA/HAZUS fragility), and (iii) rapid needs evaluation (72-hour demand-capacity matching). Seismic shaking and earthquake-induced landslide hazard layers, generated as described in Section 2-1-, constitute the primary input to the analytical workflow. These hazard layers are automatically coupled with the harmonized exposure database, which includes residential, commercial, and industrial buildings, as well as schools, hospitals, and bridges, alongside spatially distributed population data (Section 2-2-). Vulnerability models associated with each asset class translate hazard intensity measures into estimates of physical disruption and human impact.

The resulting impact metrics form the basis for the Rapid Needs Assessment module, designed to support decision-making within the first 72 hours following a seismic event. The methodological logic is based on a quantitative comparison between estimated post-event demand and available response capacity. Demand indicators are derived from modelled physical impacts and include, for example, the number of injured individuals requiring medical assistance, displaced persons requiring temporary accommodation, and areas potentially isolated due to infrastructure disruption. These indicators are spatially aggregated at municipal and regional scales to allow prioritization of intervention areas.

A core innovation of EMERGE lies in the integration of a structured and georeferenced database of National Civil Protection Authorities' (NCPAs) resources, capacities, and operational capabilities within the same analytical environment. This comprehensive database includes information on emergency facilities (e.g., hospitals with emergency departments), potential shelter buildings (e.g., structurally usable schools), civil protection offices, fire-fighting stations, police units, and other logistical assets relevant to disaster response. Each resource is characterized not only by precise geo-location but also by quantitative capacity attributes, such as bed availability, shelter capacity, and operational functionality.

By coupling estimated post-event demand with the spatial distribution and capacity of available resources, the platform enables a systematic evaluation of response capability across the CBR. The comparison between required and available capacity allows the identification of response gaps, capacity exceedance thresholds, and potential bottlenecks in emergency service provision. Routing analysis tools, continuously updated to account for possible infrastructure disruption, further support logistical optimization by identifying accessible paths to critical facilities and prioritizing safe access corridors.

This integrated approach ensures that hazard evolution, impact estimation, and resource allocation are not treated as separate analytical steps but as components of a continuous decision-support workflow. The harmonization of data structures, spatial resolution, and methodological assumptions across the three countries guarantees cross-border consistency and comparability of results. When national capacities are insufficient to meet estimated demand, the system provides evidence-based indications for cross-border assistance and coordinated resource sharing, reinforcing regional cooperation mechanisms.

Through this holistic multi-hazard and rapid needs assessment architecture, EMERGE advances beyond conventional scenario-based risk platforms and establishes an operational framework capable of supporting coordinated emergency management, enhancing situational awareness, and strengthening preparedness and resilience across the cross-border region.

3- CONCLUSIONS

This work has presented EMERGE WBP as an integrated, operational multi-hazard tool designed to strengthen transboundary seismic risk management in the Balkan cross-border region of North Macedonia, Albania and Greece. By building upon the methodological foundations established in the CRISIS project, EMERGE advances from scenario-based risk mapping toward a dynamically updated, decision-oriented framework that bridges hazard monitoring, impact estimation, and emergency capacity evaluation within a single analytical environment.

The integration of NRT seismic ground shaking mapping together with earthquake-induced landslide effects ensures spatial consistency across borders, overcoming administrative fragmentation in regions where tectonic processes are inherently transnational. The expansion of the exposure model to include the broader building stock, critical infrastructure, and spatially distributed population data enables a comprehensive assessment of both physical disruption and potential societal impact. The incorporation of social vulnerability indicators further enhances the platform's ability to capture differential response capacity and recovery potential across communities.

A central innovation of EMERGE lies in the explicit coupling of impact estimates with a structured database of National Civil Protection Authorities' resources, capacities, and operational capabilities. By quantitatively matching estimated post-event demand with available emergency assets, the platform translates analytical outputs into actionable information for rapid prioritization, resource allocation, and cross-border coordination. This demand-capacity matching mechanism represents a decisive step toward operationalizing risk assessment within the first critical hours following a seismic event.

Beyond its regional implementation, EMERGE demonstrates the value of harmonized data structures, interoperable geospatial architectures, and shared methodological assumptions in enhancing European civil protection cooperation. The platform provides a replicable blueprint for integrated multi-hazard emergency planning in other seismically active transboundary regions, aligning scientific modelling with operational needs and reinforcing resilience through coordinated preparedness.

In this perspective, EMERGE does not merely extend previous risk assessment tools but establishes a scalable and transferable framework that strengthens situational awareness, supports evidence-based decision-making, and contributes to a more resilient and interconnected European disaster management system.

4- ACKNOWLEDGMENT

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Assessing Social Vulnerability to Natural Hazards in Cross-Border Regions: The EMERGE Project

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Abstract

Assessing social vulnerability is essential for understanding how communities may experience and recover from earthquakes. In the framework of the EMERGE project, funded by the European Union Civil Protection Mechanism (UCPM), the **Social Vulnerability Index (SoVI)** methodology is applied to evaluate social vulnerability in a complex cross-border region shared by Albania, Greece, and North Macedonia. The selected indicators for the SoVI calculation capture the main dimensions of social vulnerability, including demographic structure, socio-economic conditions, institutional performance, and the availability of essential services. The resulting SoVI maps reveal pronounced spatial variability in social vulnerability both across and within national borders, highlighting strong contrasts in how vulnerability manifests in distinct administrative, territorial, and socio-economic contexts. This analysis provides valuable insights into which indicators most strongly influence vulnerability at the municipal scale and across each country's cross-border regions all-together. By distinguishing the relative contribution of social, demographic, and institutional dimensions, it becomes possible to identify the key drivers and spatial pattern of social vulnerability, thereby supporting the definition of targeted intervention priorities. Overall, the findings emphasize the importance of harmonized methodologies, integrated indicator systems, and multi-scalar analytical approaches for capturing the differentiated and context-specific nature of social vulnerability in transboundary environments and for supporting more informed disaster risk reduction policies within EMERGE and future initiatives.

Keywords: Social vulnerability, SoVI, cross-border regions, risk, hazard, exposure

1- INTRODUCTION

Natural hazards do not affect all communities equally. The scale and distribution of disaster impacts are shaped not only by the physical intensity of a hazard or the structural characteristics of exposed assets, but also by the social conditions of the populations at risk. Socioeconomic status, demographic composition, institutional capacity, and access to essential services all influence how communities prepare for, respond to, and recover from disruptive events. Landmark disasters, including the 2010 Haiti earthquake, the Pakistan floods, and the 2023 Turkey earthquake, have repeatedly demonstrated that communities with similar hazard proneness can experience profoundly different outcomes depending on their underlying social conditions [1],[2]. Despite this well-established understanding, the social dimension of risk remains difficult to quantify and is frequently underrepresented in formal risk assessments.

Addressing this challenge requires robust methodological frameworks capable of translating complex social realities into measurable, spatially explicit indicators. The **Social Vulnerability Index (SoVI)**, originally proposed by Cutter et al. (2003) [1], has become one of the most widely adopted tools for this purpose. By applying statistical analysis to census-derived data, SoVI produces composite vulnerability scores that enable meaningful comparisons across administrative units and geographic scales. Complementary approaches, such as the Resilience Performance Scorecard [3] or the Risk Management Index [4], extend this analytical reach by incorporating qualitative assessments and evaluations of institutional capacity. More integrated frameworks, including the Megacity Indicator System [5], further combine physical, social, and institutional dimensions to provide holistic evaluations of risk and coping capacity.

Within Europe, the application of social vulnerability methodologies has evolved considerably, moving from early national adaptations of SoVI-type indices towards more spatially refined assessments that couple social indicators with physical hazard models. Studies in cities such as Bucharest have illustrated the close relationship between social vulnerability, ageing building stock, and low-income populations [6],[7], while broader European analyses have identified socioeconomic status, age, and disability as consistent drivers of vulnerability across different contexts [8],[9],[10].

The cross-border region shared by Albania, Greece, and North Macedonia presents a particularly instructive context for this type of analysis. In Greece, studies have documented how social inequality, population ageing, and urban density amplify seismic risk, especially in major cities such as Athens and Thessaloniki [11],[12]. In Albania, the 2019 Durrës earthquake exposed the compounding role of poor housing quality and deep socioeconomic disparities, reinforcing calls for systematic vulnerability evaluation [13]. In North Macedonia, urbanisation patterns and the prevalence of older building stocks in vulnerable communities have similarly been identified as significant contributors to disaster risk [14],[15]. Taken together, these national contexts underscore the heterogeneity of vulnerability across the region and the importance of harmonised, transboundary assessment approaches.

In this paper, as part of the EMERGE project, funded by the European Union Civil Protection Mechanism (UCPM), the SoVI methodology is applied across the aforementioned three-country cross-border region to produce a spatially explicit characterisation of social vulnerability at the municipal scale. The selected indicators capture key dimensions of vulnerability including demographic structure, socioeconomic conditions, institutional performance, and service availability, whose contribution to the total vulnerability is properly weighted according to their importance and quality of available data. Beyond mapping, the analysis identifies the dominant drivers of social vulnerability in each national context and across the region as a whole, offering actionable insights for targeted disaster risk reduction policies and future transboundary risk governance initiatives.

2- METHODOLOGY

The social vulnerability assessment was conducted using the Social Vulnerability Index (SoVI) framework originally proposed by [1], which quantifies the degree to which a population is susceptible to the adverse impacts of natural hazards based on a set of socio-economic and demographic indicators. Figure 1 describes the methodological framework for the SoVI assessment, organised into five sequential steps: data collection, variable standardisation, weight assignment, index computation, and result interpretation.

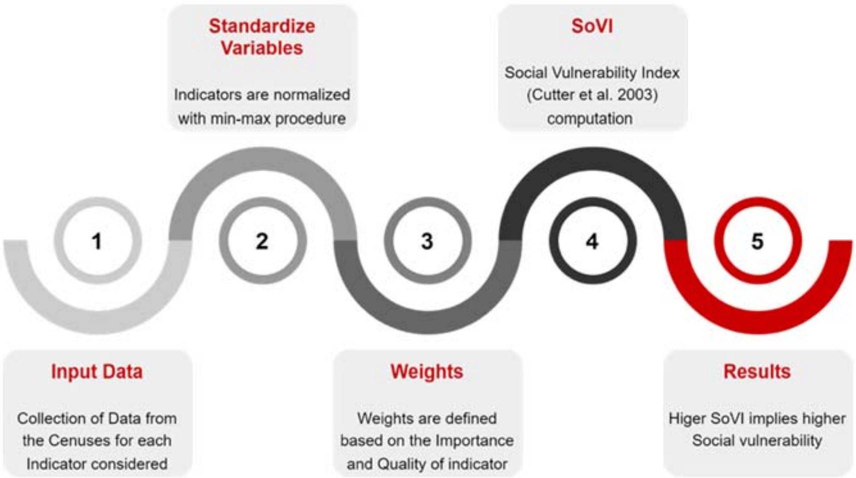

Figure 1- Methodological framework for social vulnerability assessment.

The first step involved collecting census-based data for all indicators considered in the analysis. The selected indicators were derived from national census datasets and official statistical sources for Albania, Greece, and North Macedonia, yielding a set of 35 variables organised into seven thematic groups, representing the main dimensions of social vulnerability. These groups reflect the key factors known to shape a community's capacity to prepare for, respond to, and recover from damaging seismic events, including demographic structure, socioeconomic conditions, education, access to healthcare, availability of critical infrastructure, urban–rural settlement patterns, and governance quality. Each indicator was assigned a cardinality, positive (+) or negative (–), indicating whether an increase in its value corresponds to an increase or decrease in social vulnerability, respectively. The complete set of indicators, along with the seven thematic groups and associated cardinalities, are presented in Table 1.

The table includes key standard parameters describing the population, as divulged in a census framework. These include age, formal (binary) gender, physical disability and nationality. Naturally, it cannot account for more sensitive parameters not formally collected as data (and actually often protected), but which may however affect the vulnerability of certain parts of the population to various natural hazards. These can include mental disorders and neurodiversity [16], gender identities [17] and religion/ethnicity/race [18]. The latter sensitive features become all the more important considering the recent geopolitical situation in southeastern Europe, particularly Greece, e.g. considering the increased vulnerability of refugees and immigrants [19]. Acknowledging the potential importance of such factors and the current inability to formally account for them in the study at hand, the formally collected data is analysed.

To ensure comparability among variables expressed in different units and scales, all indicators were normalised using a min–max normalisation procedure (Step 2). This approach removes scale effects and transforms each indicator to a common range between 0 and 1, where 0 represents the least and 1 the most socially vulnerable condition. The normalisation follows Equation 1:

$$X_{q,i} = \frac{x_{q,i} - \min_i(x_q)}{\max_i(x_q) - \min_i(x_q)} \quad \textbf{(1)}$$

where $x_{q,i}$ represents the value of indicator q for municipality i, and $\min_i(x_q)$ and $\max_i(x_q)$ are the minimum and maximum values of the same indicator across all municipalities and $X_{q,i}$ is the normalised index score of indicator q for municipality i.

Following normalisation, weights were assigned to each indicator based on two complementary criteria: the **importance** of the data, reflecting the theoretical relevance of each indicator to social vulnerability, and the **quality** of the data, capturing its reliability, completeness, and spatial resolution (step 3). These criteria ensure that indicators with greater conceptual significance and higher data quality exert proportionally greater influence on the final SoVI score. The final weight assigned to each indicator within a given thematic group was obtained by combining both criteria according to Equation 2:

$$w_q = \frac{w_{q,I} \cdot w_{q,Q}}{\sum_{q=1}^{n} (w_{q,I} \cdot w_{q,Q})} \quad \textbf{(2)}$$

This procedure ensures internal consistency among indicators and allows direct comparison across groups with differing numbers of variables.
The next step was the computation of the Social Vulnerability Index, following the framework originally proposed by [1]. The vulnerability score V_i for each municipality i was obtained by aggregating the normalised and weighted indicator values across all thematic groups and rescaling the results to a range between 0 and 5, where 0 represents the least and 5 the most vulnerable condition, according to Equation 3:

$$V_i = S\sum_{q=1}^{n} w_q X_{q,i} \tag{3}$$

where w_q is the weight assigned to the q^{th} indicator and n is the total number of variable/indicators considered.

Table 1- Group and sub-group Indicators for the computation of SoVI along with their cardinality

No.	Group Indicator	No.	Indicator	Cardinality
1	*Population*	1	% Population < 18/19 years	+
		2	% Population > 60 years	+
		3	% Female	+
		4	% Disabled	+
		5	% Population of foreign nationality	+
2	*Education*	6	% Illiterate	+
		7	% Population without elementary education	+
		8	% Population without high school education	+
		9	% Population with high school degree	-
		10	% Population with university graduates	-
3	*Economy*	11	Unemployment rate	+
		12	% Labor force working in secondary sector employment	+
		13	% Labor force employed in service industries	+
		14	% Female labor force participation	+
		15	Average income	-
		16	% below poverty line	+
4	*Health*	17	# Hospitals	-
		18	# Beds	-
		19	# Doctors	-
		20	Crude birth rate	+
		21	Crude death rate	-
		22	Life expectance	-
		23	Service coverage index	-
5	*Infrastructure*	24	Road network (km/km^2)	-
		25	% House without water	+
		26	% House without electricity	+
		27	% Vehicles	-
6	*Habitat*	28	% Female headed households	+
		29	Population density (# people/ km^2)	+
		30	Housing density (# people /house)	+

		31	Urban density (# buildings/ km^2)	+
		32	% House owners	+
		33	% Urban population	-
7	*Governance And Institutional Capacity*	34	Crime rate	+
		35	Abstention rate from election	+

The composite SoVI value was produced through an additive aggregation of weighted vulnerability scores across all relevant thematic groups, yielding a single index that captures the overall social vulnerability of each municipality. Since SoVI is a relative measure, the resulting scores are comparable only within the specific geographic extent considered in the analysis.

The final step includes the interpretation of the municipal-level SoVI scores, with higher values indicating municipalities with greater social vulnerability. The resulting maps reveal the spatial distribution of vulnerability across the cross-border region, enabling the identification of the most at-risk municipalities with respect to their social characteristics and the dominant drivers of social vulnerability in each national context.

3- CBR STUDY AREA AND SOVI DATA AVAILABILITY

The SoVI framework was applied to the cross-border region (CBR) defined within the EMERGE project, encompassing municipalities from three neighbouring countries: Albania, North Macedonia, and Greece. The study area comprises 17, 18, and 14 municipalities from each country respectively, yielding a total of 49 municipalities across the CBR (Figure 2).

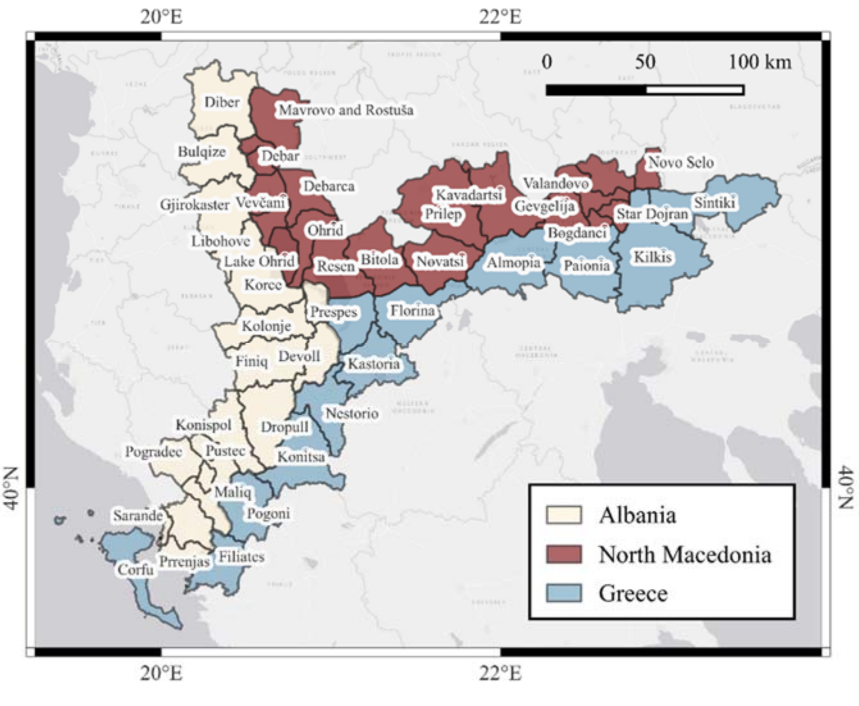

Figure 2- Cross-border region (CBR) between Albania, North Macedonia, and Greece considered for the SoVI analysis, showing the municipalities included in the study area.

The selection of indicators was guided by two complementary considerations: the availability of reliable data at the municipal scale and the socio-economic characteristics specific of the region. Census data were collected primarily from national statistical agencies, namely INSTAT [20]for Albania, ELSTAT [21]for Greece, and the State Statistical Office MAKSTAT [22]for North Macedonia, while Eurostat and other equivalent sources were used when municipal-level data were unavailable. In cases where disaggregated information could not be obtained, regional or national-level statistics or proxy variables with strong empirical correlations to the missing indicators were employed to preserve spatial consistency and cross-border comparability.

Across all three countries, the construction of a harmonised indicator dataset involved the integration of multi-source and multi-scale information, with standardisation procedures, proxy methods, and simplifying assumptions applied wherever necessary to ensure the consistency, completeness, and cross-border comparability of the final SoVI scores at the municipal level.

4- SOVI RESULTS

To gain insight into the social vulnerability discrepancies between the three CBR countries, the vulnerability score (V_i) for each group indicator, computed according to Equation (3) was aggregated among all the municipalities within each individual country. Figure 3 presents these vulnerability scores disaggregated by thematic group and country, to understand the relative contribution of each dimension to the overall SoVI.

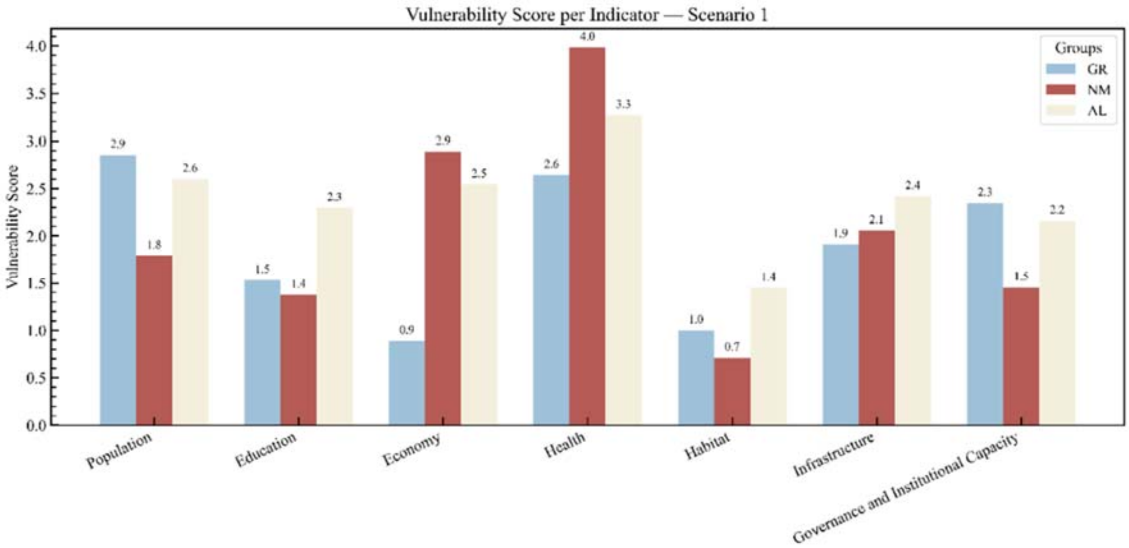

Figure 3- Vulnerability scores by thematic group for Greece (GR), North Macedonia (NM), and Albania (AL), showing the relative contribution of each group (Population, Education, Economy, Health, Habitat, Infrastructure, and Governance and Institutional Capacity) to the overall SoVI.

Health emerges as the dominant driver of vulnerability across all three countries, with North Macedonia recording the highest score (4.0), followed by Albania (3.3) and Greece (2.6), reflecting significant disparities in healthcare access and infrastructure. Economy represents the second most differentiating dimension for North Macedonia (2.9) and Albania (2.5), considerably outscoring Greece (0.9). Population structure contributes similarly across all three countries, with scores ranging from 1.8 to 2.9, while Education displays uniformly low scores, suggesting comparable levels of educational attainment across the region. Habitat records the lowest vulnerability scores overall, particularly in North Macedonia (0.7) and Greece (1.0). Infrastructure and Governance and Institutional Capacity show moderate and relatively consistent contributions across the three countries, with Albania scoring slightly higher in infrastructure (2.4) and Greece leading marginally in Governance (2.3).

Overall, the score estimates confirm that the primary drivers of social vulnerability are not uniform across the CBR but vary depending on the country considered: while Health consistently represents a dominant contributor across all three national subsets, Economy and Infrastructure play a proportionally greater role in Albanian municipalities, Governance and Health characterise the highest-scoring North Macedonian municipalities, and a more balanced distribution across thematic dimensions defines the Greek subset with Population having the highest scoring.

In order to support the prioritisation of disaster risk reduction interventions, Figure 4 reports the SoVI scores for the municipalities of the CBR, ordered from most to least vulnerable within each country. Each bar is colour-coded according to the contribution of each thematic group, allowing simultaneous reading of the total vulnerability score and its internal composition at the municipal level. It is worth noting that the values shown in Figure 4 are obtained through a weighted average of the individual group scores illustrated in Figure 3, assigning a weight of 0.15 to the thematic groups Population, Education, Economy, Health, Habitat, and Infrastructure, and a slightly lower weight of 0.1 to Governance and Institutional Capacity, which comprises only two indicators. The country average SoVI values across the municipalities of the CBR in each country, shown as dashed horizontal lines, provide a reference for interpreting municipal-level variation and highlight the overall differences in social vulnerability across the three countries. Albanian municipalities record the highest national average (≈2.40), with several approaching or exceeding 2.50. North Macedonian municipalities display an intermediate national average (≈2.10), with Mavrovo i Rostuše, Centar Zhupa, and Debar recording the highest scores, while eastern municipalities such as Vevçani and Gevgelija fall below the national average. Greek municipalities record the lowest national average (≈1.87), with a more uniform thematic composition.

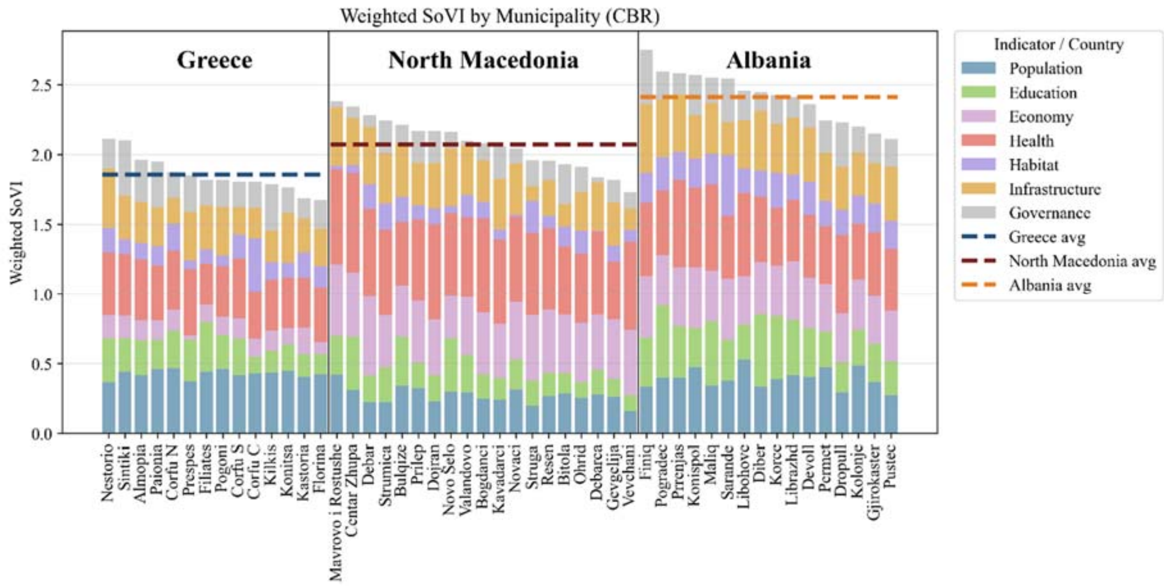

Figure 4- SoVI values for all 49 cross-border municipalities, grouped by country and ordered in descending order of vulnerability within each national subset. Dashed horizontal lines indicate the national averages for Greece (blue), North Macedonia (dark red), and Albania (orange).

Figure 5 presents the spatial distribution of SoVI scores across the municipalities of the cross-border region. The map clearly shows that the highest vulnerability is concentrated in the central and southern Albanian municipalities, with Finiq, Kolonjë, Korçë, Pogradec, and Konispol falling within the two highest classes, reflecting severe socioeconomic conditions, limited access to services, and weak institutional capacity. Several adjacent North Macedonian municipalities, including Mavrovo i Rostuše, Dibër, and Centar Zhupa, also record elevated scores, forming a contiguous high-vulnerability belt along the Albanian-Macedonian border.

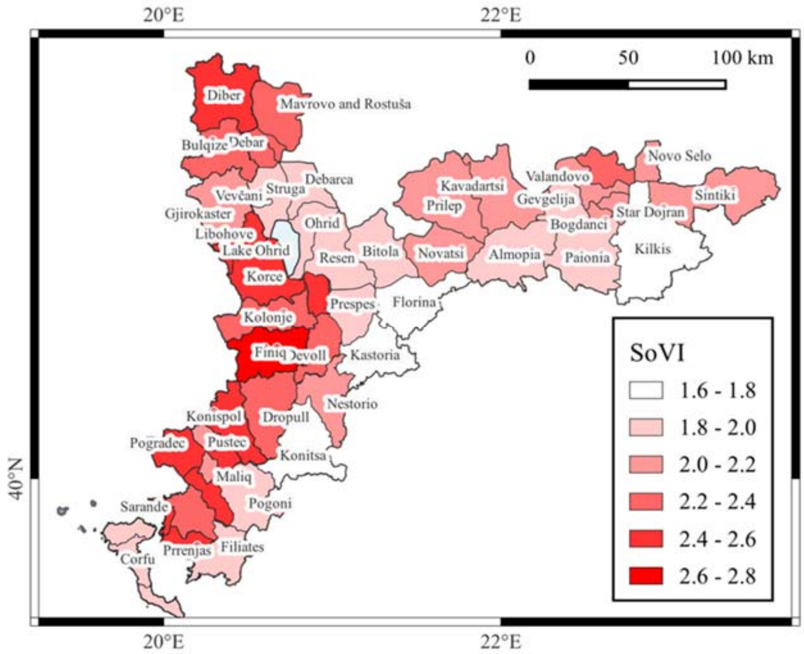

Figure 5- Spatial distribution of the Social Vulnerability Index (SoVI) across the 49 municipalities of the CBR.

Furthermore, the map shows a pronounced vulnerability contrast between municipalities that share common borders. Neighbouring municipalities on opposite sides of national boundaries, such as Kolonjë (Albania) and Florina (Greece), or Korçë (Albania) and Resen (North Macedonia), display markedly different SoVI scores despite their geographic proximity and comparable seismic hazard. This spatial discontinuity underscores how national differences in socioeconomic conditions, institutional frameworks, and data availability translate directly into vulnerability disparities at the local level and highlights the critical importance of transboundary coordination in disaster risk reduction planning within the EMERGE cross-border region.

5- CONCLUSIONS

This study applied the Social Vulnerability Index (SoVI) methodology across the cross-border region shared by Albania, Greece, and North Macedonia within the EMERGE project framework, producing a spatially explicit assessment of social vulnerability at the municipal scale. The analysis of 49 municipalities revealed pronounced spatial variability in vulnerability both across and within national borders, reflecting the differentiated influence of demographic, socioeconomic, institutional, and service-related factors in each national context.

Among the three neighbouring countries, Albanian municipalities tend to exhibit comparatively higher vulnerability levels, driven by a combination of factors such as healthcare accessibility, infrastructure and economic conditions. North Macedonian municipalities displayed intermediate vulnerability levels, with health-related factors emerging as dominant contributors, while Greek municipalities presented the lowest vulnerability scores with a more balanced distribution across thematic dimensions.

A particularly important finding is the sharp vulnerability contrast between geographically adjacent municipalities on opposite sides of national borders, despite comparable seismic hazard levels, underscoring how national differences in socioeconomic conditions and institutional capacity translate directly into local vulnerability disparities.

These results confirm the value of harmonised, multi-indicator methodologies for capturing the context-specific nature of social vulnerability in transboundary environments. By identifying the dominant drivers of vulnerability at both the municipal and national level, the SoVI framework provides actionable guidance for prioritising disaster risk reduction interventions and supports more informed, spatially targeted policies within the EMERGE project and future cross-border risk governance initiatives.

6- ACKNOWLEDGMENT

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Annex E

7th World Landslide Forum, Faridabad, India

23-27 November 2026

(Submitted Abstract)

7th WORLD LANDSLIDE FORUM
INDIA 2026
Amrita Vishwa Vidyapeetham, Faridabad | 23-27 Nov 2026

EXTENDED ABSTRACT TEMPLATE

Preferred Session

Session 1.1: International Programme On Landslides And Global And International Activities For Klc2020

Title of Contribution

Near Real-Time (NRT) earthquake induced landslide hazard and risk assessment

Authors

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Abstract

Earthquake-induced landslides represent a significant component of seismic risk, particularly in mountainous and transboundary regions where infrastructure and population are exposed to cascading impacts. Regional-scale methodologies for landslide hazard and risk assessment are increasingly required to support both emergency response and long-term planning. This contribution presents an operational approach that builds upon the harmonized methodology developed within the CRISIS (Comprehensive Risk Assessment of Basic Services and Transport Infrastructure) past project and extends it toward near real-time application through recent developments in the EMERGE (Rapid Multi-Risk Needs Evaluation and Planning Platform) ongoing project (Salic-Makreska et al., 2026), including the integration of ShakeMap data and the Rapid Needs Assessment (RNA) methodology.

The CRISIS framework proposes a harmonized methodology for earthquake-induced landslide hazard and risk assessment at the regional scale, particularly suited for areas with heterogeneous

or limited datasets, such as transboundary regions (Bojadjieva et al., 2025). The hazard component comprises several steps, including landslide susceptibility mapping and the estimation of a critical acceleration, threshold to check the onset of slope instability. These inputs are combined with seismic loading to estimate landslide hazard, expressed through expected Permanent Ground Displacement (PGD; Fotopolou & Pitilakis, 2015). In this context, PGD is used as an indicator of slope response to seismic ground shaking, allowing for the spatial delineation of areas prone to earthquake-induced deformation. The risk component of the CRISIS methodology integrates hazard, exposure and vulnerability, focusing on key elements such as schools, healthcare facilities, and bridges. The framework was applied to a cross-border region comprising North Macedonia, Albania, and Greece, using an exposure model for 191 school buildings, 46 healthcare facilities, and 372 bridges. The results demonstrated that the methodology is practical, relatively fast, and applicable even in data-limited environments, providing a useful overview of hazardous areas and potential impacts. The outputs were implemented within a web-based platform for visualization and analysis of landslide risk scenarios.

In the present work, this concept is further developed toward a near real-time application within the EMERGE framework. The key modification concerns the representation of the seismic triggering mechanism. Instead of relying on predefined earthquake scenarios, the same conceptual approach used in CRISIS is retained, with the seismic input derived from near-real-time ground-shaking estimates. In particular, ShakeMaps are used to provide spatially distributed parameters, such as Peak Ground Acceleration (PGA), describing the observed or estimated shaking conditions immediately after an earthquake.

Within this approach, set of ground motion parameters serve as proxies for seismic loading in calculating slope response, maintaining consistency with the PGD-based approach introduced in the CRISIS methodology. This keeps the estimation of landslide hazard conceptually the same while making it event-driven and dynamically updated. Near-real-time shaking intensity enables rapid computation of landslide hazard maps shortly after an earthquake, reflecting the spatial variability of observed ground motion. The RNA methodology, developed within the EMERGE project, supports this process by providing a practical link between ground shaking intensity and landslide occurrence prediction. The approach combines susceptibility and critical acceleration layers with earthquake shaking using empirical relations. These susceptibility datasets are prepared in advance, enabling rapid integration with ShakeMap outputs during an event. The result is a spatially distributed estimate of landslide probability or expected slope response, consistent with the PGD-based framework. The risk assessment component follows the principles established in CRISIS, combining hazard outputs with exposure data and vulnerability assessment to identify potentially affected critical infrastructure. In a near-real-time context, this allows also for rapid identification of routes where landslides may impact main components of transportation networks. Although simplified, these results are useful for supporting emergency response and prioritizing interventions. The proposed framework builds on the strengths of the CRISIS methodology, including its applicability in data-limited and cross-border regions, while extending its use toward operational, near real-time applications within the EMERGE framework. Integrating ShakeMap and RNA enables automated, repeatable workflows in which susceptibility and exposure data are prepared in advance, and post-event processing focuses on rapid ingestion of seismic data. Uncertainty remains inherent in near-real-time assessments due to limitations in input data and modeling assumptions. Therefore, the results should be interpreted as indicative and probabilistic, supporting decision-making rather than providing precise predictions. Overall, this work highlights the potential of real-time approaches for the rapid assessment of earthquake-induced landslide hazard and risk, enabling timely and spatially detailed evaluation of evolving ground conditions. Such capability supports improved situational awareness and more effective decision-making in the immediate aftermath of seismic events.

Keywords

[earthquake-induced landslide; hazard and risk assessment; near real-time; Shakemap; permanent ground displacement (PGD)]

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