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SEISMIC RESILIENCE THROUGH EUROPEAN RESEARCH NETWORKING - CRISIS PROJECT

Abstract

CRISIS project aims at improving the disaster and emergency management through building a harmonized and efficient system for risk assessment of basic services and transport infrastructure in the targeted cross-border region. The main project activities include: (1) Cross-border multi hazard assessment; (2) Needs assessment; (3) Cross- border multi-risk assessment; and (4) Development of cross-border web base platform for risk assessment and management. The main stakeholder of the project is the civil protection and disaster management national authorities in the cross-border region where more than 500.000 inhabitants live, as well as all academic partner institutions that will share the knowledge and strengthen the mutual cooperation.

Keywords: seismic resilience, seismic risk, critical infrastructure, landslide

СЕИЗМИЧКА ОТПОРНОСТ КРОЗ ЕВРОПСКО ИСТРАЖИВАЧКО УМРЕЖАВАЊЕ – ПРОЈЕКАТ "CRISIS"

Сажетак

Пројекат CRISIS има за циљ унапријеђење управљања катастрофама и ванредним ситуацијама кроз изградњу хармонизованог и ефикасног система за процјену ризика основних услуга и саобраћајне инфраструктуре у циљаном прекограничном региону. Главне пројектне активности укључују: (1) Прекограничну процјену вишеструких опасности (2) Процјену потреба (3) Прекограничну процјену вишеструког ризика и (4) Развој прекограничне *web* платформе за процјену и управљање ризиком. Главни носилац пројекта су националне власти цивилне заштите и управљања катастрофама у прекограничном региону, у коме живи више од 500.000 становника, као и све академске партнерске институције, које ће подијелити знање и ојачати међусобну сарадњу.

Кључне ријечи: сеизмичка отпорност, сеизмички ризик, критична инфраструктура, клизиште

1. INTRODUCTION

The European continent is characterized by a history of natural disasters: earthquakes, floods, landslides, draughts, extreme temperatures, forest fires and tempests with extensive economic, social, and ecological consequences that affect human wellbeing and the wellbeing of the society in a long run. These natural disasters often exceed the capacity of countries to manage emergency situations in the aftermath of a natural disaster and call for cross-border and regional cooperation. In addition, the preparedness and prevention level vary from country to country, whereat, achievement of the necessary preparedness level requires existence of a well-coordinated regional and international cooperation that will include recent scientific knowledge in the field of natural disaster risk management.

This paper refers to activities carried out in the frame of project entitled 'Comprehensive RISk assessment of basic services and transport InfraStructure - CRISIS' (http://www.crisis-project.org/). The CRISIS project is supported by the Directorate General for European Civil Protection and Humanitarian Aid Operations, DG – ECHO as part of the European Commission. Project consortium includes five partners: Ss. Cyril and Methodius University in Skopje, Institute of Earthquake Engineering and Engineering Seismology-IZIIS as coordinator and Crisis Management Centre, Government of the Republic of N. Macedonia, Polytechnic University of Tirana, Faculty of Civil Engineering, Albania, Aristotle University of Thessaloniki, Greece and European Centre for Training and Research in Earthquake Engineering – EUCENTRE, Italy, as partners (Fig.1).

The CRISIS project is aimed at improve the management of natural disaster consequences through establishment of a harmonized and efficient system for assessment of the risk pertaining to vital structures and transportation infrastructure in the cross-border region of North Macedonia, Greece, and Albania.

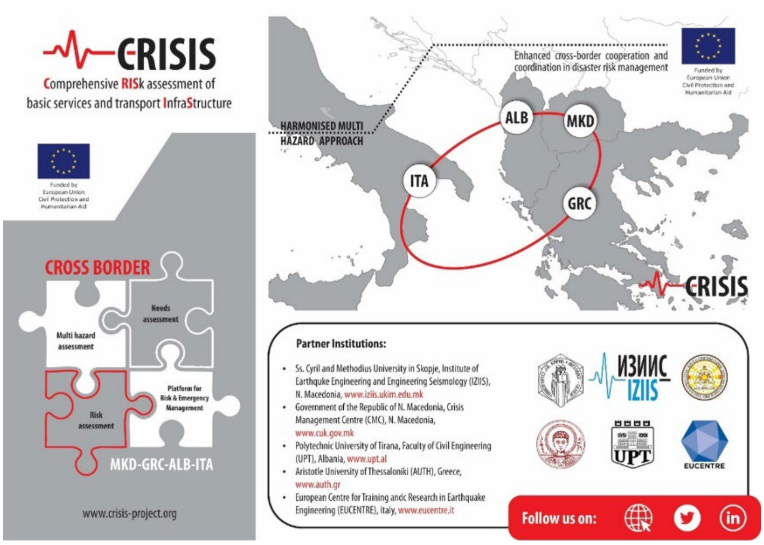

Figure 1. CRISIS Project consortium

2. PROJECT OBJECTIVES

The main objective of the CRISIS project is providing a solid basis for development of a cooperative approach to prevention and preparedness in disaster management in cross-border regions of the neighbouring countries located in the West Balkan region, by means of: (a) Assessment of natural cross-border hazards to basic services and transport infrastructure; (b) Collection, harmonization, and improvement of existing data and tools for risk assessment on critical assets; (c) Development and testing of the methodology incorporated in the web-based platform for rapid screening of vulnerable infrastructure nodes within a region.

Within the project, a comprehensive exposure model has been defined. The model is based on identified relevant goods associated with vital buildings and transportation infrastructure exposed to natural disasters that are relevant for the region of interest. To effectively manage emergency situations, a web platform that will integrate all natural hazards, the exposure model and analysis of different risk scenarios is being developed. The developed methodology and web platform will sustainability contribute to create a network of competent entities and development of disaster management plans in the cross-border regions.

3. MAIN PROJECT TASKS

The project is being realized through 4 main tasks (Fig. 2):

1. Identification of natural hazards in the cross-border region that affect the functioning of vital structures (health care institutions, institutions dealing with emergency situations, educational institutions, etc.) and the transportation infrastructure.
2. Review of existing legislation (EU and regional) related to management of emergency situations and risks. Pros and cons analysis related to management of emergency situations and risks. Pros and cons analysis with the purpose of identify existing omissions and bottlenecks.
3. Assessment of risk pertaining to vital structures and transportation infrastructure as the basis for the definition of key points in the entire system of emergency and disasters management.
4. Development of a geo-referenced web platform that will contain data related to: vital structures and transportation infrastructure in the cross-border region, natural hazards and vulnerability parameters of all elements at risk. This platform should be able to immediately provide information on the hazard, the exposure model and the risk and enable the assessment of possible losses and disruptions of the critical functions.

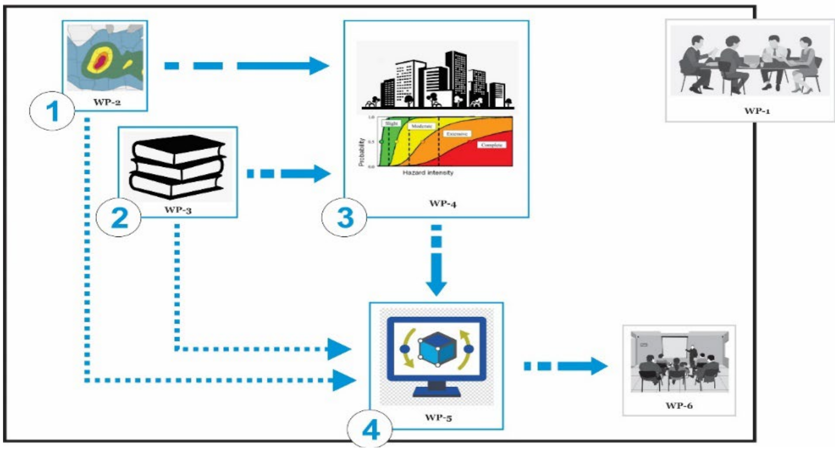

Figure 2. General block-diagram of the project

3.2. METHODOLOGY FOR IDENTIFICATION OF NATURAL HAZARDS

For the identification of hazards in the cross-border region version 2 of the ThinkHazard! screening tool (thinkhazard.org) has been used, developed by the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR - www.gfdrr.org), which enables users to screen project locations for multiple natural hazards, Fraser et al. (2017). ThinkHazard! translates technical hazard data describing hazard intensity, frequency, and susceptibility in scientific parameters. The hazard metrics is: very low, low, medium and high. The hazard classification is used to communicate hazard to users who are not expert in natural hazards but require hazard information for project planning and disaster risk management purposes. The four hazard levels (very low, low, medium and high) are derived from hazard maps, which present the spatial distribution of hazard intensity (e.g., flood depth, ground shaking) at a given frequency or return period.

3.2.1. IDENTIFICATION OF NATURAL HAZARDS AT THE CROSS-BORDER REGION

The classification of the hazard levels for all the different hazards included in *ThinkHazard! (*with the exception of volcano, tropical cyclone, tsunami, and coastal flood) are shown in Table 1. The selected municipalities extracted from the full list of municipalities of the cross-border region are taken into account.

Table 1. Classification of the hazard levels of the municipalities of the cross-border region

Municipality	Earthquake	Landslide	Wildfire	Extreme heat	Water scarcity	River flood	Urban flood
Filiates	High	High	High	Medium	Low	High	Medium
Konitsa	High	High	High	Medium	Low	Very low	Low
Pogoni	High	High	High	Medium	Low	Very low	Low
Florina	Medium	Low	High	Medium	Low	Low	Medium
Kastoria	Medium	Medium	High	Medium	Low	Very low	High
Bitola	Medium	Medium	High	Medium	Low	High	High
Bogdanci	Medium	Medium	High	Medium	Low	High	High
Centar Zupa	Medium	Medium	High	Low	Low	High	Low
Debarca	Medium	Low	High	Low	Low	Low	High
Debar	Medium	Medium	High	Low	Low	High	Low
Bulqize	Medium	High	High	Low	Low	High	High
Delvine	High	High	High	Medium	Very low	Very low	High
Devoll	High	High	High	Low	Low	Low	High
Diber	Medium	High	High	Low	Low	High	High
Dropull	High	High	High	Low	Low	High	High
….	….	….	….	…..	…..	…	….

As far as earthquake is concerned (Fig.3), the whole cross-border region is characterized by medium to high earthquake hazard. High level of earthquake hazard is concentrated at the western part of the cross-border region, covering a significant area of both Grece and Albania of the cross-border region, while North-Macedonia is characterized by medium seismic hazard level.
Regarding landslide hazard (Fig. 4), the hazard levels at the cross-border region range between very low and high. High landslide hazard level is observed at the western part of the cross-border region, with the whole of the Albanian part being characterized with high hazard level.
The earthquake and landslide hazard are considered as the most crucial types of hazards for critical infrastructure in the cross-border region.

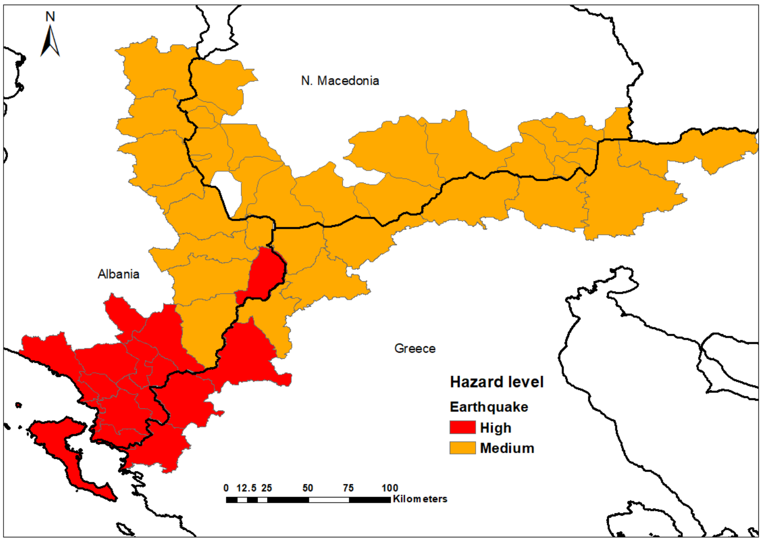

Figure 3. Spatial distribution of earthquake hazard levels at the CBR

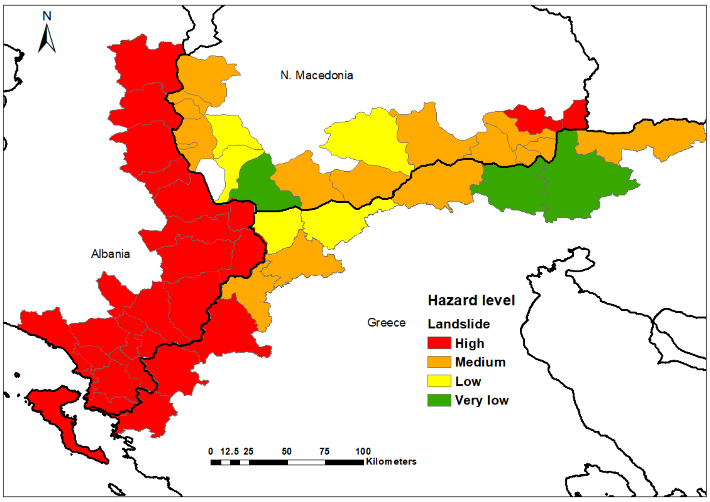

Figure 4. Spatial distribution of landslide hazard levels at the CBR

3.2.2. EARTHQUAKE HAZARD AT THE CROSS-BORDER REGION

For a more comprehensive presentation of the earthquake hazard at the cross-border region, the 2013 European Seismic Hazard Model (ESHM13) was used, Woessner, J. et al. (2015), which resulted from a community-based probabilistic seismic hazard assessment supported by the EU-FP7 project “Seismic Hazard Harmonization in Europe” (SHARE, 2009–2013) Giardini, D. et al. (2014). The ESHM13 is a consistent seismic hazard model for Europe and Turkey which overcomes the limitation of national borders and includes a through quantification of the uncertainties. Figure 5 illustrate the spatial distribution of the mean Peak Ground Acceleration (PGA) at the cross-border region for a reference rock condition, i.e. Eurocode 8 Type A with an average shear wave velocity vs_{30} = 800 m/s, for a 475-year respectively, obtained from ESHM13. Results are provided for sites equally spaced at 10 km. For T=475 years, PGA ranges between 0.21 and 0.45g. Results for T=975 years return period due to space limitation are not presented here. The regions where the highest levels of PGA are observed are the western coasts of the cross-border region to the Ionian Sea, as well as the island of Corfu. It should be noted that these PGA values refer to rock-site conditions and are expected to be amplified if local site conditions are considered.

3.2.3. LANDSLIDE HAZARD AT THE CROSS-BORDER REGION

A landslide susceptibility map subdivides the terrain into zones with differing likelihoods that a landslide may occur. Landslide susceptibility assessment can be considered the initial step towards a landslide hazard and risk assessment, but it can also be ‘end product’ in itself that can be used in land-use planning and environmental impact assessment.

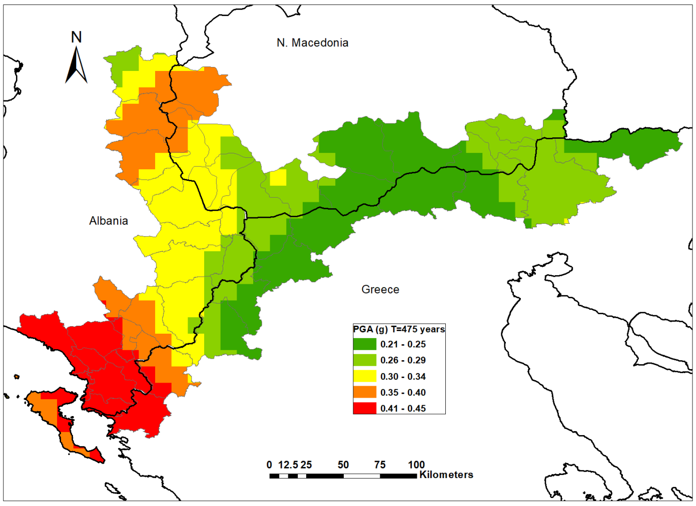

Figure 5. Spatial distribution of PGA at the cross-border region for a reference rock condition (Vs_{30} = 800 m/s) and for a 475-year return period

The landslide susceptibility map of the cross-border region is presented based on the Pan-European Landslide Susceptibility Map version 2 (ELSUS v2, Wilde, M., et al. (2018)), Figure 6. The map can be viewed at scales up to 1:200,000 as determined by the cell size of 200 × 200 m and should not be enlarged to greater scales.

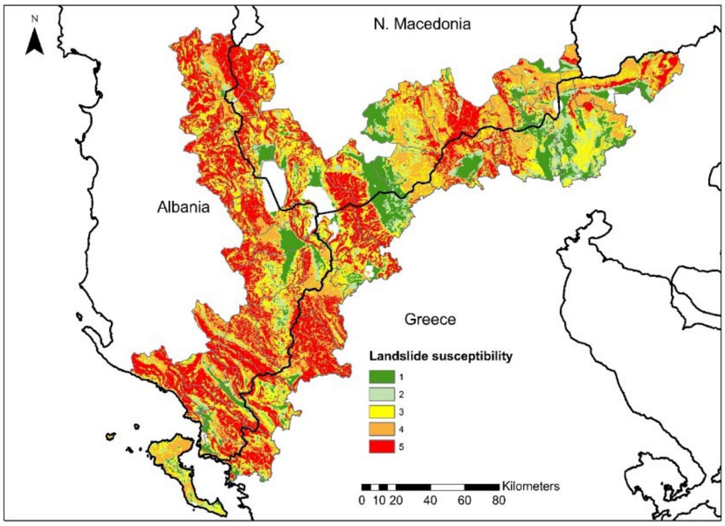

Figure 6. Landslide susceptibility of the cross-border region (where landslide susceptibility 1 = very low; 2 = low; 3 = moderate; 4 = high; 5 = very high)

The methodological approach for the elaboration, validation and classification of ELSUSV2 is the same as the previous version called ELSUS 1000 reported by Günther, A. et al. (2014). More specifically, a semi-quantitative method is used, combining landslide frequency ratios information with a spatial multi-criteria evaluation model of three thematic predictors: slope angle, shallow subsurface lithology and land cover. A landslide susceptibility index (LSI) for each model zone is computed based on the specific weight of these three thematic predictors for 'plain' and 'mountainous' model zones.

3.3. EVALUATION OF CREDIBLE SCENARIOS

3.3.1. EARTHQUAKE SCENARIOS

Evaluation of credible earthquake scenarios that may seriously affect basic services and critical infrastructure in cross border region is of the outmost importance. Scenarios are defined primarily on available seismological and seismo-tectonic data for the region of interest (databases ESHM13). For that purpose, 11 real earthquakes that have struck in the cross-border region and its vicinity were selected, as well as 9 seismogenic faults, considering the spatial distribution, level of seismic hazard and frequency of the earthquakes (see Fig.7). Although the parameters related to the selected earthquakes from SHARE European Earthquake catalogue slightly differ in relation to the parameters given in the official national earthquake catalogues, to keep a harmonization pattern, the parameters are not modified.

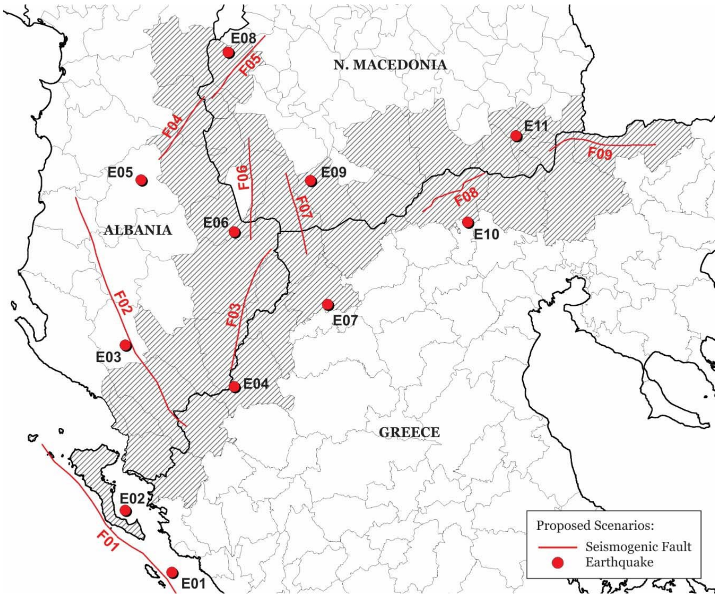

Figure 7. Spatial representation of earthquake scenarios

3.3.2. LANDSLIDE TRIGGERING SCENARIOS

Based on its scope and objectives, the earthquake as a triggering effect to cause landslides is taken into consideration to produce landslide hazard maps in terms of permanent displacements caused by different earthquake scenarios. Earthquake induced land sliding of a hillside slope occurs when the static plus inertia forces within the slide mass cause the factor of safety to temporarily drop below 1.0. The value of the peak ground acceleration within the slide mass required to cause the factor of safety to drop to 1.0 is denoted by the critical or yield acceleration a_c. Two seismic scenarios are defined with return periods equal to 475 years (magnitude M=6) and 975 years (magnitude M=7) based on ESHM13. To define the PGA value at surface, the V_{30} map proposed by US Geological Survey (earthquake.usgs.gov/data/vs30/) is used to categorize the ground type based on EC 8. The final product of the landslide hazard zonation is presented by digital maps of expected permanent displacements for the pre-defined earthquake scenarios (Fig. 8). The presented approach for the cross-border region is a simple tool which is used to recognize the hazardous areas, where limited available geotechnical and seismological datasets exist.

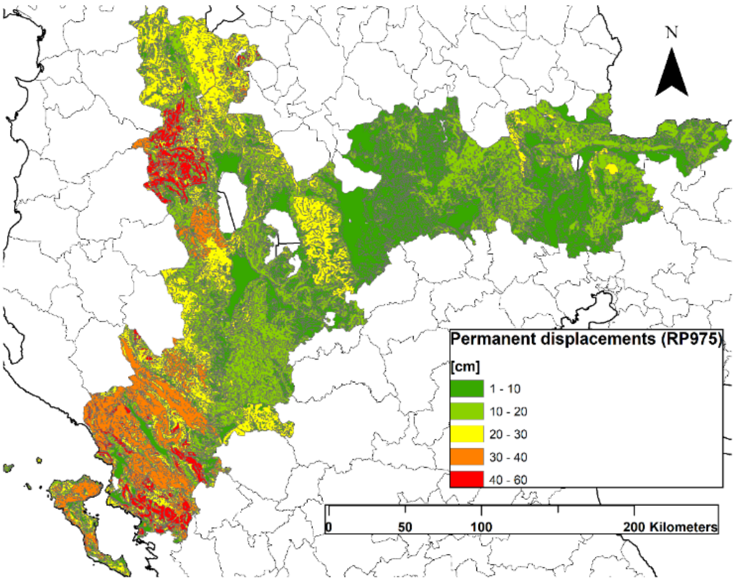

Figure 8. Spatial distribution of permanent ground displacement, seismic scenario of 975 years return period

4. CONCLUSIONS

The paper presents main findings and results achieved within the CRISIS project (project on going). Identification of natural hazards and most credible risk scenarios in the cross-border region between N. Macedonia, Albania and Greece that affect the functioning of basic structures and transportation infrastructure were presented.

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