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HARMONIZED REGIONAL RISK EXPOSURE MODEL OF BASIC SERVICES AND TRANSPORT INFRASTRUCTURE OF CBR BETWEEN N.MACEDONIA, GREECE AND ALBANIA

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Abstract

In recent years, the improvement of disaster and emergency management through building a harmonized and efficient system for risk assessment of structures in the cross-border region (CBR) has become increasingly popular. Harmonization of the risk exposure model for cross border regions is first and most important step for assessment of risk in the region. Different countries, even neighboring ones, have different frameworks in which buildings for basic services and transport infrastructures are designed, built and maintained. Hence, they involve different institutions and employ different ways of gathering information on existing structures within their networks. Each of them may use different methods and systems for keeping records on their assets. Therefore, there is no readily available inventory which covers the entire stock of bridges and buildings for basic services in any of the CRISIS adjacent partner countries. The harmonized regional risk exposure model is result of the activities carried out within one of the working packages of two-year EU-funded project CRISIS (Comprehensive RISk assessment of basic services and transport InfraStructure). In this paper harmonized regional risk exposure model for the basic services (schools and hospitals) and transport infrastructure (bridges) is shown. Herein presented are the realized activities that enabled developing a harmonized cross-border regional risk exposure model, which encompasses all relevant assets related to the basic services and transport infrastructure. A regional exposure database has been created based on contemporary practice and research compatible with the GEM Exposure Database (https://storage.globalquakemodel.org/what/physical-integrated-risk/exposure-database/). This database is specific enough to conduct numerical analysis and develop or select proper vulnerability functions.

Keywords: harmonized exposure model, basic services, transport infrastructure, risk assessment, bridges

1. Introduction

In recent years, the improvement of disaster and emergency management through building a harmonized and efficient system for risk assessment of structures in the cross-border region has become increasingly popular. This research specifically focuses on enhancing the cross-border cooperation and coordination in disaster risk management based on developed models and tools and raising public awareness and preparedness for disasters.

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The main objective of this paper is to present the harmonized regional risk exposure model for the basic services and transport infrastructure. The realized activities enable creation of a harmonized cross-border regional risk exposure model, which encompasses all relevant assets related to the basic services and transport infrastructure. A regional exposure database has been created based on contemporary practice and research compatible with the GEM Exposure Database (https://storage.globalquakemodel.org/what/physical-integrated-risk/exposure-database/). This database is specific enough to conduct numerical analysis and develop or select proper vulnerability functions. A vital phase of this work is basis for the vulnerability assessment of the representative structural typology concerning the identified levels of seismic and landslide hazards.

2. Methodology

Different countries, even neighboring ones, have different frameworks in which buildings for basic services and transport infrastructures as well as bridges are designed, built and maintained. Hence, they involve different institutions and employ different ways of gathering information on existing structures within their networks. Each of them may use different methods and systems for keeping records on their assets. Therefore, there is no readily available inventory which covers the entire stock of bridges and buildings for basic services in any of the CRISIS adjacent partner countries.

2.1 Buildings for basic services

To provide a set of tools and models for risk analysis, the Global Earthquake Model (GEM) has been used. The purpose of the GEM Building Taxonomy is to describe and classify buildings in systematic and uniform manner. It is a key step towards assessing the seismic risk pertaining to buildings.

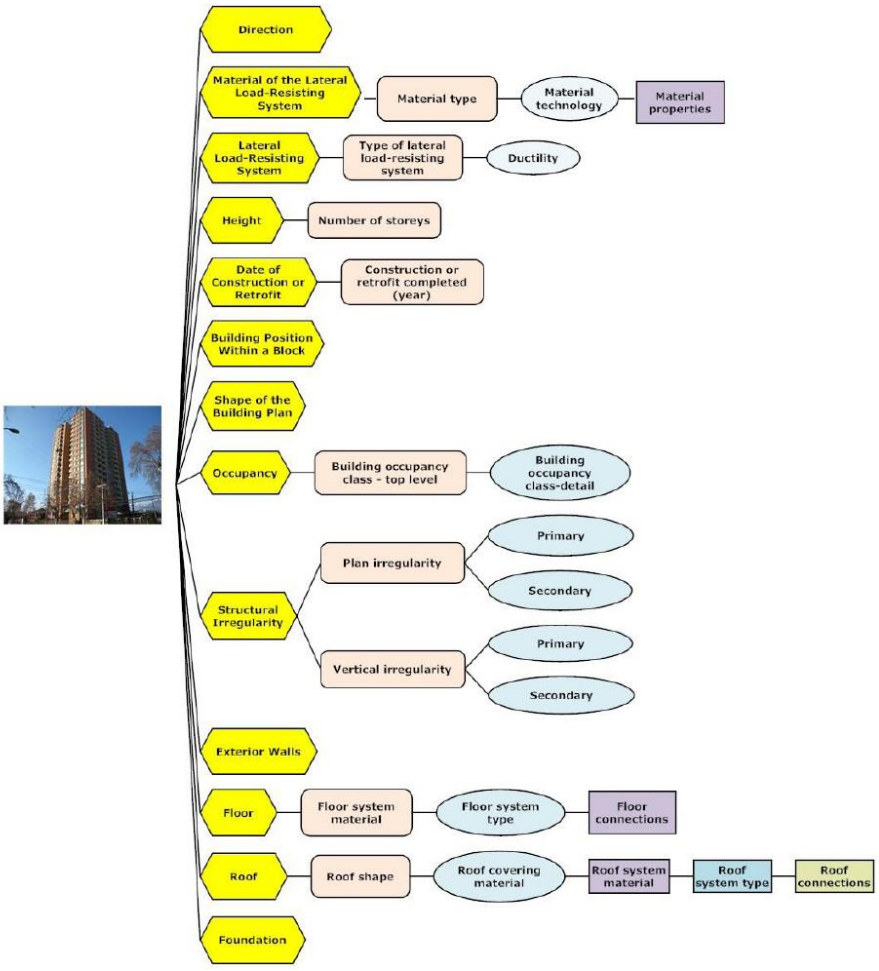

Figure 1. GEM Building Taxonomy v2.0: attributes and associated levels of detail [1]

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The Building Taxonomy data model is highly flexible and has the ability to represent building typologies using a shorthand form. This taxonomy was independently evaluated and tested by the Earthquake Engineering Research Institute (EERI), which received 217 TaxTreports from 49 countries, representing a wide range of building typologies, including single and multi-story buildings, reinforced and unreinforced masonry, confined masonry, concrete, steel, wood, and earthen buildings used for residential, commercial, industrial and educational occupancy [1]. Attributes and associated details included in the GEM Building Taxonomy are presented in Fig. 1.

The GEM Building Taxonomy describes a building or a building typology through 13 attributes which are associated with specific building characteristics that can potentially affect seismic performance:

1. **Direction** - this attribute is used to describe the orientation of building(s) with different lateral load resisting systems in two principal horizontal directions of the building plan which are perpendicular to one another.
2. **Material of the lateral load-resisting system** - e.g. "masonry" or "wood".
3. **Lateral load-resisting system** - the structural system that provides resistance against horizontal earthquake forces through vertical and horizontal structural components, e.g. "wall", "moment frame", etc.
4. **Height** - building height above ground in terms of number of storeys (e.g. a building is 3-storeys high); this attribute also includes information on number of basements (if present) and ground slope.
5. **Date of construction or retrofit** - identifies the year when the building construction was completed.
6. **Occupancy** - the type of activity (function) within the building; it is possible to describe a diverse range of occupancies - for example, residential occupancies include informal housing (slums) as well as high-rise apartment buildings.
7. **Building position within a block** - the position of a building within a block of buildings (e.g. "detached building" is not attached to any other building).
8. **Shape of the building plan** - e.g. L-shape, rectangular shape, etc.
9. **Structural irregularity** - a feature of a building's structural arrangement, such as one story significantly higher than other stories, an irregular building shape, or change of structural system or material that produces a known vulnerability during an earthquake. Examples: re-entrant corner, soft storey, etc. Recognizing the fact that a building can have more than one irregularity, the user is able to identify primary and secondary irregularity.
10. **Exterior walls** - material of exterior walls (building enclosure), e.g. "masonry", "glass", etc.
11. **Roof** - this attribute describes the roof shape, material of the roof covering, structural system supporting the roof covering, and roof-wall connection. For example, roof shape may be "pitched with gable ends", roof covering could be "tile", and roof system may be "wooden roof structure with light infill or covering".
12. **Floor** - describes floor material, floor system type, and floor-wall connection. For example, floor material may be "concrete", and the floor system may be "cast in-place beamless reinforced concrete slab".
13. **Foundation system** - that part of construction where the base of the building meets the ground. The foundation transmits loads from the building to the underlying soil. For example, a shallow foundation supports walls and columns in a building for hard soil conditions, and a deep foundation needs to be provided for buildings located in soft soil areas.

Each attribute has been described by one or more levels Level 1, 2, 3, etc. [1].

To collect data for the basic services structures: schools and hospitals in the CRISIS project, GEM – Direct Observation Tool has been used [2]. This tool, which contains all these attribute levels leads to creation of a regional exposure model. This dataset contains specifically information related to structural characteristics and population data related to general basic services in different spatial

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resolutions. This geospatial exposure database will facilitate global earthquake risk and loss estimation through the GEM's OpenQuake platform.

2.2 Bridge structures

Within this project activities, a system for data collection has been determined to gather as much information as possible about the bridge network in each country and to gain enough insight into the bridge inventory and permit further modelling and risk assessment, as foreseen by the project.

In this case, two categorizations of different type of data have been performed. The first categorization includes basic information on the structures - information on existence, location and overall length of the bridge. The second set of data includes information on the structural system and material of the bridge, as well as incomplete geometrical characteristics of the structural elements. This information has been used to classify the assets according to the taxonomy scheme. In this project, the taxonomy used in the Infra-NAT project has been applied [3].

3. Regional risk exposure model

Presented further is a cross-border harmonized regional risk exposure model related to the targeted cross-border region between the three partner countries: N. Macedonia, Greece and Albania. A regional exposure database that has been created is based on contemporary practice and research [4]. In this study, schools, hospitals and bridges are taken into account. For the purposes of this project, only structures in larger populated areas related to border crossings and serving a larger number of users have been considered. It is assumed that this type of structures will be the most beneficial in the period after any natural or human-induced hazard. Taking these structures into account, each neigbouring country in the region will be able to provide enhanced cross-border cooperation and coordination in disaster risk management. Integrated cross-border region municipality map is presented in Fig. 2.

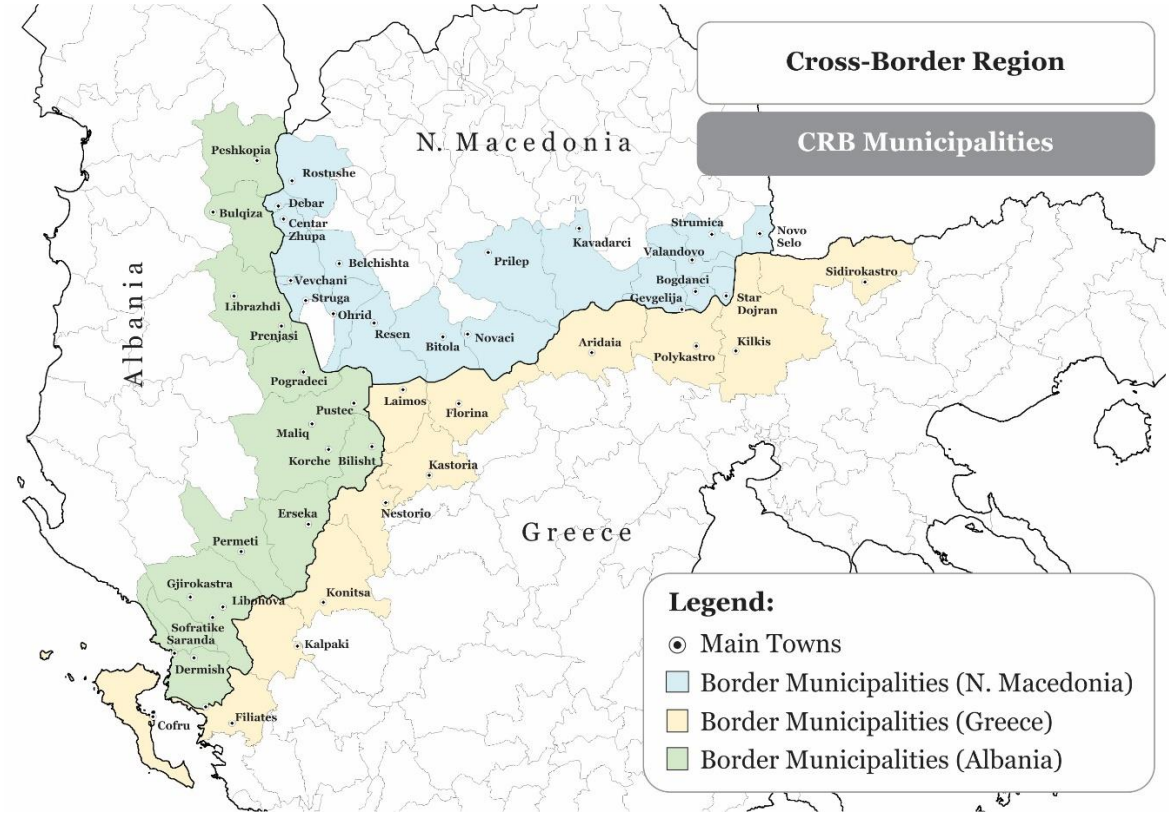

Figure 2. Integrated cross-border region; Main cities

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The cross-border region that belongs to N. Macedonia (CBR-MKD), consists of 18 municipalities, the Greek cross-border region (CBR-GR), consists of 12 municipalities and the Albanian cross-border region near N. Macedonia and Greece consists of 17 municipalities. This region covers almost all the south-east and east part of Albania [4]. The region with the largest population is N. Macedonian.

3.1 Buildings for basic services

3.1.1 Schools

To collect data regarding basic services of structures, for the needs of the project, a special form containing all data necessary to fill out the GEM Tool was prepared. These data shall further serve to create the risk and emergency management platform. The initial idea was to distribute this form through the regional centres of the Crisis Management Centre (CMC) in the cross border municipalities and people working in these centres to appoint persons who work in corresponding institutions (schools and hospitals) to provide data and fill out the forms, in which way, the collected data were to be transferred to the GEM tool. To explain data to be collected through the form, instructions were prepared additionally to present all questions and possible answers through pictures and examples.

Since the Crisis Management Centre is partner institution in this project, and given that the objective of this project is improvement of the crisis management system for the purpose of more efficient response of the authorities managing emergency situations and catastrophes, a team from the Crisis Management Centre was engaged in upgrading their already existing module (http>//procena.cuk.gov.mk/) with data that are necessary in this project phase for regional risk exposure model harmonization.

The process of data acquisition was carried out in the already adopted way, through engagement of persons from the regional crisis management centres. In this way, the Crisis Management Centre acquired an improved system for evaluation of the endangerment

According to the State Statistical Office of the Republic of N. Macedonia [5], the total number of primary and secondary schools in the cross-border municipalities including all schools in the main towns and all schools in the remaining towns and smaller villages is 322. From a total number of schools in the considered region, 281 are primary schools and 41 are secondary schools.

According to the Hellenic School Network (https://www.sch.gr/), the total number of buildings used exclusively as schools in the cross-border region is 1174, while there are additional 88 buildings with mixed use, including that of schools.

In the Albanian cross-border municipalities, there are 138 primary schools, 275 mixed primary and secondary schools, 343 secondary schools and 83 high schools, allocated in the seventeen considered municipalities.

Considered in CRISIS project have been only structures located in larger populated areas related to border crossings for which corresponding data have been provided. The number of considered schools located in larger populated areas related to border crossings on the territory of N. Macedonia is 57 (40 primary and 17 secondary), on the territory of Greece 19, and in Albania 115 (total 191). According to the material technology, most of the considered schools in all three countries are constructed of cast-in-place concrete (CIP) while others are constructed of fired clay solid bricks (CLBRS). A quite minor part of them are constructed by use of another masonry unit technology (MO), whereas the remaining ones are constructed by use of an unknown technology involving stone (ST99), masonry (MUN99) and concrete (CT99). All structures constructed by use of the cast-in-place technology are constructed of reinforced concrete (CR). Most of the structures constructed by use of the masonry technology are constructed of confined masonry (MCF) and unreinforced masonry (MUR). A quite smaller part are constructed of reinforced masonry. According to the number of storeys of the schools, most of them have two and three storeys above ground and have either one or none level below ground. Most of the school structures that have been considered in this database are built between 1960-1990.

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3.1.2 Hospitals

The buildings for basic services considered in this project have been health care buildings representing: general hospitals, clinics, special hospitals and health care centres, i.e., those health care structures that can provide corresponding care and hospitalization of the injured. The number of considered hospitals located in larger populated areas related to border crossings on the territory of N. Macedonia is 16, on the terotory of Greece 17, and in Albania 13 (total 46).

Most of the health care structures in the cross-border region for which data have been provided are constructed by use of reinforced concrete (CR). A minor part of them are constructed of masonry with unknown reinforcement (M99), unreinforced cement masonry (MUR), reinforced masonry (MR) and concrete with unknown reinforcement (C99). According to number of storeys above and below ground, more than half of the health care structures have 2 levels above ground and 1 level below ground. According to data available on these structures, most of them are regular from structural aspect.

3.1.3 Bridges

A database on bridges situated along the main roads within the cross-border region with Albania and Greece has been created. A total of 372 bridges have been considered (165 in N.Macedonia, 16 in Greece and 191 in Albania).

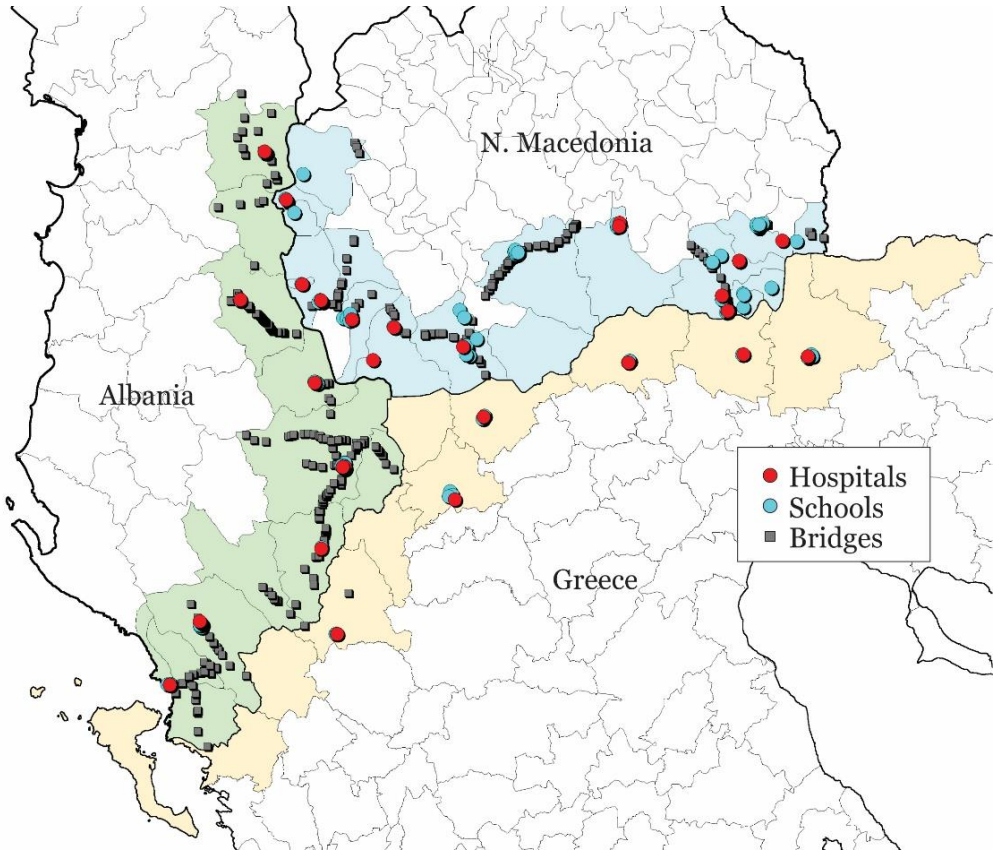

Figure 3. Cross-border region, location of the considered hospitals, schools and bridges

For some of these bridges, complete data have been available, while for some of them, there have been only basic data. Most of the bridges are situated along roads running to the border crossings on these two countries. For most of these bridges, there are basic data on the material of which they are constructed, total length, number of spans and structural system. According to type of structural system, the most frequently found bridge types in this region are bridges with frame structural system, then bridges with a girder system (with beam and slab main girders), while arch bridges account for the least

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number of bridges. As to the number of spans of structures for which there are data, more than half of them have 1 span, less than 1/3 have 3 spans, while the greatest number of spans in this region is 6.

The location of the considered hospitals, schools and bridges is presented on Figure 3.

4. Summary

The following points can be made to summarise the harmonized risk exposure model of basic services and transport infrastructures:

- For the cross-border region among the countries – participants in this project, a harmonization of the exposure model has been made for educational structures, health care structures and bridges as part of the transport infrastructure by use of the GEM taxonomy.
- In this project, only structures in larger cities related to cross-border areas and serving a larger number of users have been considered. This holds for all countries –partners in the project.
- From the cross-border region, in the territory of N. Macedonia, a total of 57 schools out of which 40 primary and 17 secondary schools have been included.
- A total of 16 health care structures from the cross-border region of the territory of N. Macedonia have been analyzed.
- For the purposes of this project, a database on bridges situated along main roads within the frames of the cross-border region has been created. From the territory of N. Macedonia, a total of 165 bridges along main roads leading to border crossings on the neighbouring countries Albania and Greece have been considered.
- For Greece, a total number of 19 schools, 17 healt-care facilities and 16 bridges were assessed.
- A database on bridges situated along main roads within the frames of the cross-border region has been created. From the territory of Albania, a total of 191 bridges along main roads leading to border crossings on the neighbouring countries N. Macedonia and Greece have been considered.
- For the considered cross border region between N.Macedonia, Greece and Albania, total number of 191 school buildings, 46 health care structures, and 372 bridges are observed.

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