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1st International Conference on Built Environment

ICBE 2026

MAY 08th-09th, 2026
POLIS University, Tiranë

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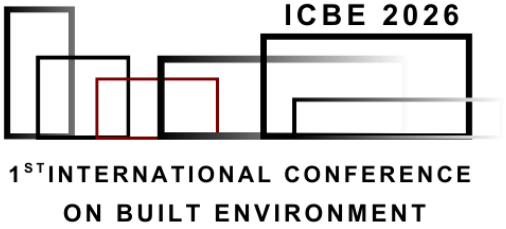
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1st International Conference on Built Environment

ICBE 2026

Conference Theme and Rationale

The 1st International Conference on Built Environment (ICBE 2026) was conceived as an international and interdisciplinary forum for advancing knowledge, critical discussion, and innovation across architecture, urban planning, engineering, construction, materials, design, and the wider built environment. Organized by POLIS University in collaboration with the National Agency for Scientific Research and Innovation in Albania (AKKSHI), the Academy of Sciences of Albania and the University of Ferrara in Italy, the conference brought together academics, researchers, practitioners, students, and industry representatives to exchange research findings, professional experience, and emerging perspectives on the transformation of contemporary cities and territories.

The conference theme reflected the increasingly complex challenges shaping the built environment, with particular attention to sustainability, resilience, technological innovation, heritage preservation, and socially responsive design. Contributions addressed sustainable architecture and green building, innovative construction technologies and materials, climate-responsive and energy-efficient design, disaster risk reduction, circular approaches to construction, and the integration of renewable energy. Equal emphasis was placed on digital transformation through Building Information Modeling, Geographic Information Systems, artificial intelligence, data analytics, automated solutions, digital fabrication, and advanced manufacturing.

ICBE 2026 also recognized that the future of the built environment cannot be approached through technological innovation alone. Urban transformation, cultural heritage, adaptive reuse, inclusive design, ecological thinking, art, and interdisciplinary research were therefore integral to the conference rationale. The scientific sessions examined topics ranging from seismic resilience, geotechnical engineering, and structural safety to urban fragmentation, public space, heritage conservation, adaptive environments, and new relationships between human and non-human systems.

Through keynote lectures, scientific presentations, case studies, and interdisciplinary debate, the conference encouraged connections between research and practice while promoting approaches capable of responding to environmental, social, cultural, and technological change. The breadth of contributions demonstrated the value of bringing engineering, architecture, urbanism, design, heritage, and emerging technologies into a shared academic framework for more resilient, sustainable, adaptive, and human-centered environments.

Held on 8-9 May 2026 at POLIS University in Tirana, with in-person and online participation, ICBE 2026 welcomed guest speakers and participants from Albanian and international universities, research institutions, professional organizations, and industry. Its sessions established a platform for presenting current research, exchanging expertise, strengthening meaningful collaboration, and identifying future directions for the built environment.

The event

The **1st International Conference on Built Environment (ICBE 2026)** is an interdisciplinary academic and professional forum dedicated to exploring contemporary challenges, emerging research, and innovative approaches shaping the future of the built environment. Bringing together researchers, academics, architects, engineers, urban planners, designers, practitioners, and industry professionals, the conference promotes the exchange of knowledge and encourages collaboration across traditionally interconnected disciplines. Its thematic scope encompasses sustainable and resilient construction, technological innovation, advanced building materials, urban transformation, cultural heritage, and interdisciplinary design approaches. Particular attention is given to the growing role of digital technologies, data-driven methodologies, intelligent design processes, and advanced analytical tools in supporting more informed and responsive approaches to architecture, engineering, and urban development. At the same time, ICBE 2026 recognizes the importance of environmental responsibility, cultural identity, social needs, and human-centered design in shaping contemporary cities and territories. Through keynote lectures, scientific sessions, case studies, and interdisciplinary exchange, the conference provides a platform for presenting current research, discussing professional experiences, and developing new perspectives capable of contributing to **safer, more sustainable, adaptive, inclusive, and resilient built environments**.

Objectives

- Promote interdisciplinary collaboration among researchers, academics, practitioners, and professionals in architecture, engineering, urban planning, construction, design, heritage, and related fields of the built environment.
- Advance the use of digital technologies and innovative methodologies, including BIM, GIS, artificial intelligence, data analytics, digital fabrication, and parametric approaches, in research and professional practice.
- Encourage sustainable, resilient, and climate-responsive approaches to architecture, construction, and urban development through innovative materials, energy-efficient strategies, and environmentally responsible design.
- Address contemporary challenges affecting cities, buildings, and infrastructure through scientific research, applied case studies, evidence-based approaches, and innovative design solutions.
- Promote the conservation, transformation, and adaptive reuse of cultural heritage, balancing cultural identity, contemporary needs, structural safety, and responsible urban development.
- Support human-centered and socially responsive urban transformation, considering public space, mobility, ecological systems, community needs, and the wider social and economic impacts of the built environment.
- Provide a platform for knowledge exchange and emerging research, enabling scholars, young researchers, professionals, and students to present innovative ideas, strengthen international collaboration, and contribute to future directions in the built environment.

Main Conference Themes

- Sustainable architecture and green building practices.
- Innovations in construction technologies and materials.
- Heritage preservation and adaptive reuse in the built environment.
- Digital tools and smart technologies in architecture and construction (e.g., BIM, GIS).
- Climate-responsive and energy-efficient design.
- Disaster risk reduction and resilience in the built environment.
- Circular economy approaches in construction and material usage.
- Integration of AI and data analytics in building design.
- Acoustic and thermal performance in building design.
- Renewable energy integration in building systems.
- Advanced manufacturing techniques in construction, such as 3D printing.
- Innovations in construction technologies and materials.
- Heritage preservation and adaptive reuse in the built environment.
- Disaster risk reduction and resilience in the built environment.
- Digital tools and smart technologies in architecture and construction.
- Advanced manufacturing techniques in construction.
- Geotechnical Engineering for Sustainable Development.
- Cartography and Geographic Information System.
- Computer Automated Solutions for Built Environment.
- Reliability in Civil Engineering.
- Urban planning strategies for resilient cities.
- Climate-responsive and energy-efficient design.
- Regulatory frameworks and policies impacting construction and urban development.
- Design in the Era of Anthropocene (Rethinking the Relation between Human and Non-Human Species)
- Speculative Design (with Attention to “Discursive” and “Critical” Design)
- Design and Cross-Disciplinarity (with Emphasis on Processes rather than Design Outputs)
- Inclusive Design
- Art and Urban Regeneration (Focus on Participatory, Collaborative, and Research-Based Practice)
- Relational Art and Architecture
- Monuments and ‘Anti-Monuments’ (Particular Attention to the Process of Designing and Building the City)

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The conference is structured around six thematic sessions, each addressing a specific area of research and practice within the built environment.
Each session is coordinated by experts in the relevant disciplinary field and is open to professors, researchers, PhD candidates, and other scholars and professionals contributing to the conference themes.

SESSION I
Urban Planning and Societal Impact

Chair: Dr. Gent Avdija

This session examines the relationship between urban transformation, spatial development, and their social implications within contemporary cities. Contributions address rapid urbanization, urban fragmentation, the transformation and loss of public space, informal and spontaneous development, and the challenges associated with balancing growth and modernization with human-scale urban environments. Particular attention is given to the evolving conditions of Albanian cities and to planning approaches capable of supporting more inclusive, sustainable, socially responsive, and livable urban environments.

SESSION II
Sustainable Materials, Resilient Construction & Smart Design

Chair: Dr. Endri Duro

This session explores innovative approaches to sustainable construction, resilient structural systems, and environmentally responsive design. Particular attention is given to sustainable materials, energy-efficient and climate-responsive strategies, prefabricated and lightweight construction technologies, and human-centered approaches to structural and architectural design. The session investigates how material innovation, technological development, and responsible design practices can contribute to safer, more efficient, adaptable, and environmentally sustainable built environments.

SESSION III
Technological Advancements and Seismic Design for Resilient Places

Chairs: Dr. Seyyed Behrad Emadi & Dr. Ornela Şen

This session examines the role of technological innovation and advanced engineering methodologies in developing safer, more resilient, and adaptable built environments. Contributions address seismic hazard and risk assessment, digital fabrication, parametric and computational approaches, transformations of building envelopes and prefabricated housing systems, and emerging concepts for future urban mobility. The session highlights how the integration of engineering knowledge, digital technologies, and resilience-oriented design can strengthen the capacity of buildings, infrastructure, and urban environments to respond to contemporary and future challenges.

SESSION IV

Cultural Heritage

Chairs: Dr. Nikolla Vesho & Dr. Marsela Demaj

This session addresses the preservation, interpretation, and transformation of cultural heritage within contemporary architectural and urban contexts. Contributions explore conservation strategies for historic buildings and sacred architecture, seismic assessment and strengthening of heritage structures, adaptive reuse, and the social implications of urban regeneration and heritage loss. Particular emphasis is placed on achieving a responsible balance between conservation ethics, cultural identity, structural safety, and the evolving functional requirements of historic buildings and urban environments.

SESSION V

Spaces of Connection: Art and Design for an Interspecies and Interdisciplinary Environment

Chair: Dr. Francesco Scasciamacchia

This session explores the intersections of art, architecture, design, technology, and the built environment through interdisciplinary and experimental perspectives. It investigates changing relationships between human and non-human systems, spatial perception, adaptive reuse, post-industrial landscapes, urban representation, digital heritage, and environmentally and socially engaged design practices. Through critical, speculative, participatory, and research-based approaches, the session examines how art and design can generate new forms of connection, reinterpret existing environments, and contribute to emerging cultural and spatial narratives within contemporary cities.

SESSION VI

Next-Generation Pioneers of the Built Environment

Chair: Dr. Flogerta Krosi

This session provides a dedicated platform for emerging researchers and students to present innovative, experimental, and forward-looking approaches to the built environment. Contributions span architecture, engineering, urban planning, environmental resilience, design, and related creative disciplines, reflecting the interdisciplinary character of a new generation of researchers and practitioners. Through projects addressing topics such as bioclimatic design, flood-risk management, structural technologies, architecture-inspired design, and critical interpretations of objects and social space, the session encourages critical inquiry, experimentation, and new perspectives on the future of the built environment.

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Technological Advancements and Seismic Design for Resilient Places

Seismic resilience and risk mitigation: Seismic hazard assessment / Structural safety / Risk-informed design / Resilient buildings and infrastructure.

Digital and computational technologies: Digital fabrication / Parametric methodologies / Computational design / Technology-assisted decision-making.

Adaptive building systems: Façade transformation / Prefabricated housing systems / Adaptive architectural solutions / Building-envelope innovation.

Resilient urban systems: Future mobility / Technology-driven urban transformation / Resilience-oriented planning / Safer and adaptive urban environments.

A Seismic Hazard Model of Albania

Case study: Kukes, Berat and Himarë

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Abstract

Albania is situated along the Alpine-Mediterranean seismic belt, making it one of the most seismically active regions in Europe. The country's complex tectonic landscape is primarily driven by the ongoing continental collision between the Adriatic microplate and the Eurasian plate. Historical records and instrumental data emphasize the severe seismic hazard across the country. Between the 3rd century B.C. and the present, Albania has experienced approximately 56 strong earthquakes with intensities of I>VIII (MSK-64), with 15 reaching intensities of IX or higher. Recent devastating events, such as the November 2019 Durrës earthquake (Mw=6.4), have further highlighted the urgent need for an updated seismic hazard model of the country. This paper focuses on a new seismic hazard model for Albania and deriving the seismic hazard profiles of three distinct urban centers: Kukës, Berat, and Himarë, which represent varying geological and tectonic environments. By analysing the probabilistic seismic hazard (PSHA) for these cities, this study aims to provide localized data on Peak Ground Acceleration (PGA) for two return periods, required for modern engineering standards.

Keywords: *Tectonic setting, earthquake catalogue, ground motion prediction equations, seismic hazard model of Albania.*

1. INTRODUCTION

Earthquakes are an unpredictable and unavoidable natural geological hazard with a significant potential for destruction. Implementing suitable measures to decrease the effects of earthquakes on infrastructure and buildings is the best protection against them. This is impossible to achieve without a reliable seismic hazard analysis, which serves as an input necessary to improve design codes for seismically resistant structures. Seismic design codes, seismic risk assessment and management, as well as improving earthquake safety, must be based on appropriate hazard models and reliable seismic hazard maps.

The present study describes the methodology used to build a new model for the seismic hazard of Albania and the results achieved. In addition to seismic hazard maps in compliance with the requirements of the Eurocode 8 standard, which are required for the implementation of this standard in our country, seismic hazard profiles are given for three different urban centers: Kukës, Berat, and Himarë. They reflect different geological and tectonic contexts, so their seismic hazard is the subject of this paper.

Kukës - situated in the interior part of the northeast region of Albania. This area is impacted by transverse fault zones. Although Kukës has historically seen earthquakes larger than magnitude 6.0, it is generally thought to be less dangerous than the coast.

Berat - located in central-southern Albania. It is the city that experienced high-intensity occurrences in the past, most notably a strong earthquake in 1851 that resulted in numerous landslides and over 400 fatalities. With large earthquakes (M>6), it continues to be one of the interior's most active zones.

Himarë - a southwest seaside town situated in the extremely active Ionian fault zone. Strong occurrences like the 1930 M=6.0 earthquake have historically struck this area, which is characterized by thrust faults.

By analyzing the probabilistic seismic hazard (PSHA) for these cities, this study aims to provide localized data on Peak Ground Acceleration (PGA) for two return periods for modern engineering standards.

2. LITERATURE REVIEW

2.1 Regional and local seismicity

Microearthquakes (1.0<M≤3.0), numerous minor earthquakes (3.0<M≤5.0), rare medium earthquakes (5.0<M≤7.0), and extremely rare major earthquakes (M>7.0) are typically common in Albania (Aliaj et al., 2009). Based on historical records, our country has seen 56

powerful earthquakes with intensities $I_0 \geq$VIII of the MSK-64 scale since the third century BC. In 2019, Albania was struck by two strong earthquakes (M_w=5.7 on September 21 and M_w=6.4 on November 26). The November 26, 2019, earthquake caused significant material damage and 51 fatalities (European Union et al., 2020). It is regarded as the world's most catastrophic earthquake of that year.

2.2 Seismic zonation and Design Code

Albania's first seismic map was compiled in 1952 by specialists from the Ministry of Construction and the Institute of Sciences (Sulstarova et al., 1980). Since then, various papers have been produced in an effort to provide the most realistic evaluation of the seismic hazard in our country (Duni & Kuka, 2004, Aliaj et al., 2010, Luzi et al., 2020, Danciu et al., 2021). The seismic zonation map compiled in 1979, an outdated empirical map created on a non-probabilistic basis, serves as the foundation for the current Albanian Design Code KTP-N.2-89. It describes the macro-seismic intensity (MSK-64 scale) and not the ground shaking intensity levels such as PGA, PGV, SA, etc., which are used nowadays in modern design codes (CEN, 2004).

As a result, it is crucial to accurately update the seismic hazard model and create a new national seismic hazard map that will serve as the foundation for our nation's new design code, aligning with Eurocode norms (CEN, 2004). Moreover, the deadly Mw 6.4 earthquake that struck close to Durrës on November 26, 2019, has brought attention to the Albanian Design Code's need for reform (Bilgin, 2023). Therefore, it is clear that these technological requirements need to be improved and brought into compliance with EU regulations.

2.3 Probabilistic seismic hazard analysis

After the disastrous Durres earthquake on November 26, 2019, with a magnitude of Mw=6.4, a major revision was conducted between 2020 and 2024 to update the earthquake database and improve the accuracy of the seismic hazard assessment for the territory of Albania (Kuka et al., 2023).

The partnership between the Institute of Geosciences (IGEO) and the GEM Foundation (Global Earthquake Model, Pavia, Italy) has made a significant contribution to update the seismic hazard. With funding from the Energy Corporation of Albania (KESH) and the European Investment Fund (CEI-Central European Initiative), GEM and IGEO carried out a one-year project (KEP2022) during the period 2023–2024 to update and enhance the probabilistic seismic hazard model of Albania (under the coordination of Dr.Marco Pagani and Dr. Anila Xhahysa, and the essential expertise of Prof. Dr. Neki Kuka).

3. METHODOLOGY

The results of the probabilistic analysis used in the NATO SfP 984374 project (Kuka, et al., 2015), applied to the updated earthquake catalogue of earthquakes and some new ground motion prediction models (Kuka, et al.,2022), combined with the new results obtained (Kuka,

et al., 2023), within the framework of the aforementioned project between GEM and IGEO (KEP2022) are merged to obtain the final seismic hazard model of Albania. A logic-tree structure, which explains the epistemic uncertainties related to the development of the seismic source model and the ground motion prediction (GMPE) models, is used in the computations for hazard assessment. In compliance with the Eurocode norms (CEN, 2004), the results are presented in terms of maximum horizontal acceleration (PGA) for the 95- and 475-year return periods. The analysis is performed with OpenQuake computational tool created by the GEM project (Pagani et al., 2014).

3.1 Earthquake catalogue

The seismological database utilized in this research is a uniform catalogue list of earthquakes that was created as part of the NATO project SfP 984374, also known as the BSHAP2 project. Over 20,000 new occurrences of magnitude MW≥3.0 that occurred in the region [36.5°–45.5°, 15.5°–24.5°] between January 1, 2013, and December 31, 2022 were included in the GEM-IGEO project (KEP2022).

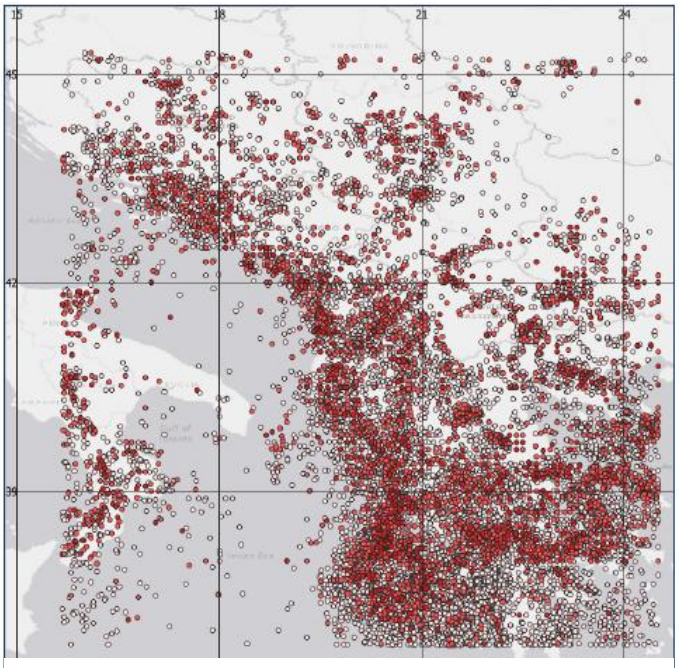


Figure 1. Updated earthquake catalogue for the period 1/1/2013-31/12/2022 in the region [36.5°- 45.5°, 15.5°- 24.5°].

The process used to unify and homogenize these occurrences in terms of M_W magnitude was the same as that used for the BSHAP catalogue. Regression models developed during the BSHAP2 project, or new relations created specifically for this study were utilized to convert various magnitudes (M_L, m_b, M_S, etc.) to M_W. Approximately *46,000* events that took place on our nation's territory or within 300km of its borders are included in the new inventory. In terms of M_W magnitude, it is uniform and homogeneous. *Figure 1* displays the spatial distribution of earthquake epicenters in this database, while *Figure 2* displays their distribution according on moment magnitude, M_W.

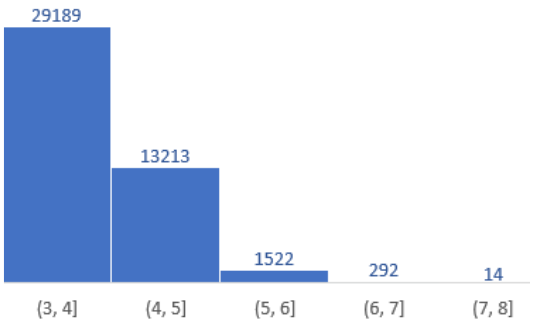


Figure 2. Earthquake distribution according to M_W.

Foreshocks and aftershocks must be removed from the earthquake database in order to calculate the Poissonian rate of seismicity. We have chosen to employ three algorithms among the different approaches suggested for this goal: Gardner and Knopoff (1974), Gruenthal (1985) and Uhrhammer (1986). The algorithms have identified *5,082*, *3,473* and *8,624* main events with magnitude $M_w \geq 4.0$, respectively.

Determining the magnitude completeness threshold, or M_c "*the minimum magnitude for which 100% of the events in a space-time volume have been detected* (Woessner & Wiemer, 2005)" is another crucial step in the data extraction process for seismic hazard analysis. The estimate of seismic hazard in a particular area could be significantly impacted by systematic errors caused by an insufficient earthquake database when identifying recurrence patterns.

Therefore, the identification of the magnitude of completeness is a clear requirement for the preprocessing of the data to be used for seismic hazard assessment. Although occurrences of magnitude $M_W \geq 3.0$ are included in the present catalog of earthquakes, it cannot be argued that all events with $M_W \geq 3.0$ are included, particularly prior to 1990, when seismological monitoring networks were relatively scarce across all of the region's countries. For the new catalog, Mc=4.0 was found using the ZMAP program (Wiemer, 2001). The methodology suggested by Stepp (1971) was applied to evaluate the temporal fluctuation in the

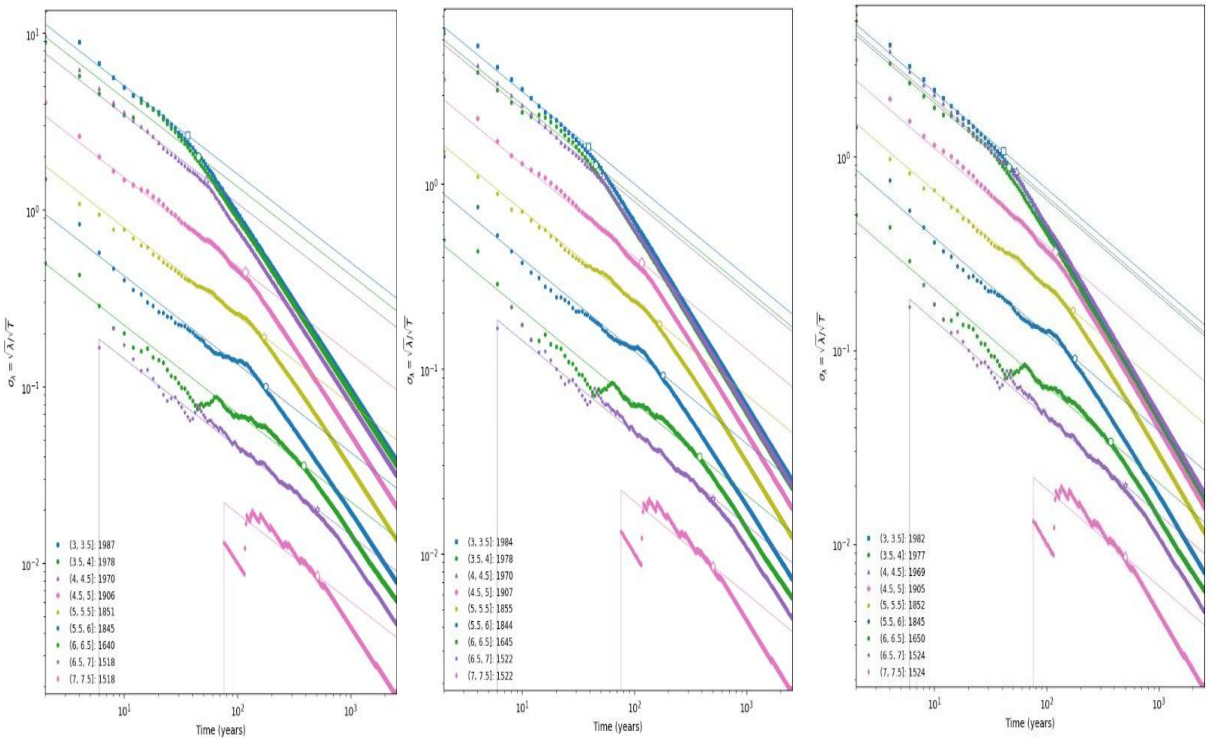


Figure 3. Assessment of completeness with the Stepp (1971) methodology. Declustering algorithms: Uhrhammer 1986 - left, Gruenthal (1985) - center, Gardner & Knopoff (1974) - right.

completeness of the BSHAP catalog. *Table 1* and *Figure 3* show the results that were achieved.

Table 1. Magnitude completeness intervals for the earthquake catalog.

M_w	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
Viti	1996	1985	1970	1925	1890	1850	1650	1585	1500	1400

3.2 Seismicity parameters and characterization of seismic sources

Based on a thorough examination of the tectonic environment, known active faults in the region, seismicity rates, measured magnitudes, and focal depths, three seismic source models are distinguished, the so-called SSM1 (*Figure 4a*), ESHM (*Figure 4b*), and ASHM (*Figures 5a-d*). The SHARE and ESHM20 projects, as well as the study of Vamvakaris et al., 2013 are taken into consideration when delineating the areas that cover the bordering region (outside the study region) in all three models.

Different zonations are taken into consideration in order to account for the epistemic uncertainties related to the definition of seismic source zones. The ESHM model is a portion of the seismic source model of the ESHM20 project (Danciu et al., 2021), whereas the SSM1 model is equivalent to the corresponding model of the BSHAP2 project (Mihaljević et al., 2017). In the context of the GEM-IGEO project (KEP2022), a new seismic source model has been defined, the so-called ASHM model. ASHM is an alternative zoning that takes into consideration the Albanian tectonic map (Saccani et al., 2015), active faults in Albania and surroundings, the earthquake distribution, as well as the GNSS velocities.

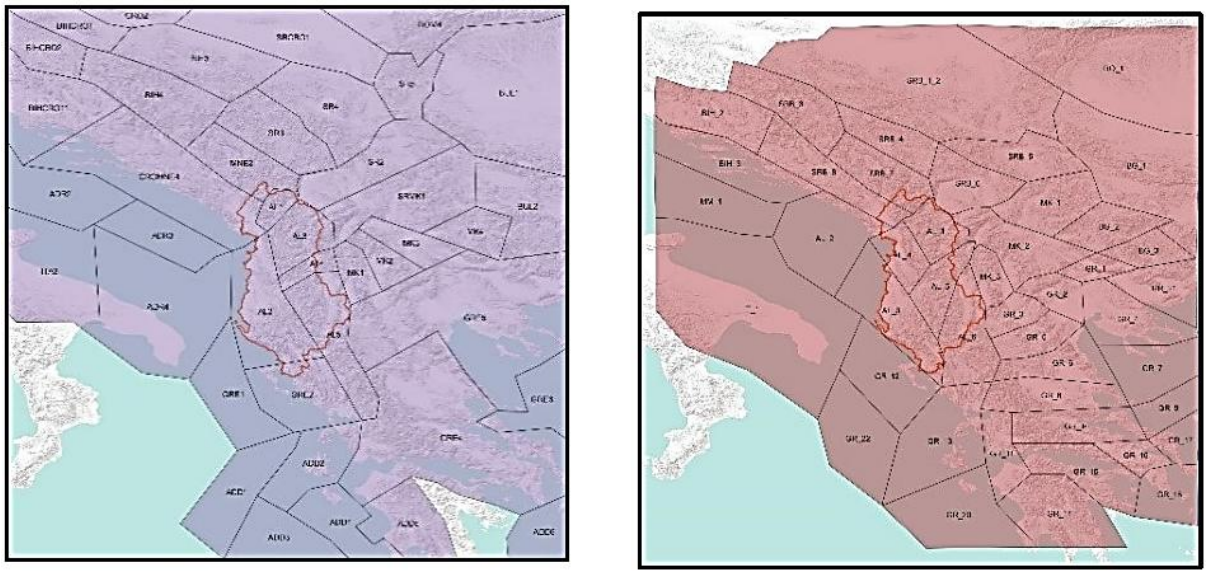
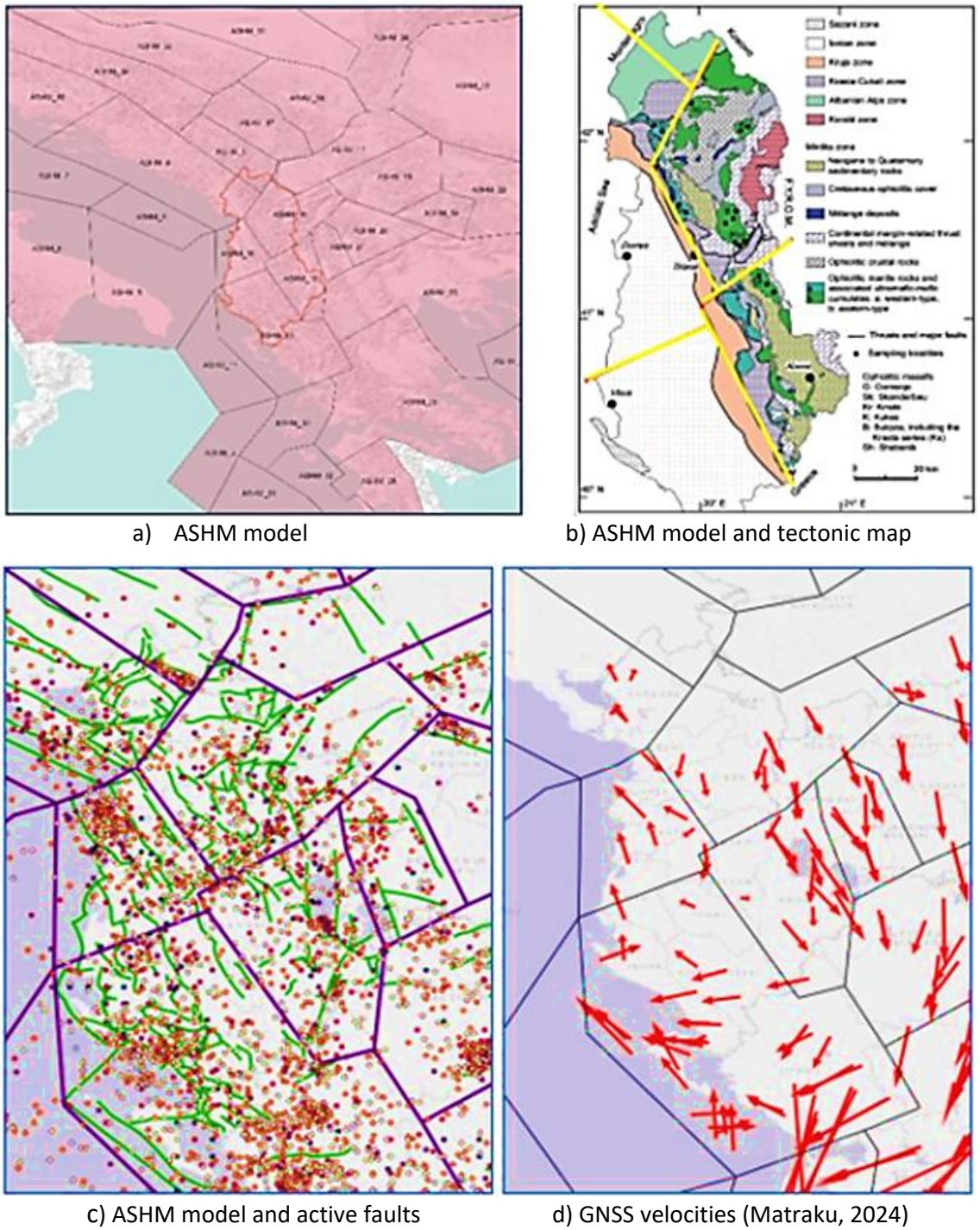


Figure 4. Seismic source models: a) SSM1 (Mihaljević et. al, 2017) - left, and b) ESHM (Danciu et al., 2021) - right, and their position vs. super-zone model (large colored polygons).

The super-zone model has been developed to enable a statistically consistent estimation of the *b* parameter. In addition to providing the information required for both fixed and adaptive spatial smoothing processes of seismicity rates, small zones within super-zones are defined in order to reflect more accurately local tectonic features.



a) ASHM model

b) ASHM model and tectonic map

c) ASHM model and active faults

d) GNSS velocities (Matraku, 2024)

Figure 5. ASHM seismic source model and the relevant information.

Other seismicity parameters (m_{max}, dominant style and fault orientations, distribution of hypocenters) have been estimated for smaller zones, delineated within alternative zoning

models: SSM1, ESHM, and ASHM, respectively. Frequency-magnitude distribution parameters vary across different seismic source areas. For each zone we used the truncated Gutenberg-Richter (GR) distribution, with maximum magnitude obtained from historical and modern seismicity:

$$l_m = l_{m_0} \times \frac{\exp[-b(m - m_0)] - \exp[-b(m_{max} - m_0)]}{1 - \exp[-b(m_{max} - m_0)]} \quad (1)$$

where: λ_m: average annual number of earthquakes with M ≥ m,
λ_{m0}: average annual number of earthquakes with M ≥ m_0,
m_0: minimum magnitude of engineering interest (in our case, m_0=4.0),
m_{max}: the maximum magnitude the seismic source can generate.

Estimated *b* values of a super-zone were used for all small zones that lie within that superzone. Estimates of the parameters *a, b*, and λ_m for each seismic zone are derived from the updated catalog analysis, using Weichert (1980), which considers completeness intervals for different magnitudes ranges (*Table 1*). For each area, two alternative estimates for the parameter *b* were used:

(1) estimation derived using the sub-catalog of the corresponding super-zone;

(2) *b=1.0,* which was obtained by applying Weichert's method for the study area (Lon: 15.5°-24.5°, Lat: 36.5°-45.5°), as a whole (*Figure 6*).

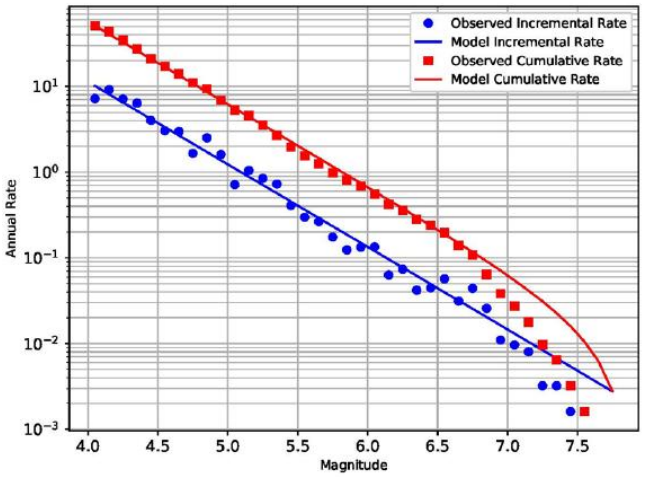


Figure 6. Frequency-magnitude distribution (*b=1.0*) for the study area.

While the superzone model has been developed for statistically consistent estimation of the *b* parameter, other seismicity parameters (m_{max}, dominant style and fault orientations, distribution of hypocentres) have been estimated for smaller zones, delineated within alternative zoning models: SSM1, ESHM and ASHM, respectively. Small areas better represent local tectonic features and provide the data needed for spatial smoothing procedures of seismicity rates, for both fixed and adaptive smoothing.

The magnitude of the maximum possible earthquake, m_{max}, is an important parameter with considerable influence on seismic hazard, at least for large recurrence periods. It is a difficult parameter to estimate, because the physical understanding of m_{max} is poor and the corresponding database is statistically very limited. In the SSM1, ESHM and ASHM models, for each zone, m_{max} is chosen considering the largest observed magnitude within it. Considering the uncertainties associated with this parameter, two alternative estimates for m_{max}, with weights of 0.6 and 0.4 respectively, are included in the corresponding branch of the logic tree,

adding 0.25 and 0.5 magnitude units to the observed maximum magnitude, respectively, in each seismic zone.

On the basis of the above analysis, and the estimates obtained using the maximum likelihood method (Weichert, 1980) that takes into account the periods of completeness of the earthquake catalog for different magnitude intervals (*Table 1*), for the SSM1, ESHM and ASHM models, for each seismic zone within them, Frequency-Magnitude Distribution (MFD) models have been built that characterize the probabilistic distribution of earthquakes in these zones. Figure 7 shows, as an example, the MFD distribution for the source zone AL2 (western area of Albania) of the SSM1 seismic source model.

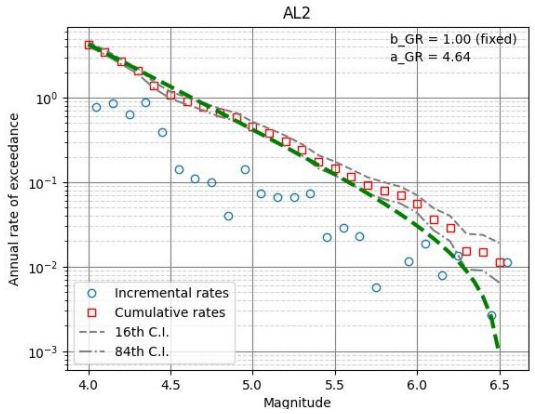


Figure 7. Frequency-magnitude distribution for the zone AL2 (Western Albania).

For the three adopted models of seismic sources in the study region [Lon: 15.5°-24.5°, Lat : 36.5°-45.5°], the epistemic uncertainties associated with the building of seismic source models (model selection, determination of Gutenberg-Richter parameters *a, b* and λ_m, taking into account the uncertainty of the maximum magnitude m_{max}, as well as the choice of the method of spatial smoothing of seismicity rates) are included in the logic tree scheme that was used for the seismic hazard assessment.

3.3 Ground motion prediction equations

Ground Motion Prediction Equations (GMPE) calculate the median and standard deviation of the intensity measure of ground shaking based on factors related to the path (source-site distance, etc.), the seismic source (magnitude, focal mechanism, etc.), and the effects of soil type (average velocity of shear waves in the upper 30 meters, basin depth, etc.). In the last 30 years, a large number of GMPE models have been developed, both global and local, which are used in different tectonic regimes. Local models have been developed using the local strong motion database, so they are expected to better reflect the regional tectonic characteristics. On the other hand, statistical uncertainties in local models can be greater compared to global models, if they are based on limited data sets, less stable.

In the framework of the KEP2022 project, a special study was undertaken (Brooks et al. 2024) to update the accelerometric database for the territory of our country (*Figure 8*) and neighboring regions, as well as to determine the most suitable GMPE models for seismic hazard assessment of Albania. Based on the statistical analysis of the residuals between some of the candidate GMPE models and our strong motion flatfile, the following models were selected as the best fit:

- K20, Kotha et al. (2020)
- L19, Lanzano et al. (2019)

- B20, Boore et al. (2021)
- CY14, Chiou and Youngs (2014)

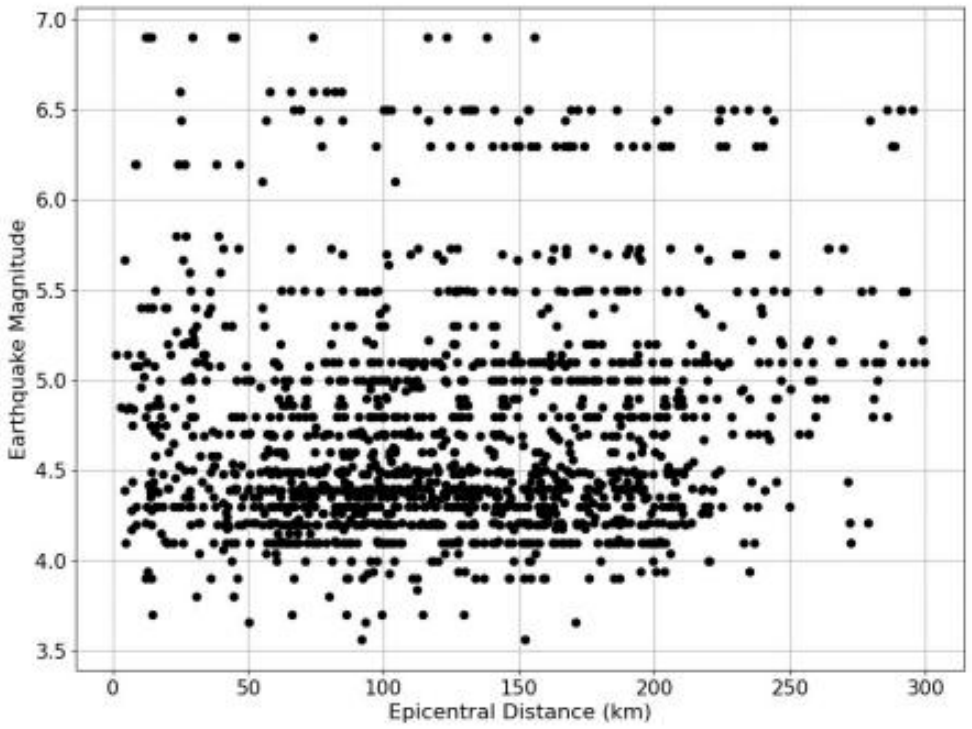


Figure 8. Magnitude-distance distribution of the Albania ground-motion dataset.

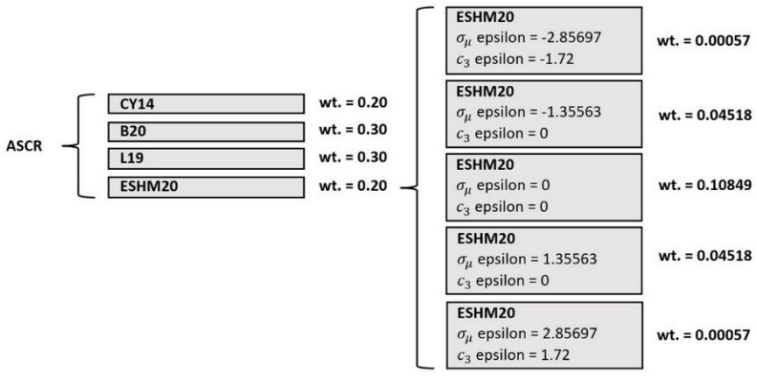


Figure 9. Logic tree for ground motion characterization (Brooks et al. 2024).

Substitution of Kotha et al. (2020) with the ESHM20 backbone model for Active Shallow Crust Regions (ASCR) enables capturing a wide range of epistemic uncertainty for prediction of the median ground shaking Intensity Measure. We selected only 5 central branches of the ESHM20 model, in order to increase the efficiency of the seismic hazard calculations, while sufficiently capturing the corresponding epistemic uncertainty. Figure 9 presents the logic tree scheme of the GMPE models that were used in our project for the assessment of the seismic hazard of Albania, as well as the corresponding weights of the selected models.

4. SEISMIC HAZARD ANALYSIS

4.1 PSHA methodology

Probabilistic Seismic Hazard Assessment (PSHA) consists of determining the relationship between any ground shaking parameter (PGA, PGV, SA, etc.) and the probability of exceeding it over a specified time interval, usually corresponding to the expected life of the structure. Then, the value of the ground shaking parameter to be used for assessing the seismic safety of the structure is chosen after determining an acceptable probability level for the structure and the site under consideration (e.g. 90% probability of not being exceeded in 50 years, which corresponds to a return period of 475 years).

Since there are few data on active faults and corresponding slip rates in the Western Balkans region, it is difficult to establish a reliable model based on the faults. Therefore, for the seismic hazard assessment we decided to use background-gridded seismicity approach, which take into account earthquakes that do not appear on modeled ruptures. The model is developed based on the assumption that future earthquakes will occur near the locations of historical earthquakes.

In general terms, seismicity modeling is based on the method of spatial smoothing of seismicity rates. Historical earthquake rates and a regionally consistent Magnitude-Frequency Distribution (MFD) are used to predict the rate of future earthquakes. The method takes into account the spatial variability of seismicity rates, and is used for regions where tectonic faults are not known or cannot be parameterized. The smoothed seismicity models are defined on a 10 km x 10 km grid in the spatial interval 36.5°-45.5° latitude and 15.5°-24.5° longitude. Seismic sources are modeled as sets of grid points located within the respective seismic source zones. In each cell of the grid, earthquakes with a magnitude greater than m_{min} that pass the completeness test (Table 1) of the regional earthquake catalogue are counted. Then, using the MLE (Weichert, 1980) method, the average annual rate of earthquakes was calculated, using the selected value of the *b* parameter and the number of earthquakes in each grid cell, adjusted according to the levels of magnitude completeness.

To take into account the epistemic uncertainties associated with the spatial smoothing of seismicity rates in the above grid cells, two methods have been used: the fixed kernel (Frankel 1995), and the nearest neighbor adaptive kernel (Helmstetter et al., 2007). Fixed kernel smoothing applies a two-dimensional (2D) isotropic Gaussian operator, while adaptive kernel smoothing applies smoothing distances that are based on the nearest neighbor parameter (Helmstetter 2007).

4.2 Incorporating epistemic uncertainties

In the present study, a logic-tree with 576 branches was designed for the seismic hazard analysis of Albania, combining different models of background-gridded sources and smoothed seismicity. Nodes in this logic-tree include:

1) Three declustering algorithms of the updated earthquake catalog: Gardner & Knopoff 1974, Grünthal 1985, Uhrhammer 1986.
2) Three seismic source models ASHM, ESHM and SSM1 (section 3.2).
3) Two alternative estimates for the *b*-value for each seismic zone in the respective ASHM, ESHM and SSM1 models: a) the estimate obtained using the super-zone sub-catalogs in order to obtain statistically stable estimates for the parameter *b*; b) *b=1.0*, which is obtained using the MLE (Weichert, 1980) method for the entire study area [lon: 15.5°-24.5°, lat: 36.5°-45.5°], as a whole.
4) Two alternative estimates for the maximum magnitude, m_{max} as explained in section 3.2.
5) Two alternative methods for spatial smoothing of seismicity rates: an isotropic Gaussian smoothing with a fixed kernel (Frankel 1995), and an adaptive kernel smoothing according to the nearest neighbours (Helmstetter et al., 2007).
6) Eight GMC models for shallow active crustal regions: Chiou & Youngs 2014, Lanzano et al. 2019, Boore et al. 2020, and five central branches of the ESHM20 model (Figure 9).

5. RESULTS AND DISCUSSIONS

The probabilistic calculations of the seismic hazard for each branch of the logic-tree described above, were performed using the OpenQuake 3.20 software (Pagani et al. 2014). The evaluations were carried out for engineering rock conditions, with an average shear wave velocity in the top 30 m greater or equal to 800 m/sec, which is classified as A category of the soil according to Eurocode 8 (CEN, 2004). The seismic hazard curves for PGA and a range of nineteen spectral accelerations (SA) varying from 0.05 up to 5 sec were calculated, which describe the annual rate of their exceedance for different levels of ground shaking. Evaluations were performed on 1177 grid nodes with a step of 0.1° longitude by 0.1° latitude, which lie within the polygon [lon: 18.4°-21.9°E, lat: 39.0°-43.3°N].

Based on the relevant seismic hazard curves, the new probabilistic seismic hazard maps for Albania have been constructed (*Figures 10* and *11*). For the 95- and 475-year return periods, the results are given in terms of maximum horizontal acceleration (PGA) in engineering rock conditions (V_{S30}≥800 m/sec). This corresponds to exceedance probability of 10% in 10 years and 10% in 50 years, respectively. The 95-year and 475-year return periods are linked to the damage-limitation requirement (PDLR=10%; TDLR=95 years) and the non-collapse requirement (PNCR=10%, TNCR=475-year), respectively, according to the Eurocode 8 standard (CEN, 2004). To make these maps more useful in the field, the seismic hazard has also been evaluated for every municipality and administrative unit in the country in terms of PGA (V_{S30}≥800 m/sec) for the return periods of 95 and 475 years.

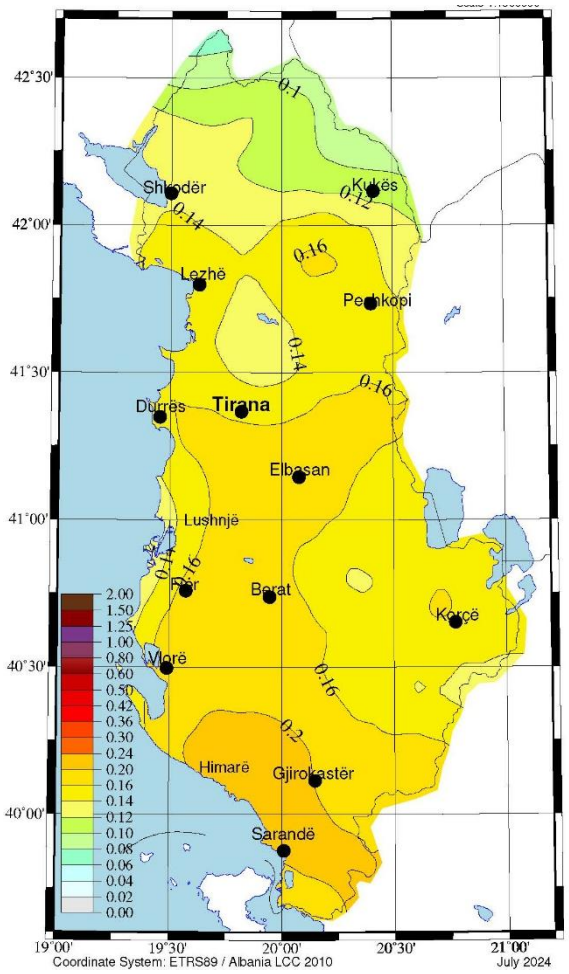


Figure 10. Seismic hazard map of Albania showing Peak Ground Acceleration for 10 % probability of exceedance in 10 years; soil conditions: VS30≥800 m/s.

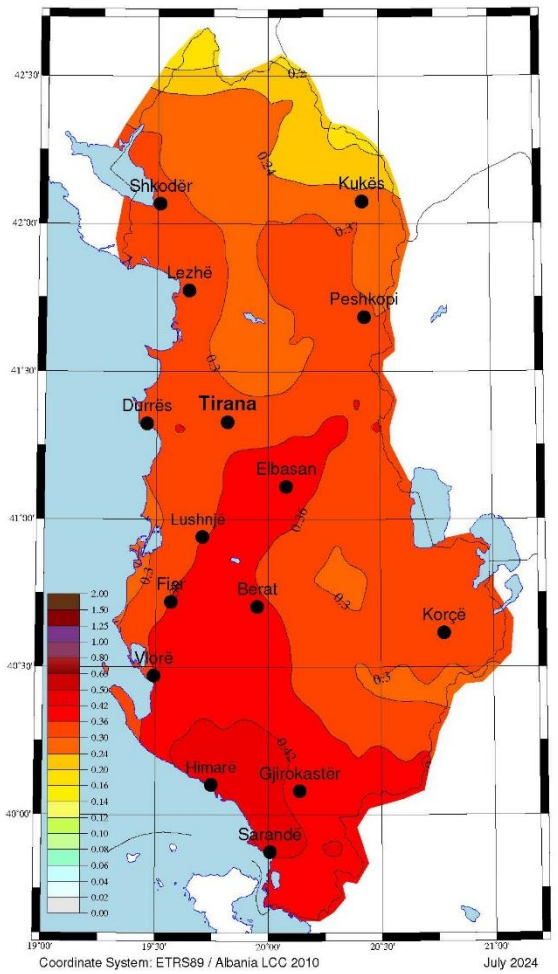


Figure 11. Seismic hazard map of Albania showing Peak Ground Acceleration for 10 % probability of exceedance in 50 years; soil conditions: VS30≥800 m/s.

The results obtained are in full compliance with the Eurocode 8 standard for seismic zoning and seismic design. As can be seen from the *Figures 10* and *11*, most of the territory of our country is characterized by a high seismic hazard, about 0.30g. The northeastern part of the country, northeast of the city of Shkodra towards Kukës, results in a lower seismic risk, 0.20-0.30g. The highest hazard is in the north-western part of the country, around the city of Shkodra, 0.30-0.32g, in the Lushnjë-Elbasan-Librazhd area (0.34-0.36g), in the Peshkopi-Pogradec-Korçë area (0.30-0.32g), and specifically in the southwestern part of Albania (especially in the Himara-Gjirokastra-Saranda region). Here, the PGA value corresponding to the probability of exceeding 10% in 50 years varies in the range of 0.40-0.43g.

This paper focused also on deriving the seismic hazard profiles of three distinct urban centers: Kukës, Berat, and Himarë, which represent varying geological and tectonic environments. Specifically for the zones under consideration the following results are obtained as shown in *Table 2*.

Table 2. Maximum accelerations (g) on Type A ground (agR), for recurrence periods 95 and 475 years.

Municipality	Administrative unit	Probability of exceedance	
		10% in 10 years	10% in 50 years
Berat	Velabisht	0.175	0.363
	Otllak	0.171	0.354
	Sinjë	0.184	0.380
	Roshnik	0.163	0.339
Himarë	Himarë	0.212	0.428
	Lukovë	0.208	0.422
	Horë-Vranisht	0.207	0.419
Kukës	Kukës	0.118	0.249
	Malzi	0.118	0.247
	Bicaj	0.136	0.288
	Ujmisht	0.141	0.289
	Tërthore	0.111	0.242
	Shtiqën	0.125	0.265
	Zapod	0.115	0.247
	Shishtavec	0.119	0.255
	Topojan	0.124	0.259
	Bushtricë	0.140	0.282
	Grykë-Çajë	0.136	0.277
	Kalis	0.146	0.294
	Surroj	0.140	0.288
	Arrën	0.152	0.309
	Kolsh	0.122	0.257

6. CONCLUSIONS AND RECOMMENDATIONS

The seismic zoning map created in 1979 (Sulstarova, et al. 1979) serves as the foundation for our present building code, KTP-N.2-89. This map is outdated, empirical, and lacks a probabilistic background. Instead of ground shaking intensity metrics like PGA, PGV, SA, etc., which are currently employed in modern design codes, this map describes macroseismic intensity (MSK-64 scale). In compliance with Eurocode standard 8, a reliable assessment of seismic hazard is required, as is the creation of new seismic hazard maps that will serve as the foundation for a new anti-seismic design code. The deadly earthquake that struck Durrës on November 26, 2019, with a magnitude of M_W=6.4, has sparked additional measures to enhance the Albanian design code. It is obvious that these technical standards need to be improved with features that align with EU standards, including Eurocode 8.

This paper focused on a new seismic hazard model of Albania, as well as deriving the seismic hazard profiles of three distinct urban centers: Kukës, Berat, and Himarë, which represent varying geological and tectonic environments. By analysing the probabilistic seismic

hazard (PSHA) for these cities, this study generated localized data on Peak Ground Acceleration (PGA) for two return periods, required for modern engineering standards.

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