applied sciences

MDPI

Editorial

Special Issue on Natural Hazards Risk Assessment for Disaster Mitigation

Željana Nikolić [1,*], Elena Benvenuti [2] and Andrea Chiozzi [2]

[1] Faculty of Civil Engineering, Architecture and Geodesy, University of Split, 21000 Split, Croatia
[2] Engineering Department, University of Ferrara, 44121 Ferrara, Italy
* Correspondence: zeljana.nikolic@gradst.hr

Knowledge and awareness of the risks generated by natural hazards are essential requirements for the enhancement of communities' resilience to disasters. The Sendai Framework for Disaster Risk Reduction 2015–2030 has recently pointed out the necessity of undertaking actions aimed to anticipate, manage, and mitigate disaster risks, to reduce their economic and social impact and protect health, socioeconomic assets, cultural heritage, and ecosystems of communities and countries. While the increasing occurrence of disasters caused by meteorological events, such as floods, storms, and droughts, can be directly ascribed to the consequence of climate change, disasters induced by earthquakes and tsunamis are increasing even if the frequency of occurrence is historically unchanged. Therefore, other anthropogenic causes intervene to determine an increment of a risk exposure and community vulnerability, such as land misuse in densely populated areas and coastal zones.

This Special Issue addresses concepts, methods, and predictive methodologies for assessing natural hazards risks. This Special Issue presents fifteen articles focusing on the single-risk assessment of a broad range of natural hazards, such as earthquakes, river, and see floods, meteotsunamis, tornados, hydrological and meteorological drought, liquefaction, as well as on multirisk assessment in the presence of multiple hazards. The adopted methodologies rely on: (a) quantitative, semi-quantitative, and qualitative methods for the assessment of the risks related to natural hazards; (b) risk analysis at different scales; (c) multi-hazard risk assessment techniques; (d) real-time hazard monitoring and warning systems; (e) disaster mitigation strategies; and (f) risk management and emergency planning at multiple scales.

Ahmad et al. [1] propose a Gaussian process regression (GPR) model for analyzing liquefaction-induced lateral displacement based on an impressive amount (247) of case studies of post-liquefaction events. The performance of the GPR model is assessed using statistical parameters, including the coefficient of determination, coefficient of correlation, Nash–Sutcliffe efficiency coefficient, root mean square error (RMSE), and ratio of the RMSE to the standard deviation of the measured data. It was shown that the GPR model can accurately capture the complicated nonlinear relationships between lateral displacements and their influencing factors.

Da Col et al. [2] present two case studies of the seismic surveys to estimate the elastic properties of the soil and rock in the shallow subsurface: (1) a town on the Croatian coast, near the city of Split, built on hard rock and (2) a site located in the Italian town of Ferrara, in an alluvial plain. A Multichannel Analysis of Surface Waves and a first-break tomography were carried out to obtain P-, SH-, and SV-velocity profiles. This acquisition allowed for computing the equivalent shear-wave velocity of the first 30 m of the subsurface (VS30) from the SH profiles, as well as it made it possible to deduce other useful parameters such as the VP/VS, and to estimate the soil's stratigraphy through the analysis of the VSV/VSH profiles.

check for updates

Citation: Nikolić, Ž.; Benvenuti, E.; Chiozzi, A. Special Issue on Natural Hazards Risk Assessment for Disaster Mitigation. *Appl. Sci.* **2023**, *13*, 1940. https://doi.org/10.3390/app13031940

Received: 17 January 2023
Accepted: 28 January 2023
Published: 2 February 2023

Gacu et al. [3] studied the spatial distribution of the flood risk of the Municipality of Odiongan using the analytical hierarchy process (AHP) and the geographic information system (GIS), considering the disaster risk factors based on the data collected from various government agencies. The weights of the hazard, exposure, and vulnerability parameters were drawn from the experts' judgment. These weights were subsequently integrated into a flood risk assessment computation which resulted in a flood risk map. The study will guide local government units in developing flood management plans able to reduce flood risk and vulnerability.

Işık et al. [4] carried out a comparative study of the effects of earthquakes in different countries based on target displacement in mid-rise regular RC structures. Five different earthquakes from six countries with a high seismic risk were selected. The measured PGA for each earthquake was compared with the suggested PGA for the respective region. Target displacements specified in the Eurocode-8 were obtained for both the suggested and measured PGA values. It was concluded that both the seismic risk and target displacements were adequately represented for some earthquakes, while not adequately represented for others.

Lin et al. [5] established a method of hazard assessment for the river terraces along the Chenyulan River in Nantou County, Taiwanand. Using GIS, the authors extracted nine parameters and identified the weightings by AHP analysis. Hazard assessment for the river terraces then proceeded via totaling the potential trends of the considered factors and the protected objects, as well as through comparing the historical disaster conditions and satellite images. The results showed different distributions of the relevant risks. Thus, the assessment can be used in reducing the disaster's impact induced by the risks inherent in the riverine terrace settlements.

Maramai et al. [6] developed the database of Adriatic tsunamis and meteotsunamis along the Adriatic coasts, providing an overview of the events and a detailed description of the effects observed at each affected location, and defining a picture of the geographical distribution of the effects for each tsunami and meteotsunami. The database contains 57 observations of tsunami effects related to 27 tsunamis along the Italian, Croatian, Montenegrin, and Albanian coasts and 102 observations of meteotsunami effects related to 33 meteotsunamis. The database can be accessed through a GIS WebApp, which allows the user to visualize the georeferenced information on a map.

Mladineo et al. [7] proposes a methodology for the multi-hazard risk assessment of the urban area of Kaštel Kambelovac, located on the Croatian coast of the Adriatic Sea. The procedure, based on spatial multi-criteria decision making and the PROMETHEE method, was used to assess the multi-hazard risks caused by seismic, flood due to sea level rises, and extreme sea waves impact. The multi-hazard risk is assessed for different scenarios and different levels was based on an exposure and vulnerability for each of the natural hazards and the influence of additional criteria to the overall risk in homogenous zones.

Nikolić et al. [8] developed a methodology for the seismic risk assessment of urban areas based on a hybrid empirical-analytical procedure that combines seismic vulnerability indices with critical peak ground accelerations computed through a non-linear pushover analysis. The procedure's outcomes are the computation of a relationship linking vulnerability indices to the peak ground acceleration for a series of limit states. The methodology was used to estimate the damage index and the index of seismic risk for the selected return periods for masonry buildings in the Croatian settlement Kaštel Kambelovac.

Nikolić et al. [9] present a unique procedure for the real-time assessment of the sea water elevation at the Kaštela Bay in Croatia to ensure a priori warning in the case of expected coastal flooding along the site area caused by barometric pressure, wind-generated waves, and tidal-induced oscillations. The procedure relies on relevant datasets which are site-specific and locally observed. The given information is visualized in a form of mobile application that implements the algorithm and allows end users to set the notifications based on the given ruleset.

Tornadoes are associated with damages, injuries, and even fatalities in Europe. Pîrloagă et al. [10] analyzed a problem of a population bias on tornado reporting in Europe. To account for this bias, a Bayesian modeling approach was used based on tornado observations and the population density for relatively small regions of Europe. The results indicated that the number of tornadoes could be 53% higher than are currently reported. The largest adjustments produced by the model pertain to Northern Europe and some Mediterranean regions.

Rocchi et al. [11] developed a machine learning framework for the assessment of a combined seismic and hydraulic risk at the regional scale. The machine learning techniques were used to aggregate large datasets made of many variables different in nature. The framework is applied to the case study of the Emilia Romagna region, for which the different municipalities are grouped into four homogeneous clusters ranked in terms of the relative levels of combined risk. The proposed approach proved to be robust and delivered a very useful tool for multi-hazard modeling at the regional scale.

Sarwar et al. [12] analyzed meteorological and hydrological drought risk at a regional scale in the Soan basin in Pakistan. The spatiotemporal analysis, statistical approaches, including regression analysis, trend analysis using Mann–Kendall, and moving average, were used to find a linkage between these drought types, the significance of the variations, and the lag time identification, respectively. The overall analysis indicated an increase in the frequency of both hydrological and meteorological droughts during the last three decades.

Shin et al. [13] systematically analyzed the National Flood Insurance Program (NFIP) claims hazard data in Florida. The claims with a presumably incorrect cause of loss fields were identified and revised by adding a variety of other available information. These datasets included tropical cyclone events, rainfall maxima, and distances to the nearest coast. The revised NFIP claims data will be intensively used to validate the outcomes from flood hazard (surge, wave, and inland flooding) models and to develop a flood vulnerability model in the forthcoming Florida Public Flood Loss Model (FPFLM).

Soldati et al. [14] proposes a qualitative multi-hazard risk analysis methodology in the case of combined seismic and flood risk, using PROMETHEE, a multiple-criteria decision analysis technique. The present case study is a multi-hazard risk assessment of the Ferrara province (Italy). The proposed approach provides an original and flexible methodology to qualitatively prioritize the urban centers affected by multi-hazard risks at the regional scale. It delivers a useful tool to stakeholders involved in the processes of hazard management and disaster mitigation.

Vlachogiannis et al. [15] analyzed a climatic multi-hazard risk for Greece, as the first-ever attempt to enhance scientific knowledge for the identification and definition of hazards, a critical element of risk-informed decision making. Many hazards (heatwaves, cold spells, torrential rainfall, snowstorms, and windstorms) were considered to correctly capture the country's susceptibility to climate extremes. The findings highlighted the areas that are exposed to multiple climate hazards in the country, considering the influence of the highly complex topography.

All the contributions gathered in the present special issue contribute to the crucial societal challenge of reducing human and material losses induced by natural hazards caused by extreme climate changes and earthquakes. For this purpose, the continuous upgrade of comprehensive databases of individual risks and the development of new procedures and methodologies for hazard and risk assessment are key to the implementation of effective actions. The present studies show the usefulness of modern technologies, such as multi-criteria decision-making methods coupled with GIS, machine learning, and artificial intelligence. These technologies allowed the authors of the collected contributions to provide robust solutions to several necessities, such as the implementation of numerical models for single-hazard and multi-hazard modeling with a low computational cost, fast training, validation, testing, evaluation, visualization of the results, and fast notification to end users. Furthermore, the presented approaches provide valuable operational tools which can be readily exploited by end users, whether modelers or decision makers, to

urgently allocate resources and increase the coping capacity of communities confronting catastrophic events. Therefore, the Editors believe that the Special Issue may significantly contribute to enhance the insight into technological and analytical procedures aimed to "Natural Hazards Risk Assessment for Disaster Mitigation".

Author Contributions: Writing—original draft preparation, Ž.N., E.B. and A.C.; writing—review and editing, E.B and Ž.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the EUROPEAN UNION, Programme Interreg Italy-Croatia, Project "Preventing, managing and overcoming natural hazards risks to mitigate economic and social impact"—PMO-GATE ID 10046122. The research is also partially supported through project KK.01.1.1.02.0027, co-financed by the CROATIAN GOVERNMENT and the EUROPEAN UNION through the European Regional Development Fund—the Competitiveness and Cohesion Operational Programme.

Acknowledgments: The Editors are deeply grateful to all authors and peer reviewers for their valuable contributions to the Special Issue 'Natural Hazards Risk Assessment for Disaster Mitigation'. Karen Men is also acknowledged for the helpful assistance in the publication process.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ahmad, M.; Amjad, M.; Al-Mansob, R.A.; Kamiński, P.; Olczak, P.; Khan, B.J.; Alguno, A.C. Prediction of Liquefaction-Induced Lateral Displacements Using Gaussian Process Regression. *Appl. Sci.* **2022**, *12*, 1977. [CrossRef]
2. Da Col, F.; Accaino, F.; Böhm, G.; Meneghini, F. Analysis of the Seismic Properties for Engineering Purposes of the Shallow Subsurface: Two Case Studies from Italy and Croatia. *Appl. Sci.* **2022**, *12*, 4535. [CrossRef]
3. Gacu, J.G.; Monjardin, C.E.F.; Senoro, D.B.; Tan, F.J. Flood Risk Assessment Using GIS-Based Analytical Hierarchy Process in the Municipality of Odiongan, Romblon, Philippines. *Appl. Sci.* **2022**, *12*, 9456. [CrossRef]
4. Işık, E.; Hadzima-Nyarko, M.; Bilgin, H.; Ademović, N.; Büyüksaraç, A.; Harirchian, E.; Bulajić, B.; Özmen, H.B.; Aghakouchaki Hosseini, S.E. A Comparative Study of the Effects of Earthquakes in Different Countries on Target Displacement in Mid-Rise Regular RC Structures. *Appl. Sci.* **2022**, *12*, 12495. [CrossRef]
5. Lin, J.-Y.; Chao, J.-C.; Hsu, Y.-M. Risk Assessment of Riverine Terraces: The Case of the Chenyulan River Watershed in Nantou County, Taiwan. *Appl. Sci.* **2022**, *12*, 1375. [CrossRef]
6. Maramai, A.; Brizuela, B.; Graziani, L. A Database for Tsunamis and Meteotsunamis in the Adriatic Sea. *Appl. Sci.* **2022**, *12*, 5577. [CrossRef]
7. Mladineo, N.; Mladineo, M.; Benvenuti, E.; Kekez, T.; Nikolić, Ž. Methodology for the Assessment of Multi-Hazard Risk in Urban Homogenous Zones. *Appl. Sci.* **2022**, *12*, 12843. [CrossRef]
8. Nikolić, Ž.; Benvenuti, E.; Runjić, L. Seismic Risk Assessment of Urban Areas by a Hybrid Empirical-Analytical Procedure Based on Peak Ground Acceleration. *Appl. Sci.* **2022**, *12*, 3585. [CrossRef]
9. Nikolić, Ž.; Srzić, V.; Lovrinović, I.; Perković, T.; Šolić, P.; Kekez, T. Coastal Flooding Assessment Induced by Barometric Pressure, Wind-Generated Waves and Tidal-Induced Oscillations: Kaštela Bay Real-Time Early Warning System Mobile Application. *Appl. Sci.* **2022**, *12*, 12776. [CrossRef]
10. Pîrloagă, R.; Ene, D.; Antonescu, B. Population Bias on Tornado Reports in Europe. *Appl. Sci.* **2021**, *11*, 11485. [CrossRef]
11. Rocchi, A.; Chiozzi, A.; Nale, M.; Nikolic, Z.; Riguzzi, F.; Mantovan, L.; Gilli, A.; Benvenuti, E. A Machine Learning Framework for Multi-Hazard Risk Assessment at the Regional Scale in Earthquake and Flood-Prone Areas. *Appl. Sci.* **2022**, *12*, 583. [CrossRef]
12. Sarwar, A.N.; Waseem, M.; Azam, M.; Abbas, A.; Ahmad, I.; Lee, J.E.; Haq, F.u. Shifting of Meteorological to Hydrological Drought Risk at Regional Scale. *Appl. Sci.* **2022**, *12*, 5560. [CrossRef]
13. Shin, D.W.; Cocke, S.; Kim, B.-M. A Systematic Revision of the NFIP Claims Hazard Data in Florida for Flood Risk Assessment. *Appl. Sci.* **2022**, *12*, 3537. [CrossRef]
14. Soldati, A.; Chiozzi, A.; Nikolić, Ž.; Vaccaro, C.; Benvenuti, E. A PROMETHEE Multiple-Criteria Approach to Combined Seismic and Flood Risk Assessment at the Regional Scale. *Appl. Sci.* **2022**, *12*, 1527. [CrossRef]
15. Vlachogiannis, D.; Sfetsos, A.; Markantonis, I.; Politi, N.; Karozis, S.; Gounaris, N. Quantifying the Occurrence of Multi-Hazards Due to Climate Change. *Appl. Sci.* **2022**, *12*, 1218. [CrossRef]