



Preface on “Natural hazards’ impact on natural and built heritage and infrastructure in urban and rural zones”

Maria Bostenaru Dan¹, Mara Popescu^{1,2}, Orsolya Kegyes-Brassai³, Margherita D’Ayala^{4,a}, Cerasella Crăciun⁵, and Animesh Gain⁶

¹Department for Management of Research, “Ion Mincu” University of Architecture and Urban Planning, Bucharest, 010014, Romania

²Architecture Study Program, Department of Industrial Engineering and Management, “George Emil Palade” University of Medicine, Pharmacy Science and Technology, 540142 Târgu Mureş, Romania

³Department of Structural Engineering and Geotechnics, Széchenyi István University, 9026 Győr, Hungary

⁴CARISMA research Centre, Scuola Universitaria Superiore IUSS, Pavia, Italy

⁵Department for Urban and Landscape Design, “Ion Mincu” University of Architecture and Urban Planning, Bucharest, 010014, Romania

⁶School of Environmental Science & Conservation, Murdoch University, Murdoch, WA 6150, Australia

^anow at: SYSTRA Italy, Rome, Italy

Correspondence: Maria Bostenaru Dan (maria.bostenaru-dan@alumni.kit.edu)

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Abstract. This is an overview of the papers published in the special issue.

1 Aim of the special issue

This special issue interrogates the multifaceted impacts of disasters on architecture, urban and cross-border territories, landscapes, protected environments, and critical infrastructure, emphasizing the intersection of vulnerability, resilience, and cultural memory. We invited contributions that integrate empirical documentation, theoretical reflection, and design- or policy-oriented strategies, engaging with advanced methodologies such as digital photography, photogrammetry, and 3D modeling to capture pre- and post-disaster states. Of interest are studies exploring decision-making frameworks that reconcile architectural, artistic, and historic value with socio-technical vulnerability, context-sensitive retrofitting, post-disaster repair, and reconstruction strategies informed by regional morphology, vernacular practices, and local knowledge systems. Contributions may address the mnemonic and symbolic dimensions of cultural landscapes, genius loci, and heritage sites, as well as nature- and ecosystem-based solutions for climate adaptation, fire

and flood risk reduction, and infrastructure resilience. By synthesizing empirical observation with conceptual inquiry, this special issue aims to advance interdisciplinary understanding of how post-disaster interventions – from restructuring and revitalization to renaturation and restoration – transform both material environments and socio-cultural imaginaries, and to foster innovative approaches that challenge prevailing paradigms in resilience, heritage, and landscape scholarship.

2 Overview of the papers

The articles cover a diverse range of natural hazards, including avalanches, cyclones, wind, rockfalls, many of them directed to infrastructure resilience. Three papers are about damage to roads, two of them examining road protection with civil engineering measures in China while the other exemplifies multi-criteria decision making for road protection. Two papers deal with hazards affecting a whole country in a different way due to its setting (wind in Poland and avalanches in Switzerland) while the final paper deals with biochemical response of the marine environment to hazards. Thus, although this session’s scope was adapted from the previous “Natural hazards’ impact on urban areas and infrastructure”

the impact on infrastructure remained central, but instead of urban areas we have the alpine or marine natural environment, which can include the human.

The findings can be used for evaluating the need and designing safety measures, disaster management as part of environmental management and infrastructure design. Among the methods used are the classical ones for engineering/natural science such as the comparison between experimental/field investigations and numerical simulations, more modern ones based on satellite data analysis and finally machine learning. One article is general, but dealing with the same problem as the other one from China, while some cover case studies, located either in Europe (Switzerland, France, Poland) or Asia (India, China).

In Europe

The paper by Sharma et al. (2023) is using machine learning, namely a neural network model employed for mountain hazards in Switzerland. Aim of the employment of artificial intelligence is automating avalanche forecasting. Historical data the Swiss Alps were used to train (accuracy 79.75) and validate (accuracy 76.54) the model and with its help predictions can be met for the current situation so warnings can be issued if the danger is high. The model helps decision making about safety measures (warning) to be taken in order to minimise incidents.

The paper by Yang et al. (2024) proposes a step-by-step guide designed to assist critical infrastructure managers in indicator systems for assessing resilience to be included in a multi-criteria decision system. Central to decision making is the benefit-cost analysis which considers also potential side effects of the actions aimed to lead to benefit. Disaster management experts will be able to prioritise actions aimed to fill the gaps after strategies to mitigate risks associated with natural hazards have been developed based on their (economic) effectiveness and feasibility. Such strategies are done according to operational management and thus operational steps are foreseen along with resources according to decision criteria and measurement indicators, reference definition and data collection. A real-world case study, the Nantes Ring Road network in France, is included as practical example.

The paper by Chmielewski and Bońkowski (2023) examines extreme wind events in Poland, focusing on the impact of wind depending on its speed. Two different estimations show that assessment is challenging but also important for effective risk assessment and mitigation strategies.

In Asia

The paper by Huang et al. (2023) is investigating the occurrence of a phenomenon not easy to understand, namely how Super Cyclonic Storm Amphan (May 2020) triggered a significant phytoplankton (chlorophyll a) bloom in a nutrient-poor region of the central Bay of Bengal, India. Dozens of

mechanisms were uncovered, including inertial oscillation (over 2 weeks), cyclonic eddy formation which reduced barrier layer thickness, horizontal and vertical nutrient transport, favourable light conditions (photosynthetically available radiation). This study highlights the impact of hazards on marine ecosystems, which dynamically respond. Such responses will be better modelled from a biochemical point of view in regions prone to similar hazards.

The paper by Luo et al. (2024) examines a rockfall disaster in southwestern China caused by the damage and thus loss of mitigation function of a flexible barrier protection of a road by falling rocks. The study dealing with this road infrastructure is classical for civil engineering and comprises field analysis compared to a numerical model of the slope, rockfall and flexible barrier. The findings permit developing an optimisation strategy for the flexible barrier so that it retains its protective function of the road infrastructure and connected of human life.

The paper by Zou et al. (2024) investigates in a more general way and not connected to a specific case study site also the protection of infrastructure from rockfall impact, this time on a pile-slab retaining wall structure. Lacking the case study, only numerical simulations were conducted. Stress distribution and deformation patterns were studied under different impact scenarios. The protective function of the retaining wall is based on its ability to absorb and dissipate the energy from rockfall impacts. The absorption capacity proved significant. To even better optimise the structure, some design modifications were proposed, thus enhancing infrastructure safety.

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References

- Chmielewski, T. and Bońkowski, P. A.: Wind as a natural hazard in Poland, *Nat. Hazards Earth Syst. Sci.*, 23, 3839–3844, <https://doi.org/10.5194/nhess-23-3839-2023>, 2023.
- Huang, H., Bai, L., Shen, H., Ding, X., Wang, R., and Lü, H.: A phytoplankton bloom caused by the super cyclonic storm Amphan

- in the central Bay of Bengal, *Nat. Hazards Earth Syst. Sci.*, 23, 2807–2819, <https://doi.org/10.5194/nhess-23-2807-2023>, 2023.
- Luo, L.-R., Yu, Z.-X., Zhang, L.-J., Wang, Q., Liao, L.-X., and Peng, L.: Optimization strategy for flexible barrier structures: investigation and back analysis of a rockfall disaster case in southwestern China, *Nat. Hazards Earth Syst. Sci.*, 24, 631–649, <https://doi.org/10.5194/nhess-24-631-2024>, 2024.
- Sharma, V., Kumar, S., and Sushil, R.: A neural network model for automated prediction of avalanche danger level, *Nat. Hazards Earth Syst. Sci.*, 23, 2523–2530, <https://doi.org/10.5194/nhess-23-2523-2023>, 2023.
- Yang, Z., Barroca, B., Mebarki, A., Laffréchine, K., Dolidon, H., and Lilas, L.: Critical infrastructure resilience: a guide for building indicator systems based on a multi-criteria framework with a focus on implementable actions, *Nat. Hazards Earth Syst. Sci.*, 24, 3723–3753, <https://doi.org/10.5194/nhess-24-3723-2024>, 2024.
- Zou, P., Luo, G., Bi, Y., and Xu, H.: Dynamic response of pile–slab retaining wall structure under rockfall impact, *Nat. Hazards Earth Syst. Sci.*, 24, 3497–3517, <https://doi.org/10.5194/nhess-24-3497-2024>, 2024.