A Dynamic Bayesian Network Approach to Multi-Hazard Risk and Resilience Assessment of Urban Infrastructure

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Keywords: Multi-Hazard, Risk, Resilience, Infrastructure, Dynamic Bayesian Network

Abstract Assessing the risk to buildings and infrastructure systems from multiple natural hazards, both spatially and temporally, is essential for evaluating the resilience of urban and metropolitan settlements. The rapidly evolving built environment, shaped by human activity and intensified by climate change, has led to an increasing occurrence of multi-hazard interactions, potentially resulting in compounding risks, where the impacts of multiple hazards interact and amplify the initial consequences (e.g., physical damage) affecting built environments. As a result, there is a growing shift from traditional single-hazard approaches toward integrated multi-hazard and multi-risk perspectives. In this study, we present a methodology based on Dynamic Bayesian Networks to probabilistically evaluate the risk and resilience of structures and infrastructure systems over time. Our analysis focuses on critical infrastructure (e.g., hospitals, schools), road networks, and residential buildings, using key risk and resilience indicators such as post-disaster hospital accessibility and building functionality (i.e., the ability of a building to perform its intended purpose). We also assess the temporal evolution of these indicators by incorporating repair actions and various mitigation interventions. To demonstrate the real-world application of the proposed methodology, we present a case study of Pompei, located in the Naples metropolitan area of Italy—a region exposed to multiple natural hazards, including pluvial flooding, earthquakes, and volcanic activity. The findings of this study aim to support decision-making for resilience-informed policies and robust mitigation strategies under multi-hazard conditions.

This study was carried out within the RETURN Extended Partnership and received funding from the European Union Next-GenerationEU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005)."