

## Simulation of wide road network flows to identify critical bridges in flash-flood events

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Floods pose a significant threat to transportation networks, particularly bridges, which serve as critical links in road infrastructure. Prioritizing bridge retrofitting is essential to enhance network resilience, minimize disruptions, and optimize resource allocation. This study, funded by the European Union - Next Generation EU, Mission 4 Component 1 (FLOOD@ROAD – CUP: B53D23006770006), develops a systematic approach for prioritizing bridge retrofitting based on macroscopic traffic assignment. The proposed approach is designed to be practical for transportation authorities and planners, enabling quick decision-making in response to floods at a regional scale, encompassing both urban and rural areas. The methodology is broadly applicable, leveraging publicly available online data and open-source software for geographic analysis (QGIS) and traffic simulation (SUMO). It integrates flood hazard maps, traffic flow modeling, and vulnerability analysis to evaluate the impact of potential bridge failures on network performance. By employing macroscopic traffic assignments, the study assesses the consequences of bridge disruptions on regional traffic flow, identifying critical structures that warrant immediate retrofitting.

The research applies the proposed framework to a case study in Tuscan region of Italy, a flood-prone area with an extensive road network. The study evaluates multiple bridge closures in flood scenarios and their impact on traffic flow. The assessment is based on key performance indicators such as travel cost increase, reduced speed, and network connectivity loss. The findings highlight the most critical bridges and provide a data-driven basis for decision-makers to allocate resources effectively. The macroscopic simulation provides a perspective by identifying the most critical edges of the road network. The results reveal key weak points where even minor disruptions could cause delays and traffic congestion, providing valuable insights for targeted mitigation and retrofitting strategies. This study contributes to the growing field of transportation resilience by offering a quantitative framework for infrastructure adaptation planning. Future research could enhance the model by integrating dynamic traffic simulations and considering climate change projections to simulate long-term infrastructure vulnerabilities.