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# Modelling cascading impacts and risks across linear infrastructure systems

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Linear infrastructure systems such as Water Supply System (WSS), electricity and transportation are considered Critical Infrastructures (CIs) because their failure would jeopardize public health and economic security, with repercussions on the whole society (Fekete, 2019). CIs are exposed to natural hazards, such as flooding, which is the most frequent and damaging natural threat worldwide; in particular, ~7.5% of road and rail infrastructures are exposed to a 1/100-year flood event worldwide.

Flooding can damage CIs directly (when impacts are due to the physical contact with floodwaters, i.e. direct impacts) and indirectly (when impacts are not due to the physical contact, and/or occur outside the inundated area in space or time, i.e. indirect or cascade impacts). Whereas the assessment of direct impacts is well-advanced, the evaluation of indirect impacts is less frequently achieved (Arrighi et al. 2019).

This work presents the risk analysis of two linear infrastructure systems, i.e. the water distribution system (WSS) and the road network system. The evaluation of indirect flood impacts on the two networks is carried out for four flooding scenarios, obtained by a coupled 1D-quasi 2D hydraulic model. Two methods are used for assessing the impacts on the water distribution system and on the road network, a Pressure-Driven Demand network model 15 and a transport network disruption model respectively. The analysis is focused on the identification of: (i) common impact metrics; (ii) vulnerable elements exposed to the flood; (iii) similarities and differences of the methodological aspects for the

two networks; (iv) risks due to systemic interdependency. The study presents an application to the metropolitan area of Florence (Italy). When interdependencies are accounted for, results showed that the risk to the WSS in terms of Population Equivalent (PE/year) can be reduced by 71.5% and 41.8%, if timely repairs to the WSS stations are accomplished by 60 and 120 minutes respectively; the risk to WSS in terms of pipes length (km/year) reduces by 53.1% and 15.6% (Arrighi et al. 2020).

This study represents one of the first attempts to model flooding impact to CIs for real-world networks, considering mutual interconnections, and it is expected to be relevant to researchers, as well as practitioners. The study highlights that resilience is enhanced by system risk-informed planning, which ensures timely interventions on critical infrastructures; however, temporal and spatial scales are difficult to define for indirect impacts and cascade effects. Perspective research could further improve this work by applying a system-risk analysis to multiple urban infrastructures.

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