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A global multi-hazard risk analysis of road and railway infrastructure assets

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This study presents first estimates of global exposure and risk of road and railway assets to the most frequently recorded and costliest disasters: tropical cyclones (wind speed only), earthquakes, surface flooding, river flooding and coastal flooding. To do so, we make use of approximately 60 million km of road and railway asset data available through OpenStreetMap, in combination with state-of-the-art global hazard maps. The study demonstrates the potential for conducting infrastructure risk analysis at a high spatial resolution on a global scale.

The total global EAD for all hazards combined ranges from 3.1 to 22 billion US dollars, with a mean EAD of 14.6 billion USD. Approximately 73% of the global EAD is caused by surface and river flooding, followed by coastal floods (15.5%), earthquakes (7.3%), and tropical cyclones (3.8%). The results for overall transport infrastructure exposure and risk are broadly in line with previous risk analyses of natural hazards which demonstrate greatest absolute levels of risk in High Income countries, but higher risk as a percentage of GDP in Middle Income countries. However, our results also reveal geographical patterns of exposure and risk, including the particular vulnerability of transport infrastructure in Small Island Developing States. Sensitivity analysis has revealed the importance of understanding asset fragility.

We have calculated the potential benefits that can be gained by adapting transport infrastructure so that it is better protected from flooding and more resistant to a range of natural hazards. We have made some preliminary estimates of the cost of adaptation, showing that improving the standards of all roads across the board is very cost inefficient. Targeting exposed roads, on the other hand, shows promising results, with over 80% of the exposed primary and secondary roads in Upper Middle Income and tertiary roads in Lower and Middle Income countries showing higher benefits than costs. Of course, care should be taken with the interpretation of these results, as local road conditions are unknown in this study and a generalized approach is taken. Nonetheless, it is clear that there are significant benefits to be gained from improving the resilience of exposed transport infrastructure. These are expected to be low-regrets investments in the context of a changing climate. Multiple studies indicate upwards trends in flood risk, which we would also expect for transport infrastructure, as flooding constitutes a large share of the total EAD (up to 89%).

This study can be considered as a starting point for further analysis. Economic consequences of transport disruptions due to extreme events go well beyond direct infrastructure damage. Most of the impacts will come from increased travel costs and time, impaired trips, and supply chain disruptions. The next research agenda is thus to assess the broader economic consequences of transport asset risk and propose mitigation measures, either through more resilient infrastructure, or by enabling users of infrastructure to cope better with service interruptions.