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## Road hydraulic vulnerability and risk: setting up a standard evaluation procedure

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### ABSTRACT

The aim of this work is to introduce and develop a suitable methodology for road hydraulic vulnerability and risk classification, to support the development of emergency plans and to increase flood risk citizen perception.

Flood risk in urban areas comes often both from the river network and the sewer network. Damages to infrastructures can be very large. Mitigation measures and adaptation strategies can be more efficiently set up through procedures involving citizen participation and experience.

Focusing on a small urban area in the province of Brescia (Comune di Cortefranca, Northern Italy), potential flooded areas shown in territorial administration plan risk maps and due to the presence of creeks and high level water tables were overlaid to the sewer network critical nodes, that is overpressure or flooded nodes. Critical nodes were found through 10 year-long continuous simulation of the sewer network accounting for the complete time series of observed precipitation. Nodes showing highest frequency of critical conditions were assumed to be critical, eventually at different levels; some of these were located along 'safe paths' in the available emergency plan.

River flood risk is reported in the maps of the hydrogeological system plan. In order to prepare the hydraulic hazard map this information was integrated with the results of the sewer network simulation, as well as with the information contained in the geological report attached to the territorial administration plan (PGT), in order to account for areas where the water table was very close to the soil surface. This complete hazard map can be used to evaluate the hazard level of the area where an infrastructure is located or of the corresponding road segment.

Following approaches reported in the scientific literature on hydraulic and seismic risk, an efficient standard procedure was set up to provide an analysis of the road hydraulic vulnerability and risk. The procedure relies on integrated check lists for the survey of infrastructures and roads and an efficient database for data collection and management, a precious support tool during emergencies. A safe road system was finally recognized and compared to what is reported in emergency plans to improve the efficiency of required operations.

A survey data sheet was prepared for easily evaluate the state of roads. Both qualitative and quantitative parameters were used to evaluate flood critical issues for the infrastructure. The

proposed sheet consists of 4 macrosections, made out of 20 subsections, besides location, vulnerability, hazard and exposition. The level of severity of the critical issue is a number between 0 (no critical issue) and 10 (most critical issue). The sum of the level number of each macrosection shows the level of severity of critical issues of the road segment (vulnerability, hazard and exposition). When levels of macrosections are instead multiplied, the level of hydraulic risk of the road segment is obtained:  $R = V \times H \times E$ .

A very important step both in the data collection and the preparation of survey check lists is the citizen involvement: their experience is a fundamental piece of information that strongly increases the level of understanding of the critical issues. The GIS framework used to georeference data is strongly versatile and easily connect different sources of information in the municipality database, increasing the local knowledge, a fundamental source for city and land planning analysis.

The hydraulic vulnerability and risk analysis could also be linked to a more detailed analysis of services location and accessibility. For example, a requalification of access roads could be planned in order to facilitate the access also during flood emergencies for safety operations.

## References

- G. Gamba, (2014), Vulnerabilità delle strade e rischio idraulico: prime considerazioni di metodo (in Italian), Master thesis, Università degli studi di Brescia.
- Benedetto, A. Chiavari (2010), Flood risk: a new approach for roads vulnerability assessment, PhD thesis, Department of Sciences of Civil Engineering (DSIC), University of RomaTRE.
- Directive 2007/60/EC: On the Assessment and Management of Flood Risks, The European Parliament and of the Council of 23 October 2007, Brussels, Belgium, 2007.
- P. Ronco; V. Gallina; S. Torresan; A. Zabeo; E. Semenzin; A. Critto.; A. Marcomini The KULTURisk Regional Risk Assessment methodology for water-related natural hazards – Part 1: Physical-environmental assessment in *Hydrology and Earth System Sciences*, vol. 18, pp. 5399-5414