Counter measures applied on levee system: Effects on flood map and probability of failure

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Historical records have shown that people living in the flood plain areas surrounded by levees are increased over the time around the world.. However, the effectiveness of different counter measures on increasing levee efficiency, and their environmental and economical consequences on the urbanized flood prone area, are not yet well exploited. The present research proposes a methodology to investigate the effects of two different counter measures on the estimation of the probability of levee failure due to overtopping and the consequent flood extent. The case study was performed in 98km-braided reach of Po River, Italy, between the cross-sections of Cremona and Borgoforte.

The adopted methodology was divided into four core categories. Firstly, reliability analysis, expressed in terms of fragility curve, of the levee system in case of overtopping was performed using the geotechnical and geometrical data of the levee considering the grass cover quality as a stochastic variable to account the uncertainties associated to it. In order to estimate the fragility curves for all sections, a Monte Carlo framework was introduced. Secondly, 1D hydrodynamic model was implemented to estimate the water level in the river in case of a synthetic flood event of 200year return period. The information of the water level was used as hydraulic load into the previous fragility curves. Then, a levee breach modeli was introduced to address the uncertainties related to the location, size and development of the breaches. Finally, a 2D hydrodynamic model CA2D_S,based on the cellular automata approach in semi-inertial formulation for flux computation, was implementd. CA2D – SCENARI (CA2D_S) is a version of the CA2D model specifically designed to simulate levee breach scenarios in low land areas. The previous methodological steps were repeated for each countermeasure scenario and the results from CA2D, expressed in terms of flood extent, were compared and analyzed.

The analysis showed that different counter measures can reduce the probability of failure of the levee system and prevent flooding locally.