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On finding optimal dike heights along the IJssel River while accounting for the uncertain effects of upstream breaches

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Abstract: Most alluvial plains in the world are protected by flood defences (e.g. dikes), whose primary aim is to reduce the probability of riverine flooding. However, the presence of dikes influences the hydraulic loads along the river. For example, upstream dike raising decisions influence the water levels downstream. Similarly, upstream flooding will reduce downstream risk. These dynamics are often neglected by the current flood risk management approaches because of two reasons. Firstly, it involves dealing with deep uncertainties about the breach locations and the way breaches can take place and develop over time. Secondly, it would further complicate the decision-making process, since deciding upon flood risk management measures at one location would require considering the interests of communities downstream of that location. This study aims at finding optimal dike heights along a stretch of the IJssel River in The Netherlands while explicitly accounting for uncertain upstream-downstream interactions. We develop a simplified flood risk analysis model that generates and propagates flood waves, assesses dike failures, and assesses flood damages and dike raising investment costs. The study is conducted following the Many Objective Robust Decision Making (MORDM) framework. We find that (1) the current approach leads to cognitive myopia, since considering interactions reveals a larger set of solutions; (2) solutions accounting for interactions are more capable of retaining their Pareto optimality when re-evaluated under deep uncertainty; (3) there is a trade-off between robustness in retaining Pareto optimality and robustness with respect to the system-wide best performance. Due to its conservative nature, the solution found with the current approach scores best in the latter. Overall, acknowledging the effect of upstream-downstream hydraulic interactions provide policy makers a more appropriate representation of spatial trade-offs and risk-transfers taking place along the river stretch.

Keywords: Large-scale flood risk management, upstream - downstream interactions, deep uncertainties, Many Objective Robust Decision Making