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# The impact of human activities on the flood risk

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ABSTRACT

The rising frequency of floods, coupled with increasing human encroachment on water corridors and floodplains, makes floods severe disasters. In 2007, the European Union enacted the Floods Directive, guiding member countries in legislation for identifying flood hazard and risk areas. Despite significant human impacts, current flood hazard mapping often neglects scenarios from extreme events. Stochastic land use changes, driven by economic and social interests, should be considered. Mitigation measures, like dams and levees, aimed at reducing flood risk can alter flow regimes and transfer risk. Levee construction changes floodplain retention capacity, influencing flood peak attenuation and propagation time. This article introduces the analysis of exceptional events in assessing flood hazards and risks through examples of man-made extreme flood events using detailed hydraulic models.

## 1. Introduction

To enhance flood risk management and spatial planning aimed at reducing vulnerability through preventive measures, the European Parliament and Council of the European Union enacted the Flood Directive in 2007. Slovenia established detailed regulations, including the Rules on flood hazard determination and land classification (Ministry of the Environment and Spatial Planning, 2007), and the Decree on conditions for activities in flood-threatened areas.

While climate change is a topic of discussion, the primary factor increasing risk is human intervention in vulnerable areas. Factors include intensive land use, economic development in flood-prone zones, reduced retention areas, minimal flood protection measures, and inadequate maintenance. Structural measures, like flood protection, have limited functionality, and their effectiveness diminishes in catastrophic events (Rak et al., 2018). Flood protection measures are designed based on the "design discharge," making protected areas attractive for intensive land use, potentially increasing damage potential during floods.

Flood risk analysis often overlooks extraordinary events such as breaches in flood protection, incorrect operation of hydro-mechanical equipment, and inadequate maintenance, leading to adverse anthropogenic effects (Šantl and Rak, 2010). Uncontrolled land use changes in retention areas alter runoff regimes, affecting the effectiveness of interventions and spatial planning. The paper provides two examples of anthropogenic impact on flood hazard: the uncontrolled land use during infrastructure lifespan altering runoff regimes and the sudden or progressive failure of flood protection embankments during extreme events.

## 2. Land use in riparian areas

Riparian areas and floodplains, especially in flatland regions, offer significant development potential. However, these areas, with their retention capacity, play a crucial role in forming the runoff regime, attenuating flood waves, prolonging propagation times, and thereby reducing flood risk downstream. Given the inherent conflicts of interest in spatial planning, building placement, and long-term land use, a judicious strategy for spatial development and intervention planning in riparian areas is needed (Rak, 2013; Rak et al., 2016).

Preserving the runoff regime in these influenced zones while avoiding adverse effects downstream is a challenging yet vital task. Achieving a static state in these areas is impractical due to the dynamic nature of spatial development. However, it is essential to analyze potential negative impacts resulting from spatial changes. Legislation aligned with the Flood Directive places restrictions on interventions in flood-prone areas, aiming to balance diverse changes within the region.

## 3. Malfunction of flood protection measures

After completing structural flood protection measures (FPMs), consolidation occurs, dependent on factors like soil quality and terrain load-bearing capacity. Regular maintenance and stability checks are essential to uphold the flood protection function. Between interventions, critical sections may emerge in areas with higher settlements, increasing the risk of embankment overflow. FPM designs typically consider normal conditions, but extraordinary events like bridge clogging or sediment transport and depositions should be factored in. Properly constructed and maintained FPMs should withstand loads, yet instantaneous collapse or gradual breaching can occur. The spilling of water mass into floodplains increases during breaches, impacting areas initially considered to have acceptable flood risk. Overflow can also happen in extreme events, termed "force majeure," exceeding design discharge. Analyzing such scenarios helps formulate guidelines, restrictions, and requirements in spatial planning and coordinated actions during extraordinary events. Predicting erosion processes, breach timing, and assessing the destructed section's width and overflow onset are crucial aspects in preparing flooding scenarios. Fig. 1 presents flood dynamics in urban area after collapse of an FPM.

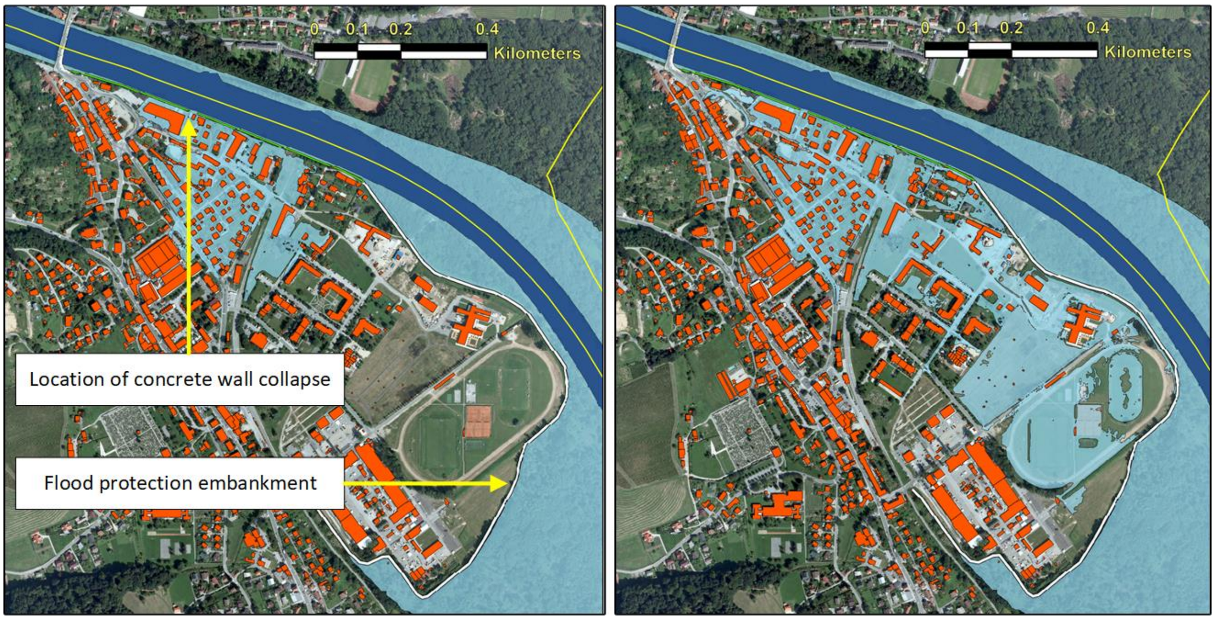


**Fig. 1.** Propagation of flooding 2 hours (left) and 4 hours (right) after the collapse of a part of the flood protection wall.

## 4. Conclusions

The paper highlights a few examples of anthropogenic activities impacting flood risk, emphasizing the importance of hydraulic research in predicting and analyzing adverse effects on runoff in river channels and riparian areas. Such analyses improve emergency plans and aid in formulating practical solutions and guidelines for spatial development planning. Establishing this expert basis enables the incorporation of concerns that could hinder protection and rescue efforts and helps prevent excessive risk. Land use planning must consider the experiences that demonstrate significant changes after interventions in riparian areas, affecting FPM objectives. The allure of reduced flood risk can lead to intensified use of riparian areas, increasing damage potential during floods. Monitoring land use from FPM completion to any changes or degradation is crucial to prevent harmful effects throughout their lifespan. A comprehensive plan for sustainable development should systematically manage flood-endangered areas, considering both temporal and spatial dynamics.

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