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Editorial: Advances in urban flood studies: modelling, monitoring, strategic planning, and lessons learned

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Editorial on the Research Topic
Advances in urban flood studies: modelling, monitoring, strategic planning, and lessons learned

Introduction

Urban flooding is one of the most complex and uncertain environmental hazards, as it results from the interplay of hydroclimatic variability, fine-scale rainfall dynamics, drainage systems, and the intricate and evolving topography of the built environment. It is a fast-evolving hazard that can claim lives and cause major disruptions to city life, including transportation, building functionality, and critical infrastructure. The short response times associated with urban flood events make both preparedness and a deeper understanding of flood processes particularly important.

The papers collected in this Research Topic span a wide range of urban flood studies, from modelling and hazard assessment to vulnerability, resilience, and the analysis of past disasters. Together, they provide perspectives from diverse geographical and socio-economic contexts, highlighting both the common challenges faced by cities and the context-specific factors that shape flood risk and its impacts.

Several contributions focus on improving the characterization of flood hazards and reducing uncertainties in urban flood assessments. These include studies on flood attribution, integrated modelling frameworks, sensitivity analyses, machine learning applications, and the use of non-conventional information sources. Other studies highlight that flood impacts cannot be understood solely through hazard analyses, emphasizing the role of vulnerability, social inequalities, governance, and preparedness in shaping disaster outcomes.

A recurring theme across several contributions is the growing use of non-conventional and high-resolution data sources, ranging from crowd-sourced information and field

observations to detailed building-level and socio-economic datasets, demonstrating their value for improving both flood-risk assessment and the understanding of flood impacts.

Collectively, the papers illustrate a broader shift in urban flood studies toward more integrated approaches that consider not only flood processes, but also the built environment and the vulnerabilities of exposed populations.

Understanding urban flood dynamics and improving risk assessment

Several contributions advance understanding of urban flood processes and improve hazard characterization through modelling, reconstruction, and predictive approaches. Wulandari et al. investigate the relative contributions of multiple river systems to urban flooding through scenario-based hydrologic–hydrodynamic modelling, highlighting flood attribution as a crucial step towards flood-risk mitigation and planning. Reliable hazard assessment also depends on how the urban environment itself is represented within flood models. In this respect, Alexopoulos et al. identify building representation in the rain-on-grid method as a critical source of uncertainty in urban flood modelling, showing that alternative building treatment approaches can lead to substantially different inundation patterns and hazard assessments at fine scales, with important implications for risk-informed decision making. Sigourou et al. develop an integrated methodology that combines complementary hydraulic modelling approaches for more robust flood-model calibration and risk evaluation, and supports the identification of vulnerable areas at the building scale. Beyond hazard characterization, Kabeyama et al. propose the use of multimodal LSTM methods to enrich building-level exposure information and improve flood damage estimation, highlighting the potential of data-driven approaches for high-resolution risk assessment. Finally, moving from predictive analysis to disaster learning, Dal Sasso et al. perform a detailed post-event reconstruction using non-conventional information sources such as testimonies, images, and videos and derive valuable insights into flood pathways, local exposure, and disaster interpretation, reinforcing the importance of learning from past events.

Beyond the hazard: vulnerability and resilience

A second major theme emerging from the Research Topic concerns the uneven distribution of flood impacts and the importance of vulnerability, resilience, and governance. Kunguma et al. reveal how vulnerability in informal settlements emerges from the combined effects of socio-economic marginalization, infrastructure deficits, and environmental conditions, illustrating that flood risk cannot be adequately understood through hazard exposure alone. Raphela broadens the scope of urban flood-risk assessment by drawing attention to the indirect and often overlooked social and psychosocial consequences of recurrent flooding, emphasizing that the impacts of flood disasters extend well beyond physical losses. Together, these studies illustrate that flood risk is more than just a function of physical event characteristics, but is strongly shaped by social conditions and community capacity. In this respect, Orimoogunje and Aniramu argue that urban flood resilience should be viewed not merely as a flood-management objective, but as an integral component of sustainable urban development, requiring coordinated action across governance, infrastructure, and community levels.

Conclusion and remaining challenges

Overall, the studies collected in this Research Topic illustrate a broadening of urban flood research beyond hazard characterization alone. Advances in modelling, data availability, machine learning, and post-event analyses are enabling more detailed and uncertainty-aware assessments of urban flood risk, while growing attention is being given to vulnerability, resilience, and the social dimensions of flood impacts.

A notable observation emerging from the Research Topic is that challenges related to representing the urban environment recur across different case studies and geographical settings, highlighting the inherent complexity of modelling flood processes in densely built areas. In contrast, flood impacts and vulnerabilities are far less uniform, varying substantially across communities and disproportionately affecting populations with limited infrastructure, resources, and flood protection measures.

Progress in urban flood-risk research will therefore depend not only on advances in modelling and data collection, but also on a better understanding of vulnerability and the wider social processes that shape risk. The studies in this Research Topic collectively emphasize the need to combine structural and non-structural measures, including preparedness and resilience-building strategies, while recognizing the central role of the built environment. As both a driver of flood behaviour and a receptor of flood impacts, the built environment stands out as a key component of urban flood-risk assessment and management.

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