Identifying Strategic Locations for Blue-Green Infrastructure: A Holistic Source-to-Impact Approach Considering Stakeholder Interests

Identification d'emplacements stratégiques pour les infrastructures bleues et vertes: une approche holistique de la source à l'impact intégrant les intérêts des parties prenantes

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RÉSUMÉ

Les inondations urbaines et les déversements des déversoirs d'orage (CSO) s'intensifient en raison du changement climatique et de l'urbanisation. Cet article présente une méthodologie holistique pour la sélection d'interventions d'infrastructures bleues et vertes (IBV) utilisant le modèle hydrodynamique CityCAT et une analyse spatiale de la source à l'impact. Nous démontrons un nouveau cadre stratégique qui optimise l'emplacement des interventions pour satisfaire simultanément plusieurs autorités de gestion des risques. Cette méthode intègre des paramètres d'ingénierie aux priorités spécifiques des autorités, telles que la réduction de l'exposition des bâtiments et l'atténuation des déversements d'égouts, tout en incorporant des co-bénéfices comme la valeur d'agrément. Les résultats indiquent que cette approche intégrée offre une alternative prometteuse à la planification traditionnelle en silo, en assurant une réduction ciblée des inondations tout en maximisant l'agrément et la valeur environnementale.

ABSTRACT

Urban flooding and Combined Sewage Overflow (CSO) spills are escalating due to climate change and urbanisation. This paper presents a holistic methodology for selecting Blue-Green Infrastructure (BGI) interventions using the City CAT hydrodynamic model and spatial source-to-impact analysis. We demonstrate a novel strategic framework that proposes intervention placement to satisfy multiple Risk Management Authorities (RMAs) simultaneously. This method integrates engineering parameters with specific RMA priorities, such as reducing building exposure to flooding, improving roads' conditions, and mitigating sewer spills from CSOs, while also incorporating co-benefits like amenity value. Results indicate that this integrated approach offers a promising alternative to traditional siloed planning by delivering targeted flood reduction while maximising amenity and environmental value.

KEYWORDS

Blue-Green Infrastructure, Co-benefits, Hydrodynamic Modelling, Spatial Prioritisation, Urban Flood Management

1 BACKGROUND AND NATURE OF THE ISSUE

Flooding remains a critical global hazard, with the UK alone incurring estimated damages of £1.6 billion during the 2015-2016 winter floods (Environment Agency, 2018). Beyond direct property damage, these events disrupt critical infrastructure and transport, cascading into significant economic losses. This vulnerability is exacerbated by urbanisation, where impervious surfaces convey approximately 55% of rainfall into runoff, overwhelming traditional combined sewage systems.

The current crisis is two-fold. First, climate change is increasing rainfall intensity, leading to higher peak flows that surpass the capacity of aging drainage infrastructure. This results in frequent Combined Sewage Overflows (CSOs), discharging untreated effluent into water bodies—a practice facing stringent regulatory pushback from both the UK and EU (DEFRA, 2022). Second, flood management is hindered by fragmented governance. Local authorities, highway agencies, and water companies operate with distinct, often siloed, objectives and possess vastly different financial capabilities. This economic disparity makes it exceptionally difficult to align interests and secure simultaneous commitment from all parties for collaborative projects. There is a critical lack of holistic tools capable of proposing interventions that satisfy multiple stakeholders simultaneously. Traditional "grey" infrastructure solutions are increasingly viewed as expensive, resource-intensive, and lacking resilience against future climate uncertainty.

2 FINDINGS AND RESULTS

To address these challenges, we developed a comprehensive decision-making strategy centred on the CityCAT (1D/2D) hydrodynamic model, utilising the metropolitan area of Newcastle upon Tyne as a case study. Unlike standard approaches that simplify urban geometry, CityCAT explicitly models buildings as non-computational domains, ensuring highly accurate representation of urban flow paths (Figure 1.1) (Bertsch et al., 2017).

The core innovation of this research is the development of a unified spatial strategy that assesses the entire urban domain for intervention suitability. Rather than relying on a single engineering metric, our method prioritises locations using a multi-criteria analysis that integrates Targeted Flood Reduction (utilising "source-to-impact" analysis) (Iliadis et al., 2024; Vercruysse et al., 2019), System Relief (reducing CSO spill volume), and Co-benefits (amenity value).

Application of this methodology to the Newcastle catchment yielded preliminary results identifying a strategic set of interventions capable of storing 150,000 m³ of runoff (Fig 1.3, 1.4). By simulating the "source-to-impact" pathways (Fig. 1.2), we demonstrated that this specific configuration achieved tangible physical risk reductions, providing a quantifiable basis for future economic valuation. The selected interventions resulted in:

- Property Protection: The reducing of flood risk for 338 buildings, directly benefiting the City Council and property owners.
- Infrastructure Resilience: The unblocking of 900 m of major road network, ensuring critical transport continuity for Highway Authorities.
- System Relief: A verifiable reduction in surface water entering the combined sewer system, mitigating spill risks for Water Companies.

The analysis reveals that optimal BGI placement is not merely a function of hydraulic capacity but of strategic alignment with these diverse goals. We demonstrated that specific interventions could be selected to maximise these distinct benefits within a single coordinated plan.

Current ongoing work focuses on finalising the pond optimisation methodology and extending the framework to include street-level interventions. Furthermore, we are concluding the precise quantification of intercepted runoff volumes and the associated reduction in pollutant load on CSOs to fully validate the system-wide benefits.

3 SIGNIFICANCE AND IMPACT

This research presents a strategic evolution in urban flood management, moving beyond the efficiency of individual assets to the resilience of the whole system. The significance lies in the strategy's ability to bridge the operational gap between disconnected stakeholders.

By employing the Analytical Hierarchy Process (AHP), we successfully embedded conflicting priorities into a transparent decision-making matrix. This allows for the identification of "win-win" scenarios where a single intervention provides verified value to multiple authorities. Consequently, this holistic tool not only improves technical flood resilience but also acts as a catalyst for unlocking joint funding mechanisms. It provides the evidence base needed for collaborative governance, ensuring that future flood management investments are cost-effective, multi-functional, and socially equitable.

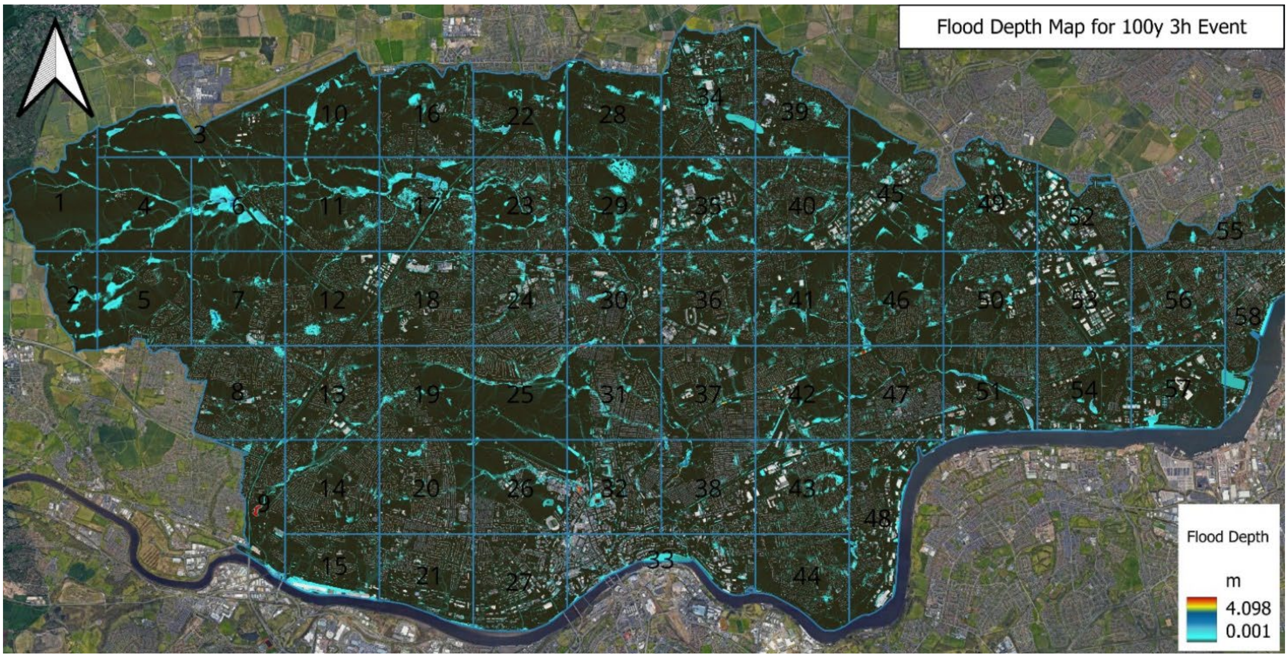

Figure 1.1 Flood depth from a 3h 100-year storm.

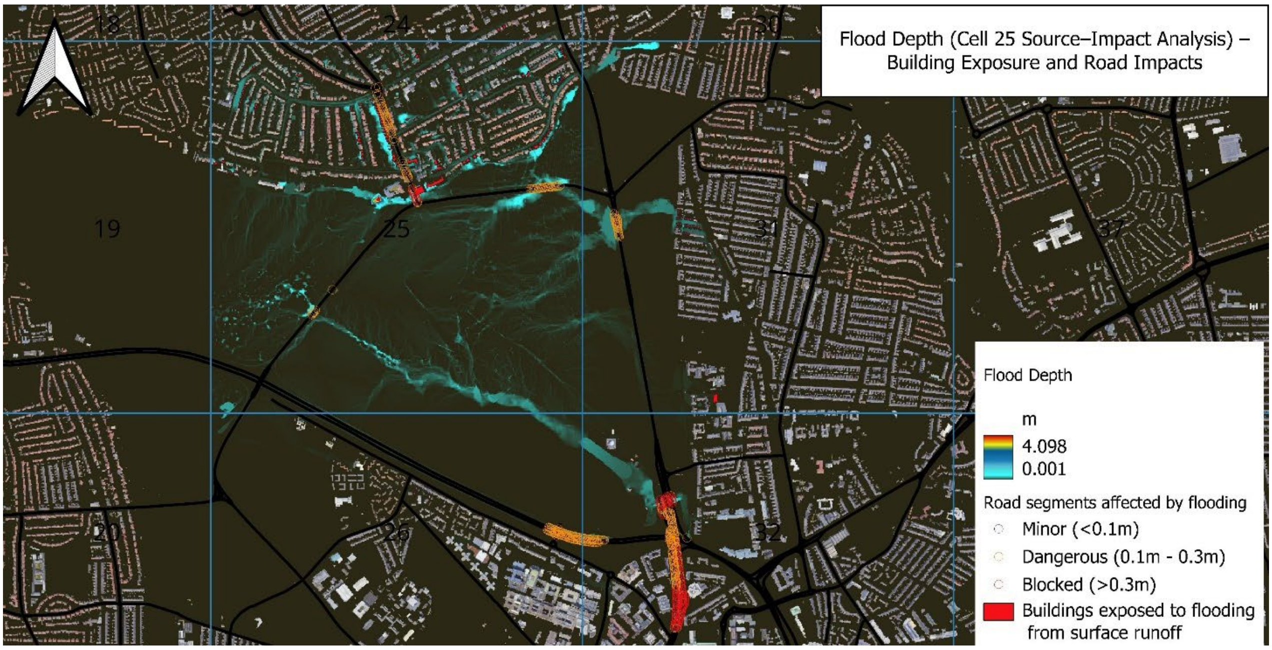

Figure 1.2 Runoff from Cell 25 showing exposure of buildings and roads.

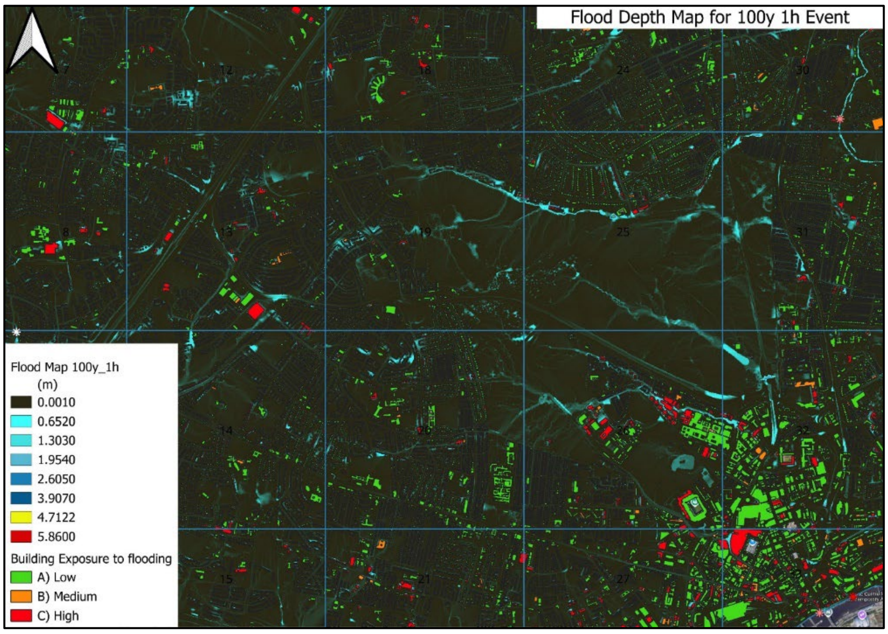

Figure 1.3 Flood depth for a 1-hour, 100-year storm event without interventions, illustrating building exposure to flooding.

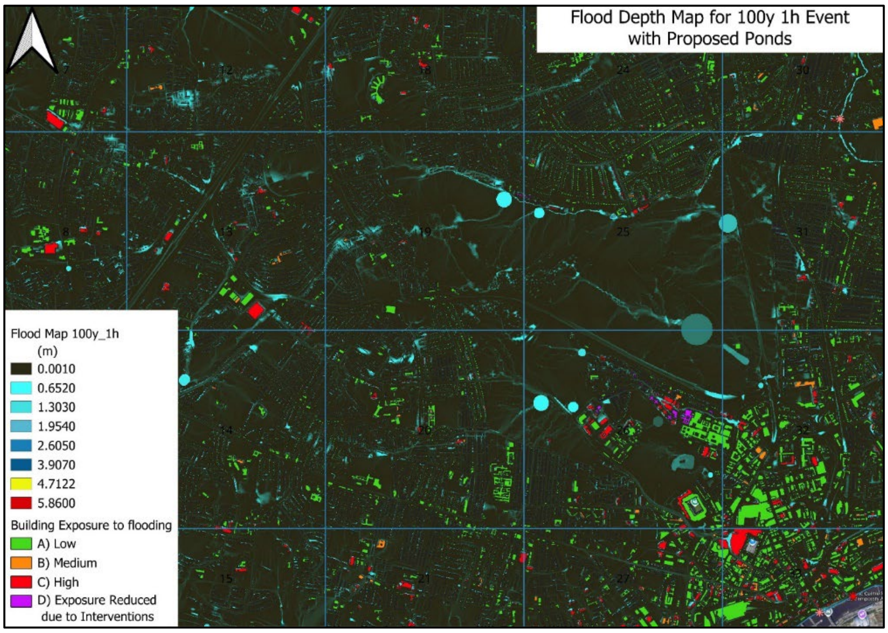

Figure 1.4 Flood depth for a 1-hour, 100-year storm event with interventions, illustrating reduction of building exposure to flooding.

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