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Building urban flood resilience with rainwater management

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EXTENDED ABSTRACT

Introduction

Urban stormwater is a significant hazard and a promising resource. Recent studies have highlighted that effective and smart rainwater management provides both flood and drought mitigation benefits through capturing extreme rainfall and contributing to water demands at the property scale [1], indicating opportunities to upscale benefits across urban areas. However, for stormwater management to reach this potential, planners must move away from ad-hoc and localised application towards integrated catchment-wide strategies, capable of delivering catchment-wide benefits. New planning methodologies are required to achieve this shift and key questions remain regarding how strategies could be applied to maximise flood resilience, supply augmentation and cost-effectiveness across urban scales. This study responds to these emerging challenges through assessing the potential benefits of catchment-scale rainwater management across the Pandon Dene surface water catchment in Newcastle-upon Tyne, NE England.

Methods and Materials

The Pandon Dene catchment is highly urbanised, with a history of high magnitude surface water flooding. To assess potential impact of rainwater management on urban flood resilience in the catchment, this study is subdivided into four components (Figure 1). Firstly estimating the potential scale of household level rainwater harvesting (RWH); secondly evaluating the performance of these systems; thirdly examining the effects of catchment scale RWH application for reducing flooding; And finally, evaluating performance of the rainwater management strategies using key performance indicators (water supply, overflow control and benefit-cost).

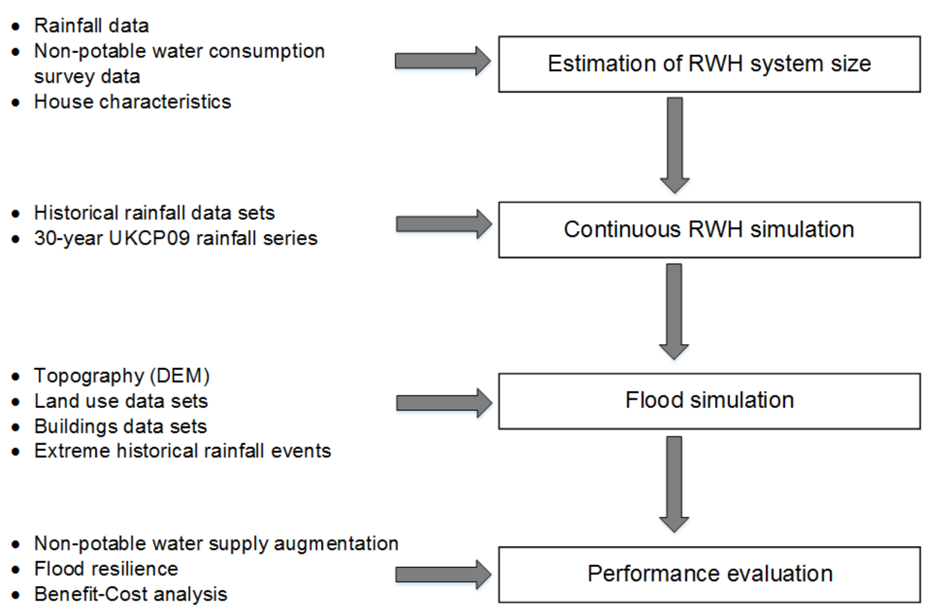

Figure 1. Methodology

Household supply and demand is characterised using property scale monitored high frequency (15-minute resolution) non-potable household water consumption, evaluated in the context of long-term continuous mass-balance based simulation [2] carried out over a 30-year period (1984-2015). The impact of changes in rainfall patterns on rainwater management are investigated using 100 equiprobable independent UKCP09 daily rainfall data sets of 30-year time horizon from 2010 to 2039. The British Standard BS 8515:2009+A1:2013 [3] is adopted to size the household rainwater harvesting systems at individual houses across the catchment. Long-term simulation enables quantification of water supply efficiency and overflow from the rainwater management systems at individual houses. The estimated overflow from each of the household is then applied as a model input to assess surface flood risk across the study catchment. This is achieved using a rapid two-dimensional cellular automata flood model (CADDIES) which is applied to examine catchment and rainwater management strategy response to both the historical rainfall events and projected climate scenarios. The final part of the study assesses the benefit-cost relationship of the rainwater management system by using a GIS-based hazard impact assessment tool.

Results and Discussion

To illustrate the potential for rainwater management, a 3-bedroom house with a roof area of 80 m^2 located in Newcastle-upon Tyne, NE England has been initially evaluated in terms of water saving and stormwater control efficiencies. The 20 largest roof runoff events over a 30-year period were considered to evaluate the impact of a rainwater management system on flood peak attenuation. Results indicate that a rainwater harvesting system that is primarily designed for water supply augmentation with a tank volume of 2.4 m^3 contributed 64% of non-potable demand (toilet flushing) and a 77% (median) reduction of stormwater peak runoff into the sewer system. A larger system (6.5 m^3) which was sized for both water supply augmentation and flood management provided 70% non-potable water supply and 100% (median) reduction of stormwater peak runoff. However, both tanks were unable to cope with an extreme 2012 historical rainfall event, during which the 2.4 m^3 and 6.5 m^3 tanks provided just 0% and 9% of flood peak attenuation. However, performance was improved by an actively managed 2.4 m^3 rainwater management system, which provided a 54% flood peak reduction for the 2012 event (Figure 2).

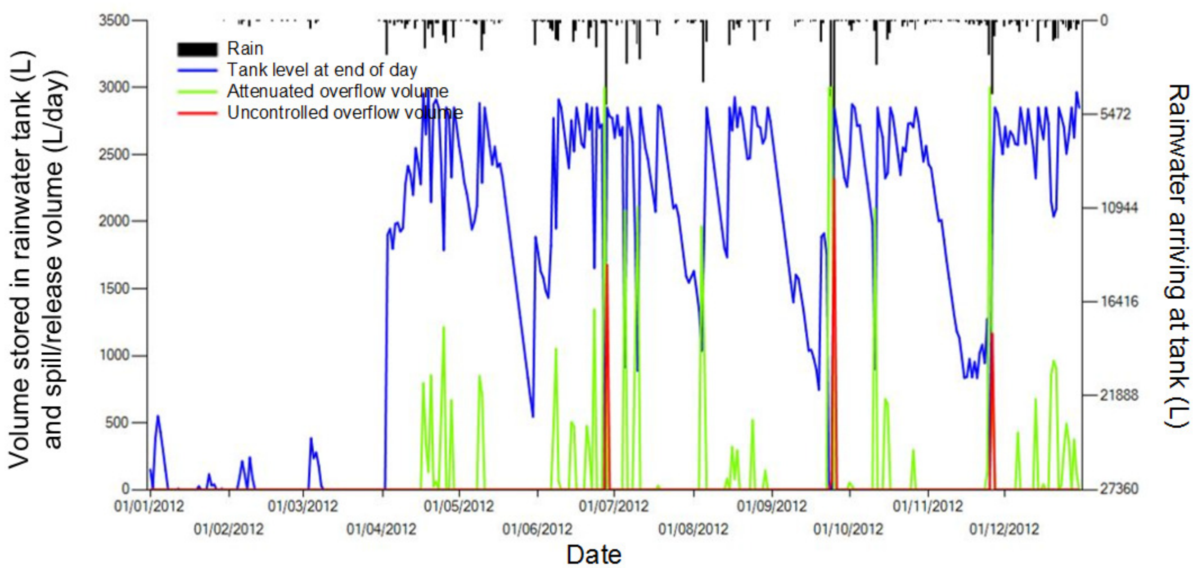

Figure 2. Active rainwater management system

A 30% increase in tank size would be required to retain the existing water supply efficiency over the next 30 years to cope with extreme climate change scenarios.

Conclusions

This study demonstrates that the catchment scale application of RWM strategies can accommodate both flood and drought management objectives. Future developments, such as actively managed tanks were found to manage even extreme events. Increase in storage tank would be required to maintain current water supply efficiency of the rainwater management system.

References

[1] S. Ahilan, P. Melville-Shreeve, Z. Kapelan and D. Butler, The influence of household rainwater harvesting system design on water supply and stormwater management efficiency. In: New Trends in Urban Drainage Modelling (Ed. G Mannina), pp. 369-374, Springer, ISBN 33199986762018, 2018.

[2] A. Fewkes and D. Butler, Simulating the performance of rainwater collection and reuse system using behaviour models. Proc. CIBSE A: Building Serv. Eng. Res. Tech. vol. 21(4), pp. 257-265.

[3] BSI (2013) BS 8515:2009 + A1:2013 Rainwater harvesting systems – Code of practice. BSI – London.