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Delivering And Evaluating Multiple Flood Risk Benefits In Blue-Green Cities

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DELIVERING AND EVALUATING MULTIPLE FLOOD RISK BENEFITS IN BLUE-GREEN CITIES

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In the UK a research consortium has been funded to develop new strategies for managing urban flood risk as part of wider, integrated urban planning intended to achieve environmental enhancement and urban renewal in which multiple benefits of Blue-Green Cities are rigorously evaluated and understood. This approach is very much part of the resilience paradigm and seeks to develop the socio-technical tools required to fully evaluate resilience options as part of a wider system.

INTRODUCTION

It is widely acknowledged that flood risk is increasing across the globe due to the combination of urbanisation, economic growth and a changing climate. This combination makes those living in cities particularly vulnerable.

In England over 2.4 million properties are at risk of fluvial or coastal flooding, with a further 2.8 million properties susceptible to surface water flooding [1]. Recent increases in the frequency and magnitude of intense precipitation events are expected to continue with a consequent increase in damages [2]. There is therefore a need for new and radical responses to reduce both the probability and consequences of urban flooding by making our cities more resilient and able to adapt to flooding [3]. The most recent IPCC report has shifted focus from mitigation towards adaptation as the likelihood of significant changes to our climate increases.

Water-sensitive urban design (WSUD) seeks to develop urban water management that holistically considers the environmental, social and economic consequences of different responses and it is increasingly being used in policies, for example in the UK [4]. WSUD regards urban surface water runoff as a resource, rather than a nuisance, diverging from the traditional paradigm of removing surface water quickly and efficiently to advocating the protection of urban water resources and generation of multiple benefits from multifunctional land use [5]. This paper introduces the Blue-Green Cities Research Project and the novel interdisciplinary resilience approach using hydroinformatics tools that will allow procedures for the robust evaluation of the multiple functionalities of Blue-Green Infrastructure components within FRM strategies to be developed and later tested in a Demonstration Case Study.

THE BLUE-GREEN CITIES CONCEPT

A Blue-Green City aims to recreate a naturally oriented water cycle while contributing to the amenity of the city by bringing water management and green infrastructure together [6]. This is achieved by combining and protecting the hydrological and ecological values of the urban landscape while providing resilient and adaptive measures to deal with flood events (Fig 1). Key functions include protecting natural systems and restoring natural drainage channels, mimicking pre-development hydrology, reducing imperviousness, and increasing infiltration, surface storage and the use of water retentive plants [7].

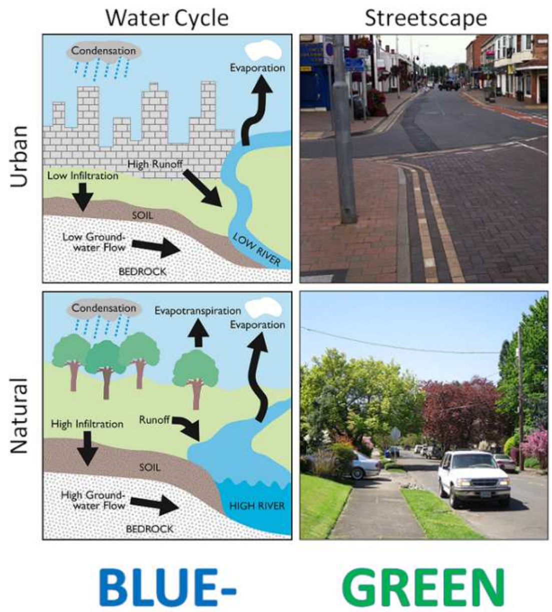

Figure 1: Comparison of hydrologic (water cycle) and environmental (streetscape) attributes in conventional (upper) and Blue-Green Cities.

INTERDISCIPLINARY RESEARCH AND THE BLUE-GREEN CITIES PROJECT

'Blue-Green Cities' is a highly interdisciplinary project funded by the Engineering and Physical Sciences Research Council (EPSRC, February 2013-2016). The Research Consortium comprises academics from eight UK institutions and numerous disciplines; hydrodynamics, geomorphology, ecology, physics, social sciences, engineering, and environmental economics. Fig 2 shows the main research components brought together by a communications package (WP1) to promote interdisciplinarity and coherent, integrated results, based on shared conceptual, methodological and theoretical ideas [8]. In this way it aims to move away from an approach where discrete disciplinary work packages are completed and subsequently combined at the end of the project, to an approach with data exchanges and common epistemological approaches to marry the interdisciplinary activities. Co-evolution of understanding and knowledge, aided by tight integration within the team, will ensure that the sum of the whole (in terms of deliverables) exceeds the sum of the parts.

The Consortium is developing new strategies for managing urban flood risk focusing on a common case study (Newcastle, WP5) in the third year of the project (2015). This case study involves key stakeholders (including decision makers) and local communities from the outset.

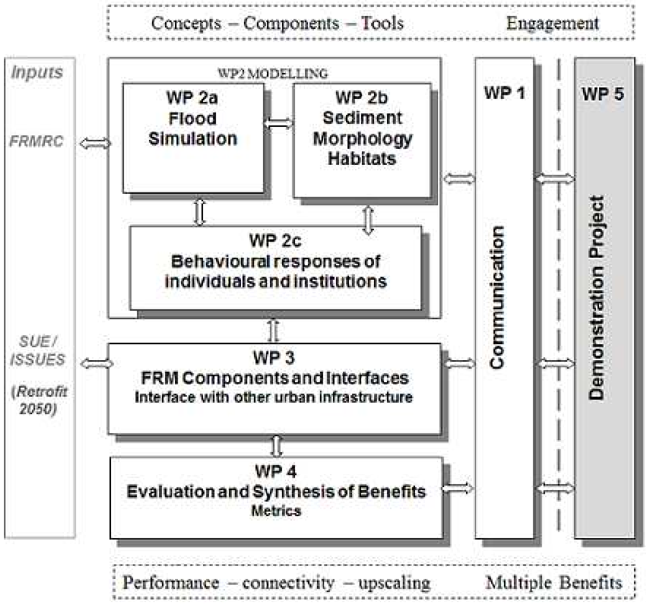

Figure 2: Structure of the Blue-Green Cities Research Project. FRMRC; Flood Risk Management Research Consortium, SUE; Sustainable Urban Environment, ISSUES; Implementation Strategies for Sustainable Urban Environment Systems.

KEY DELIVERABLES

Research will focus primarily on fluvial and pluvial flooding; the latter typically caused by extreme local storms and insufficient capacity of subsurface drainage networks. The Consortium is developing a hydroinformatics tool for urban flood assessment that realistically represents the urban environment (land use and terrain) in its complexity. Coupled surface/sub-surface hydrodynamic models produce inundation predictions across a range of events of different frequencies and lengths, visualised in probability maps for inundation across an urban area. The hydroinformatics tools will include the movement of water through Blue-Green features such as blue and green roofs, retention ponds, permeable paving, green space and bioswales, to enable a comparison of flow velocity, depth and inundation extent before and after the adoption of Blue-Green Infrastructure.

The hydroinformatics tool is being linked to semi-quantitative assessments of sediment and debris dynamics in emerging vegetated and naturalized urban drainage systems. Fieldwork will fill knowledge gaps in network forms and functions as part of a source-pathway-receptor analysis. This will also address the movement of sediment from catchment surfaces into and through Blue-Green Infrastructure and the potential for debris to block culvert trash screens, developing the understanding of how sediment and debris sources and transportation dynamics may impact on urban flooding.

Successful simulation of the movement of water and sediment through the urban environment will indicate design benefits of select infrastructure components and generate recommendations to achieve multiple benefits. However, the physical system cannot be assessed in isolation from its societal context. WP2c is using interviews with stakeholders to generate rules for agent-based simulations that are linked to the inundation model described above.

WP3 will develop tools and methodologies to represent FRM and Blue-Green networks in a single urban environment, as part of a wider complex ‘system of systems’ that services urban communities. Various series of interrelationships link energy, transportation, water (supply and wastewater), emergency services, and information and telecommunication sectors.

WP4 will develop methodologies to assess, quantify and value the multiple benefits of adopting Blue-Green Infrastructure in urban FRM strategies at both the local/regional and global /international scales, developing procedures for the robust evaluation of the multiple functionalities of Blue-Green Infrastructure components and inherent uncertainties. By evaluating the relative significance of benefits in context specific locations we aim to establish preference ratings linked to a multi criteria analysis for component selection. This will provide sound science and recommendations for design guidance to assist policy makers in the choice of FRM strategy. The lack of guidance and legislation are key barriers to the limited uptake of Blue-Green Infrastructure and Sustainable urban Drainage Systems (SuDS) in the UK to date.

WP4 will develop an online spreadsheet-based valuation tool for the design of Blue-Green Cities. It will also assess the influence of connectivity in enhancing multiple benefits through developing a conceptual model in net-logo using cellular automata along with a physically based model in GIS for the study cities.

APPLICATION IN THE DEMONSTRATION CITY (NEWCASTLE, UK)

The deliverables from Blue-Green Cities research will be exhibited in the Demonstration Case Study, Newcastle, UK, in the final year of the project (2015) to demonstrate the applicability of the methods, measures and evaluations developed in WPs 1-4. Newcastle encompasses hydrological, topographic, urban density and socio-economic conditions that are representative of those found more widely in UK cities and has experienced recent major flooding events. Much of the city centre is impermeable and vulnerable to pluvial flooding, piped drainage systems are often unable to cope with intense rainfall and the risk of sewer incapacity and surcharge is relatively high. The need for increased housing provision may also reduce available green space. Interest in Blue-Green Infrastructure for FRM from key stakeholder groups plus active research into climate change adaptation and mitigation [9] and urban green space [10] suggests Newcastle may be highly receptive to the Blue-Green concept.

SUMMARY

The Blue-Green Cities Research Project adopts an interdisciplinary approach to identify and rigorously evaluate the multiple flood risk benefits of natural flood risk management strategies using Blue-Green Infrastructure. This paradigm shift from traditional grey infrastructure designed to remove water as quickly as possible from the urban surface is in line with WSUD and urban water management that holistically considers the environmental, social and economic consequences FRM strategies.

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