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Water in the city: Green open spaces, land use planning and flood management – An Australian case study

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ABSTRACT

With increasing worldwide recognition of the influence of urban development on the hydrological functions of water, there is growing pressure for urban planning to play a greater role in water resources management. Planning for green open spaces in particular can play an important role, as they support important ecosystem services, including those that assist in flood management. It has been argued that interconnected and strategically planned networks of green open spaces should be planned for early in land use planning and design processes, with consideration of water-related ecosystem values and landscape functions in concert with land development, growth management and physical infrastructure planning. Although there is growing recognition of the importance of green open space planning for water sensitive cities and supportive planning measures, there are few analyses of the actual inclusion of this recognition in plans and strategies, or the presence of related actions and planning mechanisms. This paper addresses this gap by comparatively analysing the approaches taken to regional green open space planning in three Australian capital city-regions. Findings indicate the acknowledgement of relationships between flood regulation and green open space planning and various associated planning mechanisms. However, there is limited explicit integration of flood management and green open spaces planning, and significant on-ground barriers to enabling this integration to occur given the legacy of past planning decisions and the lack of information to support implementation. The paper concludes with recommendations for further research to assist planning for green open spaces as an ally to ecosystem services relating to flood management.

1. Introduction

In many metropolitan areas worldwide, urban expansion and population growth coupled with climate change is resulting in costly flood management challenges (Keath and Brown, 2009; Jha et al., 2012). Metropolitan regions can be particularly vulnerable to devastating impacts of flood where human settlements expand into vulnerable areas and where urban development alters the water balance of metropolitan regions (Vorosmarty et al., 2005). It is argued that impacts of floods are increasing in many regions globally, demanding appropriate management of ecosystems to assist in flood management (Bravo de Guenni et al., 2005).

Legacies from past planning decisions and water infrastructure have greatly altered hydrological functions of urban areas, and also reduced areas of green open space to small fragments that are geographically disconnected from each other (Donofrio et al., 2009). For example, increased impervious surfaces, filling of wetlands and development on floodplains to accommodate population growth has resulted in frequent flooding in many of Australia's earlier settlements (Coombes and Roso, 2015). To address these issues, there is now a rising interest globally in the role of carefully planned networks of green open spaces to achieve greater resilience to flood (Carmon and Shamir, 2010; Ashley et al., 2011; Ellis, 2013; Demuzere et al., 2014; Lennon et al., 2014).

Additionally, the role of ecosystem services to improve environmental outcomes in urban regions is increasingly recognised (Niemelä et al., 2010; Hansen and Pauleit, 2014). Ecosystem services derived from green open spaces that relate to flood management most closely fit the description of 'regulating' services, although green open spaces also have implications for a range of cultural and provisioning ecosystem services that relate to urban water management (Mirza et al., 2005; De Groot et al., 2010).

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Although the role of carefully planned networks of green open spaces in contributing to flood management has been documented, there is a dearth of policy-driven overviews looking holistically at the ways in which ecosystem features can be managed to reduce vulnerability to floods (Depietri et al., 2012). Additionally, there are few analyses of the inclusion of considerations of the potential for ecosystem services derived from green open spaces to contribute to flood management in plans and strategies in growing metropolitan regions, or of related planning mechanisms (De Groot et al., 2010; Andersson et al., 2014).

This paper aims to improve our understanding of how urban and regional planning supports green open space planning for improved water resources management, with a particular focus on flooding and related ecosystem services. This paper starts by identifying attributes of green open spaces relevant to ecosystem services beneficial to flood management, and related planning approaches suggested in literature. This is followed by a description of the framework used to review the approaches taken in the Australian metropolitan regions of South East Queensland (SEQ), Melbourne and Perth. The planning documents reviewed along with the methods used to extract relevant data are then presented, followed by the results of the evaluation. The paper finishes with a discussion of main findings and some recommendations to facilitate planning for green open space as an ally to flood management through the maintenance of ecosystem services.

2. Planning for green open spaces to aid flood management

2.1. The role of green open spaces in aiding flood management

Floods can be naturally occurring phenomena that benefit ecosystem health (Mirza et al., 2005). However, human activities can reduce the capacity of ecosystems and soils to absorb excess water and attenuate floods (Bravo de Guenni et al., 2005; Vorosmarty et al., 2005; Coombes and Roso, 2015). Population growth and settlement preferences also strongly influence the regulation of floods, the expansion of human settlements onto floodplain areas being a common cause for increased vulnerability to flood impacts in human settlements (Bravo de Guenni et al., 2005; Mirza et al., 2005).

Efficient transport of runoff from impervious surfaces in urban settlements by piped stormwater drainage systems have generally resulted in urban streams that exhibit a flashy hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness (Meyer et al., 2005; Walsh et al., 2005; Haase and Nuissl, 2007). The accompanied decreased infiltration, increase in surface runoff, and reduced baseflow discharge in urban streams often leads to increased risks of flash flooding (Haase and Nuissl, 2007) and reduced potential for groundwater recharge (Hough, 1995; Paul and Meyer, 2001; Walsh et al., 2005). These consequences are especially likely where impervious surfaces are directly connected to urban streams (Walsh et al., 2005) and are related to a range of other factors such as the spatial pattern of land conversion, and the previous quality of converted land (Haase and Nuissl, 2007).

In this paper, green open space is defined as space that is dominated by a 'natural' environment and characterised by ecosystem and landscape values, as opposed to a built-up environment with a higher degree of intervention in ecosystem and landscape processes (Maruani and Amit-Cohen, 2007). This definition includes a range of different land uses such as agricultural and conservation areas through to greenways and green belts or corridors, and constructed and natural wetlands (Bengston et al., 2004; Bomans et al., 2010).

The literature highlights the role of green open spaces and inherent ecosystem services in aiding flood management and mitigation. Key attributes of green open spaces that have implications for flood management and mitigation include their potential capacity to prevent disturbance caused by floods through to flood regulation (Millennium Ecosystem Assessment, 2005). Green open spaces can contribute to flood regulation through increased soil permeability, which leads to reduced surface runoff and peak stream flows (Bravo de Guenni et al., 2005; Gill et al., 2007; Kaźmierczak and Cavan, 2011; Ellis, 2013). Green open spaces can also provide storage capacity for floodwaters in urbanised areas (De Groot et al., 2010), while riparian vegetation helps to reduce stream bank erosion during flood events (Tubman and Price, 1999). These functions are also performed by corridors and networks of green open spaces that incorporate stormwater infrastructure alongside or adjacent to water bodies (Gill et al., 2007; Handley, 2007; Wheater and Evans, 2009; Ellis, 2013), which can be used as surface flow pathways, providing water storage and retention areas at times of high water flow. Site vegetation and neighbourhood riparian corridors can also reduce runoff from low intensity, short duration rainfall events (Ellis, 2013).

Green open spaces retained in upstream catchment areas help maintain streamflow and reduce peak streamflow in lower parts of the catchment (Sinai et al., 2006 in Carmon and Shamir, 2010). Inland water components such as natural and constructed wetlands, floodplains, lakes and reservoirs can assist flood attenuation through increasing residence time of rivers, reservoirs and soils (Bravo de Guenni et al., 2005; World Resources Institute, 2005; Demuzere et al., 2014). These flood regulating services clearly justify attention paid to green open space planning in the context of ecosystem services that contribute to flood management.

In addition to these flood regulating attributes, water sensitive urban design (WSUD) structures (such as rainwater tanks, bioretention swales and basins, constructed wetlands, and stormwater harvesting and storage) in green open spaces can reduce stormwater runoff volumes and peak flows at site level (Barton and Argue, 2007; Coombes, 2009; Walsh et al., 2012). WSUD and water sensitive urban development are based on approaches that seek to integrate urban water systems with the water systems found in the natural hydrological cycle (Barton and Argue, 2007). This includes considering impacts of urban water services on catchment ecosystems (Sharma et al., 2012). The particular tools to achieve integrated water sensitive urban design will vary depending on stakeholder and site-specific factors (Sharma et al., 2012). The effectiveness of WSUD features in green open spaces for flood attenuation increases at a catchment scale when they are combined with a range of other decentralised storage and infiltration approaches (Grose and Hedgcock, 2006; Mell, 2008; Davis et al., 2009; Ellis, 2013; Demuzere et al., 2014).

In choosing to focus on the planning of green open spaces and ecosystem services for flooding, we acknowledge that this is one aspect of a range of different actions that may relate to water sensitive planning and integrated urban water management, and that due to the connected dynamic movements of water through urban regions specific water management issues (such as flood management and planning for green open spaces) are intrinsically connected and difficult to separate from a range of other water management issues and actions. Nonetheless, green open spaces (Benedict and McMahon, 2002; Keeley et al., 2013), flood management (Godden and Kung, 2011) and ecosystem services (Liu et al., 2013) are crucial aspects in the shift to total water cycle management that need to be mainstream in policy (and planning initiatives) (Ellis, 2013). These are concepts and ideas that have received significant attention in applied science (Lennon et al.,