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# Connecting land-use and water planning: Prospects for an urban water metabolism approach

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ABSTRACT

The current fabric of urban areas is largely the result of past land development and land-use planning decisions. Historically, there was relatively little consideration of the impact of these decisions upon hydrological systems within and outside urban areas. Despite their close relationship, urban and regional planning and water resources management have typically been carried out separately and guided by different institutional arrangements. The range of impacts of urbanisation on hydrological systems at the city-region scale, and the dependence of urbanised areas upon these systems, call for better integration between the sectors of urban and regional planning and water resources management to ensure the sustainability and resilience of cities and their regions to future changes and uncertainties.

This paper evaluates the extent to which planning mechanisms currently support integration between land-use and water resource sectors. The evaluation draws on a comparative analysis of 113 statutory and non-statutory planning mechanisms in three Australian capital city-regions: South East Queensland, and the Melbourne and Perth Metropolitan regions. Results indicate that the function of water at the city-region scale, including its role in supporting environmental connectivity, needs to be better understood and considered by land-use planning systems; improved institutional capacity is required to enable both sectors to deal with future changes and uncertainties related to water resources; and emergent planning trends supportive of the consideration of water connectivity at the city-region scale are yet to be fully implemented. Based on the results, the paper concludes by exploring how the concept of urban metabolism may facilitate better integration between the two sectors, along with the identification of best suited planning mechanisms and needed changes in governance and institutional arrangements conducive to integration.



## 1. Introduction

Globally, water resources management in urbanised areas is facing increased pressures and challenges. Pressures range from an increased demand for water supply and a decline in water quality due to ongoing population growth through to climate change impacts (Fu & Tang, 2013; Butscher & Huggenberger, 2009). In parallel, urbanisation processes generate hydrologic and water quality changes that significantly impact and will continue to impact hydrological systems at the city-region[1] scale (Brown, Keath, & Wong, 2009b; Jiménez Cisneros et al., 2014). These challenges are likely to lead to further social-economic and ecological implications and demand a rethink in the way decision-making processes account for climatic change and promote resilient urban systems[2] and inherent water resources that support these systems (Zwolsman et al., 2010; Huntjens et al., 2012).

Nevertheless, water resources management in Australia (National Water Commission, 2013) and elsewhere (Gain, Rouillard, & Benson, 2013; Brown, Farrelly, & Keath, 2009a) is undertaken by multiple government and non-government agencies without being coordinated and/or integrated to address the total water cycle. For example, it is common to find government agencies working separately and independently to manage water supply and distribution, wastewater and stormwater. Additionally, land-use planning decisions with implications for water quality and availability are often not carried out in association with water resource planning and management (Plummer, de Grosbois, de Loë, & Velaniškis, 2011).

Better integration between water and land-use planning is necessary for both enabling urban systems to continue to exist while reducing their impact on water resources at the city-region scale. Hence, current planning mechanisms need to:

(i) address environmental and hydrological connections between cities and their regions;

[1] The city-region scale refers to urban, peri-urban and adjacent rural areas as well as the multiple catchments that sustain those areas.
[2] In this paper, the term urban system refers to an integrated system that encompasses both urban and peri-urban areas whose boundaries are not clearly defined.

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(ii) consider future change to and uncertainty concerning water resources; and
(iii) take a whole of landscape perspective.

The first recognises that urban systems are not isolated entities. They depend on and impact water resources beyond their jurisdictional boundaries (Pincetl, 2012; Agudelo-Vera, Leduc, Mels, & Rijnaarts, 2012; Lin & Grimm, 2015). Hence, the function of water at the city-region scale needs to be better understood by, and considered in, decision-making processes concerning urban areas. The acknowledgement of hydrological and environmental connections within and outside urban areas is both critical to reduce urbanisation impacts on water resources and enhance sustainability of urban systems. Such acknowledgement provides further evidence on the need for improved integration between the urban planning and water management sectors. It also contributes to support initiatives that seek to improve knowledge related to restoring hydrological and environmental connectivity, a non-straightforward task tainted with knowledge gaps that challenge decision and policy-making processes. In particular, there are significant knowledge gaps concerning hydrological and environmental connectivity that are critical for land-use planning. These include agreed measurements of connectivity (Ziółkowska, Ostapowicz, Radeloff, & Kuemmerle, 2014), selection and prioritisation of habitat corridors (Brodie et al., 2014), the dynamics of transfer of water, sediments and organic matter across landforms (Fryirs, 2013), and antagonistic effects such as increased water flows through urbanised areas (Amoros & Bornette, 2002). Additionally, as urbanisation processes intensify it will be critical to improve water management (e.g., water supply, stormwater and wastewater) to reduce their impact on ecosystem services and functions such as environmental and cultural functions performed by water resources (Le Maitre, Kotzee, & O'Farrell, 2014).

The second acknowledges that it is crucial to adequately respond to future change (including social and environmental change) and uncertainty related to water resources that urban planning and water sectors are consistently confronted with. In particular, future population growth and urbanisation will continue to impact hydrological systems at the city-region scale and therefore need to be considered by decision-making processes (Brown et al., 2009b). Additionally, there is wide recognition that climate change is likely to increase the frequency and intensity of extreme events that are directly related to water resources such as floods and droughts (IPCC, 2014). Climate change is also likely to alter and make it more difficult to predict rainfall patterns (Jiménez Cisneros et al., 2014). Climate change impacts are further compounded by increased urbanisation and population growth, making it imperative to urban systems to plan for future changed water demands. Hence, it is critical that decision-making processes consider future change and uncertainty affecting urban systems to ensure their resilience to future scarcity of, and increasing demand for, water resources (Desouza & Flanery, 2013). A key challenge that confronts decision makers however is the difficulty to predict the extent and amplitude of these changes. In this context, decisions need to be supported by adaptive management systems that allow the incorporation of new information as these become available (Varady et al., 2013).

The third relates to the recognition of the need for a whole of landscape planning perspective. Support for the consideration of water connectivity at the city-region scale in decision-making processes may be facilitated by emerging land-use planning trends such as landscape scale planning and values-led planning. For example, issues regarding hydrological and environmental connectivity at the city-region scale may be anticipated if planning decisions are implemented at the landscape scale. Landscapes are a product of the relationships between its social, economic and biophysical components in which humans are an integral part of it (Matthews & Selman, 2006). A landscape has inherent structures (natural and human-made environmental features and land use patterns), functions (provision of ecosystem services) and values (heritage, ecological, social, cultural) that support the quality and resilience of places (Selman, 2009). Hydrological and environmental connectivity throughout a landscape may be supported by a system of interconnected greenspaces and their inherent ecological (Whitford, Ennos, & Handley, 2001; Kong, Yin, Nakagoshi, & Zong, 2010), social (Flink, 2002), economic (Barthel, Sörlin, & Ljungkvist, 2010) and

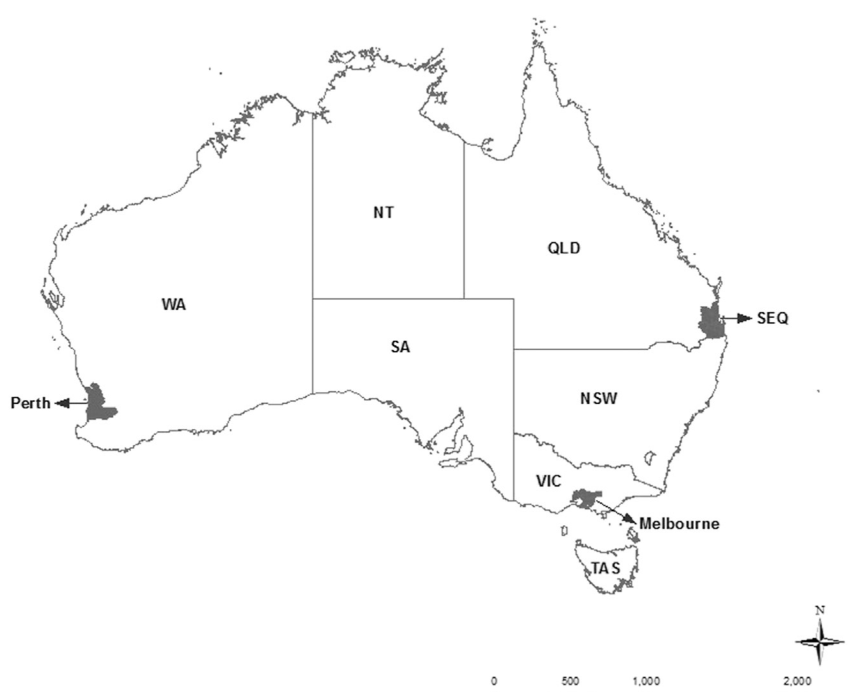


**Fig. 1.** Australian Metropolitan region case study areas.