Emerging trends in modelling integrated urban water systems

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EXTENDED ABSTRACT

With the beginning of the 21st century, the proportion of the world's population living in urban environments surpasses that living in the rural environment. By mid-century, as much as 70% of the world population will be living in cities and towns. The 21st century is indeed the century of cities and urbanisation.

An emerging challenge to urban communities is its design for resilience to the impact of climate change, particularly in regards to sustainable management of urban water resources and the protection of water environments. This challenge has now expanded to include questions of the role of urban water management on enhancing urban liveability and the innovative exploitation of the urban water-energy-waste nexus. Planning and designing liveable, and environmentally responsible communities involves a holistic approach centred on a clear appreciation of the interconnections between key design elements that affects the ecological footprint of urban environments, particularly in relation to energy and carbon emission, water conservation, environment protection, and biodiversity.

Integrated Urban Water Management has emerged in recent years, drawing on the view that sub-optimal outcomes have been produced from the traditional compartmentalisation of water supply, sewerage and stormwater services. This compartmentalisation has been both physical, in terms of infrastructure, and institutional in terms of responsibility for service provision, operation and maintenance, which, over time, has led to philosophical compartmentalisation and shaped perceptions of system boundaries. The word 'integration' refers to both the physical system of technologies and infrastructure and the non-physical system encompassing the institutional structures that many players who create, maintain, and are served by urban water systems.

Many governments around the world have made the creation of liveable, sustainable and productive cities one of their national priorities. In Australia, a stated goal of the Australian Government's National Water Initiative is to 'create Water Sensitive Australian Cities'. Establishing water sensitive cities requires the transformation of urban water systems from a focus on water supply and wastewater disposal (the 'taps and toilets' water utilities) to more complex, flexible systems that: integrate various sources of water; operated through a combination of centralised and decentralised systems; deliver a wider range of services to communities (e.g. ecosystem services, urban heat mitigation); and integrate into urban design.

These emerging trends in integrated urban water management strategies require understanding and sophisticated simulations of the dynamic interactions of hybrid centralised/decentralised urban water systems. The systems operate a diversity of water supply sources, wastewater and stormwater resources recovery, and water management for multiple benefits that include enhancing urban liveability. From a modelling standpoint, our ability to reflect the social-technical interplay of urban planning and design of urban infrastructure, under a variety of future landuse and climate change scenarios, will define our capacity to influence the development or transformation of cities into resilient, liveable and sustainable places.

The presentation will outline some of these emerging trends, including:

1. Access to a diversity of water sources underpinned by a diversity of centralised and decentralised infrastructure enabling cities the flexibility to access a 'portfolio' of water sources at least cost and with least environmental impact. Each of these alternative water sources have unique reliability, environmental risk and cost profile that can be optimised dynamically (even on a short term basis) through the availability of diverse infrastructure associated with the harvesting, treatment, storage and delivery of the water sources.

2. The concept of *Ecological Landscape* for embedding ecosystem services into urban ecology will feature prominently in the planning and design of urban water infrastructure, particularly in urban drainage and stormwater management systems. With contemporary approaches, stormwater runoff will be detained and treated on site with vegetated systems and, through a combination of stormwater harvesting and infiltration, managed to preserve key hydrological and water quality characteristics through a combination of greening cities and stormwater harvesting supporting the ecosystem health of urban rivers and creeks.

3. Future urban forms will be defined by a network of 'green and blue corridors' of open spaces as an integral element of the city's stormwater infrastructure. These corridors cleanse urban stormwater through vegetated treatment systems, detain and convey flood waters, and consist of productive landscapes which are themselves intrinsically linked to the opportunities for ready access to stormwater and local recycled water. The increased distributed greening of the urban environment will also contribute to the mitigation of urban heat, improve human thermal comfort of local communities, and increase the biodiversity of the urban environment.

4. Future sewage treatment plants will be facilities for recovery of resources including energy, water and nutrients. Water recovery technologies are well developed and energy recovery technologies are advancing. Emerging research efforts are directed at phosphorus and potassium recovery to overcome imminent global peak production of phosphorus and potassium. Furthermore, localised recycling of sewage linked to local productive landscapes is perhaps the simplest form of resource recovery (water and nutrients) from a city's sewerage system.

5. The advent of real-time control technologies, linking advancements in weather forecasting to infrastructure operation, has enabled the supplementary use of stormwater infrastructure as flood mitigation systems in high density developments.

6. Increased urban density will support co-generation and tri-generation systems where ready access to waste heat will support technologies akin to auto-claving for disinfection of recycled water and harvested stormwater, and the reticulation of hot water services to households.