

Modelling the Water Metabolism of Cities

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Project B1.2 - Catchment-scale landscape planning for water sensitive city-regions in an age of climate changes

Introduction

There are goals for better managing water in cities (Fig. 1), but a lack of frameworks for evaluating performance for cities and their regions. So it's difficult to monitor progress towards these goals or to optimise improvement efforts. We take a first step to address this by proposing a framework for modelling urban water flows at the city-region scale, based on Urban Metabolism and using a city water balance method.

How will it make cities better?

The utility of modelling water metabolism is seen by comparing the information it generates against goals for a Water Sensitive City (Fig. 1)

Goals of a Water Sensitive City ³

- Liveability / amenity**
 - heat island mitigation
 - multi-purpose greenspace
 - integrating water into landscape

- Protection of natural systems**
 - healthy waterways (pollution mitigation)
 - urban stream ecology

- Supply security**
 - diverse, fit for purpose supplies
 - water conservation
 - resilient to external shocks

- Resource efficiency**
 - minimising resource use
 - considering the nexus between water and other resources (energy, nutrients)

- Integrated management**
 - of potable water, wastewater and stormwater to manage optimally
 - of multiple objectives (productivity, waterway health, flooding, amenity)

- Engagement**
 - monitoring and reporting
 - water sensitive behaviours

Information generated by Urban Water Metabolism Evaluation

- Strategic:**
- Accounting and budgeting for diverse water sources and functions in the urban landscape
 - Understanding trade-offs between urban water demands and needs of supporting regions
 - Evaluating drain-on regional supplies
 - Optimising opportunities for water (and energy) efficiency and supply security by:
 - Integrated evaluation of natural and managed flows
 - evaluating capacity for water self-sufficiency
 - evaluating influence of local-scale initiatives on city-scale metabolic efficiency and supply security
 - evaluating energy implications
 - considering multiple functions of water and synergies from multi-functionality
 - Simulating future water efficiency and security under population and climate change

- Tracking and reporting progress towards water sensitive cities:**
- Highlighting scale and trajectory of city-scale water use
 - Monitoring the effects of planning policy
 - Framing indicators (water use efficiency, water-related energy efficiency, resilience) for:
 - comparing between cities and urban typologies
 - monitoring improvements over time
 - comparing urban entities with natural systems

Figure 1. Utility of urban metabolism for advancing water sensitive cities ⁶

References

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Urban metabolism evaluation framework

Urban metabolism considers resource flows in and out of cities as you might for an organism^{1,2}. Fig. 2 shows what this looks like for water.

Its perspective is on the whole city, with an implied intent of replicating the higher efficiencies of natural systems through circular rather than linear flows, and maximising functionality per resource input.



Figure 2. Example of urban water flows at the whole city scale

The evaluation framework quantifies managed and natural water flows through a defined urban boundary using a city water balance (Fig. 3) to generate water metabolism indicators (Fig. 4).

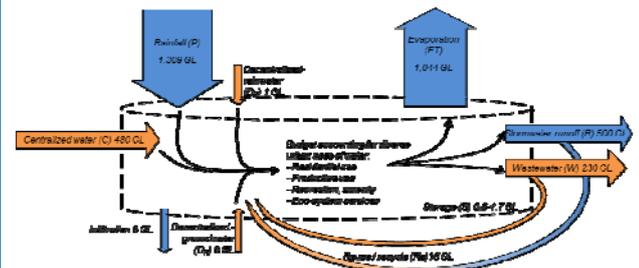


Figure 3. Proposed city water balance model ⁴

Water metabolic efficiencies	Per-capita water input from external supplies Per-capita water-related energy input Local-sufficiency ratio (internal inputs : internal demand)
Replicability of external inputs	Potential for decentralised supplies to meet demand
Departure from natural hydrology	Runoff naturalness ratio (post : pre-urbanisation) Evapotranspiration naturalness ratio Infiltration naturalness ratio Stream discharge naturalness ratio

Figure 4. Example water metabolism indicators ⁵