'Roses are red, water is blue, multi-functional green spaces are for you' – An integrated model for strategic liveability planning

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Highlights

- We investigate the multi-functional benefits of urban green spaces (UGS) in two cities
- Zurich and Melbourne's UGS show differences in accessibility, clustering, and connectivity
- Differing opportunities to harness UGS for human, ecological and urban water management

Introduction

Rapid urbanisation, population growth and climate change are imposing greater pressure on urban areas to adapt to future challenges. In planning sustainable and liveable cities. Blue Green Infrastructure, in particular, urban green spaces (UGS) including local parks and gardens and larger nature reserves play a vital role in delivering a range of multiple benefits (Giles-Corti et al., 2005, Tian et al., 2014). Research into the role of UGS has highlighted their multi-functional nature including physical and mental well-being (De Vries et al., 2003, Maas et al., 2006), ecological benefits including habitat provision and supporting urban biodiversity (Kong et al., 2010) and spaces for flood conveyance and protecting surrounding environments (Zhang et al., 2015). Furthermore, UGS also provide necessary space for large decentralised stormwater management assets for pollution control and harvesting of stormwater and other major services (e.g. safe connected routes for cyclists, major electrical and telecommunications infrastructure).

With rapid urban growth, such spaces are threatened by strategies that minimise city expansion beyond urban limits and instead densify existing areas (Haaland and van Den Bosch, 2015). Planning of UGS is thus increasingly becoming challenging and an integrated approach has the potential to ensure that their multiple benefits can be harnessed. Many studies have investigated the value of UGS in terms of human and ecological benefit. Adopting spatial analysis (Kong et al., 2010, Tian et al., 2014) using Geographic Information Systems (GIS) as well as local surveys (Maas et al., 2006) to evaluate local parks, useful insight has been gained into their role and importance, but also a realisation that cities are not fulfilling minimum provision requirements. To support future planning efforts, rapid and integrated spatial assessment tools that can assess the multi-functional benefits of open spaces and integrate these with city and infrastructure planning are required. As no such tool currently exists, this paper aims to demonstrate a new approach to rapid assessment of multi-functional UGS and their relationship with the urban environment and urban water management.

Methodology

Modelling Platform Overview

The Urban Green Space Mapping Module is a new addition to the UrbanBEATS Planning-Support System (PSS) (Bach et al., 2018), an integrated model for planning urban water infrastructure. UrbanBEATS uses a conceptual spatial representation to simulate the planning of the urban form (Bach et al., 2018) and a variety of urban water infrastructure (most notably, decentralised stormwater management options). Three essential input maps are required to run UrbanBEATS: (1) land use, (2) population and (3) elevation. A number of additional maps that enhance the simulation (e.g. rivers, lakes, roads) can be added to the model's geospatial database for more detailed analysis. The model creates a gridded presentation with each cell containing detailed information about land use proportions as well as their rough spatial arrangement (i.e. clustering of land uses known as *patches*), allowing for results to still be spatially explicit. Using this gridded representation and input parameters that represent statutory planning rules (see Bach et al., 2018 for further details), UrbanBEATS calculates a range of urban characteristics for each land use in each cell including urban geometry (typical building and road areas, impervious fractions, occupancy and other allotment characteristics). This information is then used in other modules for planning urban water infrastructure or, in this case, investigation of UGS.

Urban Green Space Mapping Module

The urban green space mapping and assessment module assesses the multi-functional benefits of urban green spaces (classified as one of three specific land uses: *Parks*, *Reserves* and *Forests*) at the land use *patch* level. The model focuses on a range of benefits including: (1) anthropogenic benefits, (2) ecological/biodiversity and (3) opportunities for urban water management. To accomplish this, several key spatial relationships are analysed, summarised in Table 1.

Table 1. Key aspects of multi-functional urban green spaces analysed by UrbanBEATS' Urban Green Space Mapping Module

Relationship	Category	Types of Analyses
Access to urban green space	Anthropogenic	Distance to nearest green space, number of green spaces within 'walking distance'
Service levels of urban green space	Anthropogenic	Overall provision of green space [m^2/person], Service load of individual green spaces
Continuity and connectivity of urban green space	Ecological	Node degree, largest connected component, quality of connections, barriers to connection
Stormwater management potential	Urban Water	Position in hydrological catchment, upstream impervious area, continuity of flow path, distance to waterways

The module is executed at the land use *patch* level, where the location of each green space patch (of known size and elevation) is analysed in relation to all other land uses. A spatially explicit network structure is established within the model, where nodes represent the centroids of each land use patch and two types of links are used to represent either the proximity to the nearest green spaces within a given distance or the connectivity between two green spaces (separated by a minimum threshold distance). This network is then further analysed to identify critical locations in the urban landscape including UGS: (1) with high volumes of service, (2) representing important connections for the ecological network, (3) at key positions in the hydrological catchment based. Overall metrics are also calculated to understand, at the city or municipal level, green space provision and quality.

Case Study & Model Application

To demonstrate the module's capabilities, we selected two contrasting cities and delineated an approximately 250km^2 area of their downtown area: Zurich (Switzerland), a European city with a dense core and interspersed with forests and villages and Melbourne (Australia), a sprawled Australian city known for its lush waterways and award-winning liveability. Spatial data was obtained for each city from their respective open data platforms[1] and census bureaus[1] and prepared for model input by reclassifying each land use system into UrbanBEATS' categories (Bach et al., 2015). The discretisation grid in the model was selected as 200m, which is the finest possible resolution that UrbanBEATS uses. Impervious fractions were calibrated for each case studies based on locally available cadastres and land cover maps. The UGS Mapping Module was run for both cities, considering the aforementioned characteristics in Table 1.

Results and discussion

A detailed spatial output is shown in Figure 1 for both Zurich and Melbourne along with some basic aerial and demographic information. It is visible from the impervious fractions that Melbourne's population is more spread out whereas in Zurich's population is highly concentrated near the central business district (CBD). Despite similar size, Zurich has almost three times more green space within its region, much attributed to its surrounding forests. Melbourne's green spaces on the other hand appear to be lumped and aligned with its major waterways, thereby limiting access in many urban residential areas. Statistics show that median distance to nearest green space in Melbourne is 230m compared to 120m in Zurich. Connectivity of green spaces in both cities appears to be high, but with vulnerability around the central business district due to major railway lines in Zurich and major industrial activity in Melbourne. From an urban water perspective, only limited green spaces are found near major water bodies in Zurich potentially

[1] *Sources include: City of Zurich (maps.zh.ch), VIC Open Data (data.vic.gov.au), ABS (abs.gov.au)*

limited space for WSUD, whereas in Melbourne, many open areas follow waterway corridors, allowing buffering against fluvial floods or stormwater treatment prior to entering local creeks.

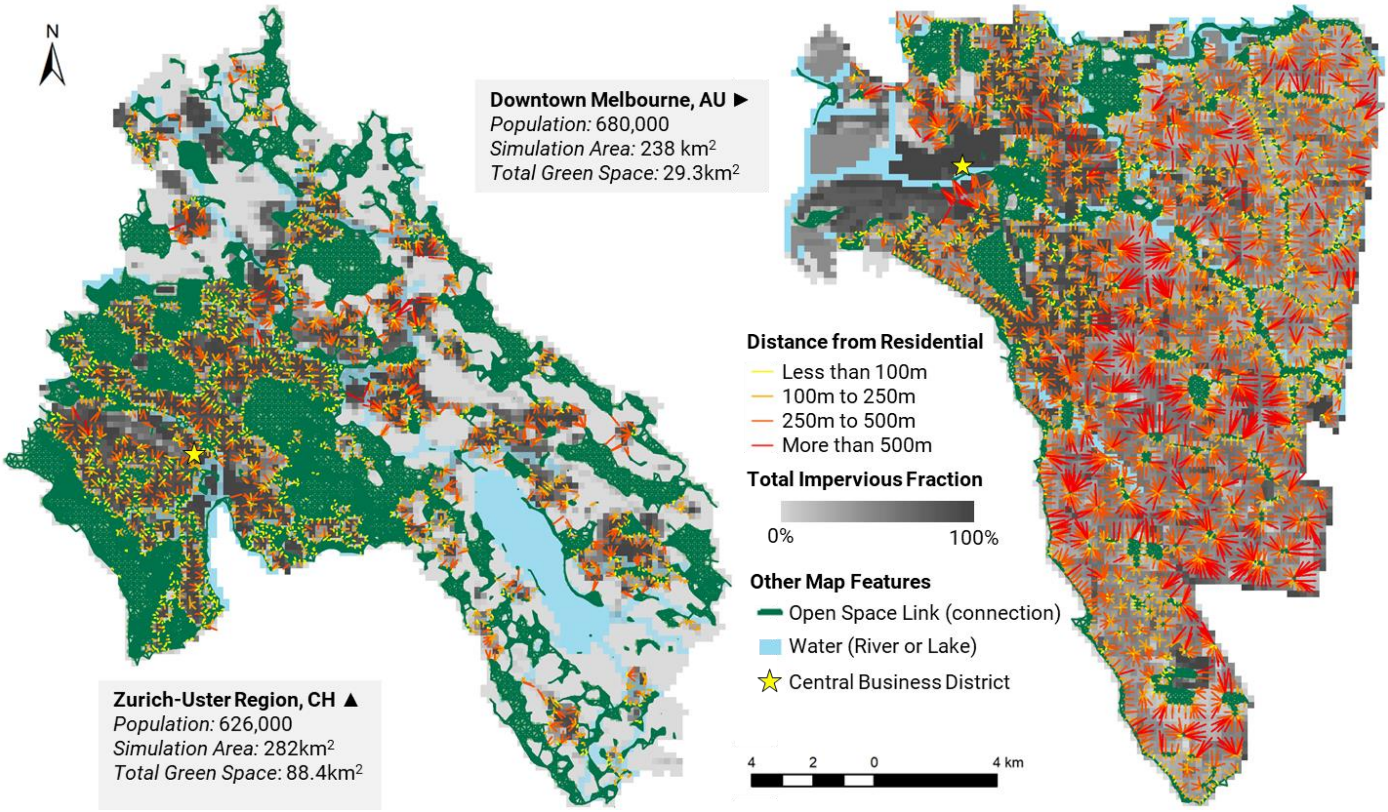

Figure 1. Output from UrbanBEATS' Urban Green Space Mapping Module for Zurich and Melbourne case studies showing impervious fractions, water bodies, green space connectivity and access distance to nearest green space from residential districts.

Conclusions and future work

The urban green space mapping and assessment module shows promise in mapping and assessing the multiple benefits of urban green spaces. It is particularly useful for urban water managers and city planners, who can better understand the value-add of these spaces to the urban environment and make better-informed strategic decisions for the protection of existing and provision of new green spaces given the impending growth of the urban environment. The presented case study shows stark contrast in the configuration and role of green space in two different cities and further analysis will be shown in the full presentation.

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