Water Sensitive Urban Design in the City of the Future

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ABSTRACT
With timeframes for addressing the issues of the City of the Future (CotF) rapidly approaching (e.g. 2020, 2025, 2050), this paper integrates international research knowledge and expertise from four continents. It critically evaluates the role of water sensitive urban design (WSUD) in the CotF in terms of overlapping theory and practice. The aspirations of water sensitive cities are reviewed and multiple drivers for applying WSUD are described from developing and developed country perspectives In addition, the potential for WSUD to support cities in 'leap-frogging' towards their visions are explored. The role of WSUD within the wider context of achieving sustainable living objectives (e.g. greater resilience, low carbon living, sustainable transportation, local food supply and social stability) is debated and the concept of the 'multi-objective city' introduced. Conclusions are drawn regarding opportunities for the WSUD process to provide a framework within which professionals from many disciplines can support landscape architects and urban planners in achieving multi-objective liveable cities are identified.

KEYWORDS
Governance; knowledge; planning; principles; water sensitive urban design (WSUD)

INTRODUCTION
Emergent water and environmental issues and associated drivers include adapting to climatic extremes, reducing flood risk, managing increasingly stressed water resources and improving water quality. These issues need to be balanced with a range of other planning priorities and objectives, including meeting new housing, public health, transport and energy needs and demands, whilst facilitating economic growth and creating and maintaining quality places (Potter *et al*., 2011).

Over the past 30 years, the concepts of 'integrated water management' and 'sustainable development' have emerged, as society aspires to lessen its impacts on global resources for the benefit of the environment and future generations. Consequently, water managers and planners (landscape/urban architects and designers) are faced with a complex challenge – the 'designing-in' of sustainability from a range of perspectives. Coupled with this new agenda is

an emerging reconfiguration of roles and responsibilities, which require all stakeholders to work in new, sometimes unfamiliar ways (Potter *et al*., 2011). Furthermore, half the world's population lives in urban areas and this proportion is predicted to increase to 69% by 2050 (UN, 2009).

Within this broad urban development context, this paper discusses the current impact of urban water management strategies on the urban quality of life agenda. Drivers for and benefits to be derived through integration of the urban water cycle and urban design and planning regimes are discussed with reference to both developing and developed country urban contexts using the emerging concept and language of water sensitive urban design (WSUD). WSUD is a process through which water, wastewater and stormwater flows are integrated, bringing sensitivity to water in urban design and giving it due prominence within the context of urban planning and design. The WSUD philosophy incorporates flexibility in supply and demand to meet the needs of users and the environment, which subsequently informs urban design and the collection, storage, treatment, use and movement of water. It also underpins the technologies that support these activities in a way that provides a sensory manifestation of process for all to acknowledge and appreciate (tangible visual realities of how water sits and functions within a landscape). The term WSUD is often used synonymously with other stormwater management approaches such as low impact development (LID), low impact urban design and development (LIUDD), stormwater best management practices (BMPs) and sustainable drainage systems (SuDS). However, in its aspiration of making water central to the design and functioning of many facets of city living, it is argued here that WSUD should be seen as over-arching design philosophy; one that represents a fundamental re-think of the role and place of water in urban environments as opposed to, more narrowly, a resource management challenge. In summary, this paper explores the role of WSUD in providing a holistic mechanism for the delivery of complementary integrated water management and sustainable development.

WATER SENSITIVE URBAN DESIGN – DRIVERS, AMBITIONS AND EXPERIENCES

A transition towards a WSUD approach is an attractive proposition and there is abundant diversity in drivers for and approaches to its delivery. This section provides insights into these drivers, together with an overview of the changing 'visions' of the role of water within cities and progress on its integration within the planning systems in a range of countries. Of necessity, only a 'snapshot' of some of the countries implementing WSUD or a similar approach is provided here, with countries selected to illustrate where there may be commonalities or contrasts.

Australia The evolution of WSUD philosophy in some Australian cities over the last 15 years has been rapid, from an early focus on managing stormwater quality to integrated urban water management and beyond, using urban design as the integrative discipline (Brown and Clarke, 2007). The concept of the Water Sensitive City (WSC) is a stated goal of the Australian Commonwealth's National Water Initiative (COAG, 2004). The vision and concepts of the WSC are emerging directly in city-shaping policies, notably a recent Australian Government policy (Department of Infrastructure and Transport, 2011) that consolidates the various elements of productive, sustainable and liveable cities into a vision for Australian cities that explicitly incorporates WSUD as an integrative element. In this, urban water cycles are designed and managed as integrated systems enmeshed with urban design and communities, forming an important niche within this vision of the CotF. Similarly, Brisbane City Council's WaterSmart Strategy (2010) aims to guide Brisbane towards becoming Australia's most

sustainable and water smart city. Victoria's Living Melbourne, Living Victoria Roadmap (Living Victoria Ministerial Advisory Report, 2011) sets a framework to transform urban water management and, in so doing, enhance Melbourne's liveability.

Many of the water sensitive cities initiatives in Australia are underpinned by three key principles (espoused by Wong and Brown, 2010) - (i) that cities are water supply catchments with access to diverse water sources; (ii) that cities can be designed to provide ecosystem services including water quality improvement for the protection of natural ecosystems, flood protection, micro-climate management and supporting biodiversity; and (iii) that future sustainable cities comprise water sensitive communities with empowered communities participating in co-design of urban water service and a skilled professional community for implementation of water sensitive urban design enabling government policies for innovation and adaptive management of urban water systems.

Singapore After a successful campaign to clean-up and revitalise the Singapore River and the introduction of the '4-Taps Strategy', the Public Utilities Board (PUB) of Singapore's National Water Agency embarked on a programme to better integrate water within the urban environment. The holistic and strategic 'Active, Beautiful and Clean Waters Programme' (ABCWP), embodies the vision of transforming engineered concrete drains, canals and reservoirs into clean, vibrant, recreational (i.e. multi-objective) waterways. It is hoped that by bringing people closer to water this will lead them to cherish, appreciate and take ownership of what is a precious resources and value the associated ecosystems. While the focus initially relates to the assets of the PUB, the ABCWP nevertheless plays a major role in the national initiative to regenerate Singapore into a vibrant 'City of Gardens and Water'. PUB has adopted the role of a bridging organisation to facilitate the collaboration amongst the various stakeholder organisations to effectively implement catchment-scale public and private-based WSUD initiatives (Tan and Wong, 2009).

France Water, stormwater and sewage have been managed by local authorities in France since the early twentieth century. To date, Nantes, Lyon and Paris have developed specific organisations to monitor impacts of urban waters on the environment. Supporting this, 'HURRBIS' (a network of hydrologists and local authorities) was initiated in 2007 and the entire water cycle is taken into account. Partners challenge the use of conventional approaches whilst sharing good practice, data experiences and concerns. Exchanges have been beneficially two-way, with public authorities acquiring access to a better level of expertise and researchers being incorporated into the decision-making process. In Lyon, for example, hydrologists and urban designers work together to manage urban stormwater and sewage for the future (Soyer *et al*., 2011).

The UK There is a lack of common vision; different approaches to water management and planning exist in the constituent countries of the UK (Shaffer et al, 2012). In England, planning policy provides a framework for managing flood risk and requiring SuDS, whilst Building Regulations and the Code for Sustainable Homes provides a baseline for water efficiency. Water Cycle Studies resemble WSUD, but they only highlight its need and do not provide guidance on its delivery (Shaffer *et al.*, 2012). Consequently, this disparate arrangement of responsibilities constrains the ability of local authorities to integrate water with the wide range of public services within their remit, resulting in the lack of a common vision of WSUD (Ashley *et al*, 2011). Scotland is perhaps more progressive, where water services are still notionally state owned and the implementation of SuDS is further mandatory for new developments. However, despite clear design guidance (CIRIA, 2007) and benefits,

systems are often implemented using 'end-of-pipe' ponds and no source control. Indeed, over 70% of sites in Scotland were reported as using only a single treatment component (Bastien *et al*, 2010). Even in this context, other aspects of WSUD (e.g. water reuse) have yet to be widely considered or implemented and many organisations and stakeholders confuse it with SuDS and BMPs as evidenced in the new Water White Paper (HM Government, 2011).

The USA In the USA, a more co-ordinated approach to surface water and land management is emerging through the increased use of BMPS within LIDs. LIDs, pioneered in Prince George's County, Maryland in the 1990s (EPA, 2000), are site-based design strategies for maintaining the predevelopment hydrologic regime with, in this context, BMPs focused on water quality. Although LID techniques may be retrofitted to existing urban environments and often include large elements of Green Infrastructure (GI), neither LIDs or BMPs currently fully represent an overall vision for water cycle integration within urban planning and design (EPA, 2000), as they do not generally incorporate water supply and sanitation within their remit (both key components of WSUD).

The Republic of South Africa (RSA) RSA is a middle-income developing country, with a fragmented water management structure and massive inequities between rich and poor. Basic water, sanitation and drainage services do not exist for a large proportion of the population. Stormwater management is generally part of highway management and separated from water and sanitation services and, as it does not generate income, is underfunded. Although water demand management is becoming increasingly important (including the limited re-use of treated sewage effluent), there is a heavy reliance on large-scale surface water schemes with limited use of groundwater. The use of stormwater as a resource has largely been over-looked. Essentially, RSA does not have a vision for WSUD, but it does have a water problem, a service delivery problem and a fragmented approach. The multi-objective approach offered by WSUD could offer a way forward subject to political acceptance, perhaps based on the creation of green jobs to alleviate high unemployment (the carrot) and the prevention of economic decline due to the lack of water (the stick). Additionally, the WSUD approach enables human and environmental disparities to be addressed in parallel. However, as WSUD is a young and relatively untested approach, concerns will require assuaging regarding risks, costs, and timescales for delivery (Butterworth *et al*., 2011).

TOWARDS THE MULTI-OBJECTIVE CITY?

Urban environments provide the platform for the interaction and interplay of socio-technical systems that cut across numerous sustainability issues and involve many industrial and community sectors. The fundamental principles of WSCs reflect the trans-disciplinary approach to developing socio-technical solutions that are delivered through the integrative practice of urban planning and design. The broad intent of these principles is equally applicable to other sectoral sustainability issues associated with urban infrastructure such as transportation, waste and energy, as well as other agendas, such as low carbon cities. For these multiple objectives to be achieved requires effective trans-disciplinary working.

Brown *et al.* (2009) investigated the evolution of urban water management across Australian cities over the last 200 years and considered a series of sustainable futures perspectives. They suggested a nested typology of six types of dominant water management regimes (water supply, sewered, drained, waterways, water cycle and water sensitive) that represent a nested continuum of socio-political drivers and service delivery responses. As cities evolve, water management becomes necessarily more complex, but may also become more resilient through responding to major system 'disturbances'. The adaptive capacity to create

opportunities from these disturbances may develop, where innovation and development facilitate the pursuit of new, multi-objective trajectories. This same framework could serve as a template for mapping the socio-political drivers and service delivery responses associated with transportation, energy and other public urban infrastructure development trajectories.

From the country perspectives presented above, it is clear that the CotF will require the fulfilment of multiple objectives simultaneously through trans-disciplinary working; WSUD may present an opportunity to achieve this. This raises the prospect and concept of the 'multi-objective city', perhaps a step beyond the WSC. Inevitably, this means the complexity of designing, planning and delivering cities will become increasingly recognised. Coping with rising levels of complexity requires more 'synergistic' combinations of different forms of knowledge into innovative 'wholes'. Under present organisational conditions, which largely fail to acknowledge this challenge, this is not easy (Geldof *et al*., 2011). This culture change involves transitions of governance, institutions and organisations (Brown *et al.*, 2011) and new methods of working, but crucially it also involves hearts and minds (Shaw, 2006). There must be a willingness to communicate innovative ideas and knowledge between and within, disciplinary, institutional and political structures (Ward *et al.*, 2011; Lundy and Wade, 2011).

MULTI-OBJECTIVE CITIES - A NEW GOVERNANCE?

The complexity of issues surrounding water management and the impacts upon and synergies with urban planning means that alliances and partnership working are essential to achieve an integrated approach. Planners need the expertise, and crucially the understanding, of engineers and hydrologists. However, there can be considerable misunderstanding and miscommunication between disciplines, often concerning the institutional context in which the various parties operate (Ashley *et al*., 2011; Brown *et al.*, 2011). A plethora of policies, tools and assessments exist which can make WSUD an overwhelming prospect for the water manager or planner. As the international perspectives highlight, whilst there may be limited understanding of the planning processes by engineers and water managers, WSUD approaches require mainstreaming in planners' strategic policy making, regional and master planning, as well as in detailed decisions on location specific developments. The real challenge is to understand *and* prioritise water management in line with other recognised infrastructure – building layout, transport networks and energy provision. Another significant challenge is engagement between urban planners/designers and engineers. In many cases planners view water provision and removal as the engineer's problem, whilst engineers argue that planners are focussed on delivering token amounts of blue/green space. There are synergies to be delivered and multiple benefits to be achieved, but they need to be clearly articulated between parties to present a convincing case for following a WSUD approach.

Multiple dialogues, as identified in the French and Australasian perspectives, are crucial for the development of horizontal and vertical integration of WSUD. The expertise necessary to understand the complexities of the issues cannot always reside within a single organisation or discipline (Thomson, 2009; Lundy and Wade, 2011). Engineers are often seen to reason from tried and tested civil engineering norms, based on probabilistic risk analysis, safety engineering and modelling to predict the behaviour of water. Spatial planners view space in a qualitative way; as a landscape, a locality or place (Wiering and Immink, 2006). WSUD bridges the gap between the two, qualitatively viewing landscapes as the quantitative spaces for water, spanning landscape architects and urban designers, as well as planners (Digman *et al.*, *In Press*). However, whilst the motivations and benefits of integrating water management within urban planning may be clear from the perspective of a water resource manager, the benefits for urban planners of taking on a challenge of this magnitude have yet to be fully

scoped or communicated. From the cases presented above, it is clear that approaches to governance vary widely. Opportunities for water and urban professionals (of all types) to support each other in the delivery of WSUD lie in the richness of these divergent contexts and experiences. The multi-objective CotF will require new, multi-objective governance.

Working together to bring about change

The big challenge in bringing WSUD fully into the dominant regime for water sensitive cities is not technical or economic but socio-technical (Ward *et al.*, 2011). In developed countries this means changing communities' interactions with the water cycle as well as breaking the 'locked-in' behaviour of professionals and their organisations (Brown *et al.*, 2011; Ashley *et al.*, 2011a; Shaffer *et al.*, 2012). Major efforts have recently been expended on understanding how to help professionals to work more effectively together. For example, a pertinent 'real' lesson for a 'new governance' is the recognition of the need to ensure that 'tacit knowledge' is retained in coping with the complexity of water management (as opposed to complicatedness). It can be argued that transitioning from abstract WSUD concepts and plans to delivery becomes ever harder without this (Geldof *et al*., 2011).

The limited ability of professionals to understand each other's language and share experiences further reduces tacit knowledge in a 'vicious circle'. Several approaches are being taken to try to overcome some of these problems in the water domain. Learning Alliances (LA) are being used successfully to innovate and produce responses outside the normal boundaries (van Herk *et al.*, 2011). The use of LAs globally has recently been shown to be a valuable way of ensuring effective engagement in innovation (Butterworth et al, 2011). Despite a long tradition of holding meetings in professional practice (Lloyd, 2010), effective, clear communication between major actors in the water and urban domains has not been as good as it could be (Lems *et al.*, 2011) even among similar groups of professionals. Water systems *were* managed in 'silos', without a clear integration across the water cycle and beyond into the urban planning domain. Now, in view of the complex, wicked problems that need to be tackled if WSUD and WSCs are to be attained, better communication will be essential across *all* of the actors. In Europe at least, under the Aarhus convention, communication with the public needs to work; a missing ingredient in the development of River Basin Management plans in England (Lerner *et al.*, 2011). This needs to be coupled with the better utilisation of social networking and at professional levels, social learning (Pahl-Wostl *et al.*, 2008). New work on 'framing' how water professionals and policy makers 'see' the system, their roles, together with their implicit behaviours, values, cultures, perceptions and frames of reference (Lems *et al.*, 2011; Dudley *et al.*, 2012) is provoking and essential if the regime change needed is to come about.

CONCLUSIONS

Emerging resource and environmental issues (from water shortages and floods to energy crises and elevated pollutant levels), combined with numerous planning priorities and objectives to meet the needs of a growing urban population, results in a complex array of challenges. Ensuring quality-of-life for current and future generations will require multi-disciplinary innovations in both thinking and practice if identified challenges are to be addressed and emerging opportunities exploited within our cities. As the country-specific overviews have shown, the drivers behind and current capacities for dealing with integration complexities vary across the globe, with WSUD emerging as a multi-disciplinary process to facilitate a city's transition from a water wasteful to a water-sensitive environment within a range of social-economic and environmental contexts.

The WSUD process has also been postulated as providing a framework within which other 'sustainability agendas' could integrate. This underpins a new approach to facilitating governance in the 'multi-objective' city, where communication and knowledge exchanges occur between and within professionals' own spheres of influence. From a developing country perspective, WSUD potentially presents opportunities for 'leap frogging' through the described water management regimes (Jefferies and Duffy, 2011), providing a process through which 'survival' and 'aspirational' needs of a community could be simultaneously addressed. For developed countries, WSUD presents an opportunity to demonstrate greater commitment to broader sustainable development goals directly impacting on the mental and physical well-being of residents through, for example, the provision and protection of a range of ecosystem services (Lundy and Wade, 2011). The crucial factor in both developing and developed country contexts, however, is that the visions for WSUD and water sensitive and multi-objective cities must be shared within a new trans-disciplinary governance, where old and new knowledge are both valued and gaps bridged by a common language.

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