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The water sensitive city: principles for practice

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ABSTRACT

With the widespread realisation of the significance of climate change, urban communities are increasingly seeking to ensure resilience to future uncertainties in urban water supplies, yet change seems slow with many cities facing ongoing investment in the conventional approach. This is because transforming cities to more sustainable urban water cities, or to Water Sensitive Cities, requires a major overhaul of the hydro-social contract that underpins conventional approaches. This paper provides an overview of the emerging research and practice focused on system resilience and principles of sustainable urban water management Three key pillars that need to underpin the development and practice of a Water Sensitive City are proposed: (i) access to a diversity of water sources underpinned by a diversity of centralised and decentralised infrastructure; (ii) provision of ecosystem services for the built and natural environment; and (iii) socio-political capital for sustainability and water sensitive behaviours. While there is not one example in the world of a Water Sensitive City, there are cities that lead on distinct and varying attributes of the water sensitive approach and examples from Australia and Singapore are presented.

Key words | ecosystem protection, resilience, sustainable cities, water sensitive urban design

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INTRODUCTION

The commencement of the 21st century marks the period when the proportion of the world's population living in urban environments surpasses that living in the rural environment. The 21st century is indeed the century of cities and urbanisation. Urban developments to support a growing community have consequential impacts on the land and water environments. The pursuit of sustainability is aimed at initiatives for protecting and conserving natural resources and promoting lifestyles, and their supporting infrastructure, that can endure indefinitely because they are neither depleting resources nor degrading environmental quality (Wong & Eadie 2000). While such ambitions may seem beyond reach, they set a challenge that can reap benefits – environmental, social and economic – with each step towards the ultimate, and ever moving, goal of sustainability.

A critical challenge to urban communities is its design for resilience to the impact of climate change and population growth, particularly in regards to sustainable management of water resources and the protection of water environments. It is now well accepted that the conventional urban water management approach is highly unsuited to addressing current and future sustainability issues (Butler & Maksimovic 1999; Newman 2001; Ashley *et al.* 2003, 2005). This critique is based 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 (Ashley 2005; Brandes & Kriwoken 2006; Brown 2008).

With the widespread realisation of the significance of global warming and climate change, urban communities are

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seeking resilience to future uncertainties in urban water supplies brought about by a combination of climate variability, population growth and climate change. Yet despite the development of new technologies and infrastructure in the service of urban water sustainability goals over the last 20 years, both practitioners and scholars recognise that change remains too slow (Maksimovic & Tejada-Guibert 2001; The Barton Group 2005; Mitchell 2006; Wong 2006*a*). Consequently many cities face ongoing investment in conventional approaches which perpetuates a significant delay in the widespread diffusion of sustainable, or water sensitive, alternatives.

Transforming cities to more sustainable urban water cities, or as termed in this paper to *Water Sensitive Cities*, will require a major socio-technical overhaul of conventional approaches. Best-practice urban water management, is widely acknowledged as complex, because it requires urban water planning to protect, maintain and enhance the 'multiple' benefits and services of the total urban water cycle that are highly valued by society. These include supply security, public health protection, flood protection, waterway health protection, amenity and recreation, greenhouse neutrality, economic vitality, intra and inter-generational equity; and demonstrable long-term environmental sustainability. Part of the complexity of realising this best-practice is the need for identifying and employing approaches that protect and enhance these multiple and interdependent benefits and services. In the past, water managers have often reduced this complexity by focussing on optimising singular parts of the water cycle such as 'supply security' in isolation and/or in absence of reliable consideration to the other dimensions of the cycle. This often results in outcomes that compromise a significant proportion of the multiple objectives of best-practice urban water management, including the numerous well known social, ecological and economic costs, which overall increases the vulnerability of cities. Water supply solutions that best protect and enhance full suite of values and benefits from a total water cycle perspective are likely to result in more resilient solutions over the long-term.

While there is not one example in the world of a Water Sensitive City, there are cities that lead on distinct and varying attributes of the water sensitive approach. This thinking has evolved through the innovation of new concepts such as Water Sensitive Urban Design (WSUD) (Wong 2006*a*, 2006*b*), which is based on the integration of the two key fields of 'Integrated urban water cycle planning and management' (IUWCM) and 'urban design'. WSUD brings 'sensitivity to water' into urban design, as it aims to ensure that water is given due prominence within the urban design process through the integration of urban design with the various disciplines of engineering and environmental sciences associated with the provision of water services including the protection of aquatic environments in urban areas. Community values and aspirations of urban places necessarily govern urban design decisions and therefore water management practices. Consequently WSUD is an interdisciplinary social and physical sciences concept accounting for context and place (Wong & Ashley 2006).

The concept of the Water Sensitive City is a stated goal of the Australian Commonwealth's National Water Initiative directed at 'Innovation and Capacity Building to Create Water Sensitive Australian Cities' (COAG 2004, Clause 92, p20). While the Australian Government is yet to provide a definition for the envisaged Water Sensitive City, contemporary research in IUWCM highlights that it is a significant departure to the conventional urban water approach. Recent envisaging processes involving 19 scholars across seven disciplines strongly suggest that a Water Sensitive City would ensure environmental repair and protection, supply security, public health and economic sustainability, through water sensitive urban design; enlightened social and institutional capital, and diverse and sustainable technology choices (Brown *et al.* 2007).

RESILIENCE AND THE HYDRO-SOCIAL CONTRACT

Ensuring socio-technical resiliency, and overcoming system (or city-wide) vulnerability to climate change and population growth, is an important condition for the Water Sensitive City. When a city is a 'resilient' system, major system 'disturbances' (such as floods, droughts and waterway health degradation) provide the potential to create opportunities for systemic innovation and new (and more sustainable) development trajectories. However, when a city is a 'vulnerable' system, even small disturbances, such as extended storm events, are likely to cause dramatic social consequences (Adger 2006).

A resilient system is interpreted as: (i) the amount of disturbance the system can absorb and still remain within the same state; (ii) the degree to which the system is capable of self organisation (versus lack of organisation, or organisation forced by external factors); and (iii) the degree to which the system can build and increase the capacity for learning and adaptation. Resilience is not only about being persistent or robust to disturbance, it also reflects how that system creates opportunities from the disturbance for renewal and the pursuit of new trajectories (Folke 2006).

As highlighted by Folke (2006, p. 253) "the major challenge is to develop governance systems that make it possible to relate to environmental assets in fashion that secures their capacity to support societal development for a long time into the future". There is an active scholarship focused on how socio-institutional systems respond to disturbances and surprises, as well as on the adaptive governance mechanisms for improving self organisation, such as institutional leadership, social networks and bridging organisations (Elzen & Wieczorek 2005; Folke *et al.* 2005; Smit & Wandel 2006). Much of this work however lacks insight into how the physical realm can be best harnessed to support the transition to more resilient systems and cities. Adopting a socio-technical perspective has been identified as the most promising for addressing the need for resiliency and advancing sustainable development (Meadowcroft 2005), but is yet to be systematically applied to the urban water environment.

While Kemp *et al.* (2007, p. 79) believe that the resiliency of systems to disturbances in their environment is well understood, approaches to transform "*subsystems and their environment–has received far less attention*". This approach for change has been characterised by some as the concept of the 'hydro-social contract' (Lundqvist *et al.* 2001), which is a term used to describe the pervading values and often implicit agreements between communities, governments and business on how water should be managed. This contract is shaped by the dominant cultural perspective and historically embedded urban water values, expressed through institutional arrangements and regulatory frameworks, and physically represented through water systems infrastructure. The approach of the Water Sensitive City is particularly focussed on this question of 'how' to transform cities through reconnecting best thinking and practice in urban water management, urban design, and social and institutional systems.

This paper attempts to scope the hydro-social contract needed for systematically underpinning the Water Sensitive City. This is based on the insights of the urban water transitions framework presented in Brown *et al.* (2009) '*Urban Water Management in Cities: Historical, Current and Future Regimes*' and shown in Figure 1. This transitions framework presents a typology of different states that cities transition through when pursuing change towards more sustainable futures, with the dominant socio-political drivers and service delivery functions indicated. The six transitions states are a nested continuum, so the hydro-social contract in previous city states influences and shapes the hydro-social contract in subsequent transition states.

The research of Brown *et al.* (2009) revealed that the basic structure of the hydro-social contract was largely unaffected while progressing through the first three transition states, namely the Water Supply, Sewered and Drained Cities. The hydro-social contracts of each of these city states were logical expansions of the services provided by governments for a tax on behalf of communities with the implicit promise of providing cheap and unlimited water supply, public health protection through sewerage services, and drainage and flood control to support urban expansion. These contracts had been subsidised by the common practice of not accounting for environmental services, leading to the over extraction and pollution of water resources, reflecting the old, yet still institutionally dominant perspective that not only are the economy and environment mutually independent but that the environment is benign and of much lower priority.

The structure of the hydro-social contract is currently being significantly challenged with the advent of the Waterways City, with the players in this contract now expanding to represent environmental protection needs through government departments, NGOs and professional communities advocating for urban stormwater quality management. With the Water Cycle City the players in the hydro-social contract, and the distribution of functions and responsibilities, need to be fundamentally re-structured compared to the incremental structural

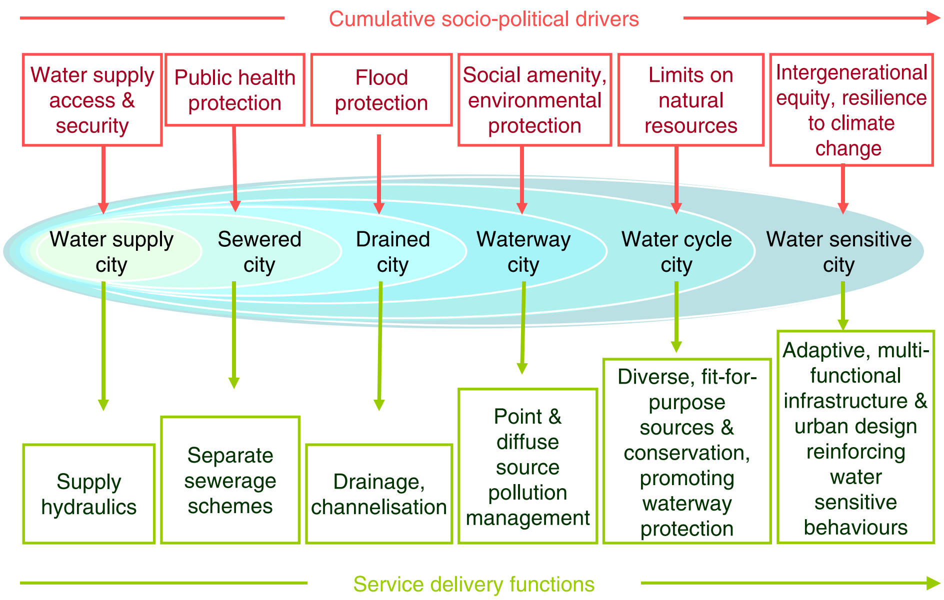

Figure 1 | Urban Water Management Transitions Framework (source: Brown *et al.* 2009).

adjustments associated with the transition from a Sewered city to a Drained city.

Brown *et al.* (2009) propose that the hydro-social contract in a Water Sensitive City is adaptive and underpinned by a flexible institutional regime, and co-existing and diverse infrastructure. Therefore it is envisaged that the establishment of a Water Sensitive City will require a major socio-technical overhaul of conventional approaches. The social capital social capital would be likely to reflect a sophisticated and engaged community supportive of a sustainable lifestyle and would extend to the professionals and practitioners in the water sector, in relation to their capacity for innovation and sustainable management of the city's water resources. Technologies, infrastructure and urban form would be diverse and flexible, designed to reinforce sustainable practices and social capital, recognising the implicit link between society and technology.

THREE PILLARS OF THE WATER SENSITIVE CITY

The remainder of this paper is an attempt to translate the theory on system resiliency and the development of the hydro-social contract into principles for practice. It is a proposition of this paper that a Water Sensitive City may be characterised by the following three key pillars of practice which must be seamlessly integrated into the urban environment, including:

(i) Cities as Water Supply Catchments: access to a diversity of water sources underpinned by a diversity of centralised and decentralised infrastructure;
(ii) Cities Providing Ecosystem Services: provision of ecosystem services for the built and natural environment; and
(iii) Cities Comprising Water Sensitive Communities: socio-political capital for sustainability and water sensitive decision making and behaviours.

Cities as water supply catchments

Like many cities, the majority of Australian cities are almost exclusively dependent on water resources derived from capture of rainfall runoff from largely rural or forested catchments. Communities are increasingly susceptible to the impacts of increasing temperatures and soil moisture deficit in water supply catchments, climate variability, drought and climate change. Continuing the conventional approach of 'building another dam' is often not the most effective option. A possible mitigating initiative to these challenges is breaking the dependency of cities on regular rainfall and favourable soil moisture conditions in water supply catchments for security of their water supply. Although in many regions of Australia, the effect of climate change on rainfall is very uncertain and may not necessarily lead to any consistent trend of reduced rainfall, there is a higher certainty that climate change will increase global temperature and thus will have a more certain effect on soil moisture in traditional water supply catchments (ie. a drier catchment) and consequently the reduction in catchment runoff during storm events.

Cities can have access to a diverse range of water sources in addition to the established convention of capturing rainfall-runoff from rural and forested catchments. These alternative water sources for cities include groundwater, urban stormwater, rainwater (roof runoff), recycled wastewater and desalinated water. Many of these sources are within city boundaries and ready access to this diversity of water sources in water sensitive cities may be framed under the general theme of “Cities as Water Supply Catchments”. As recently highlighted by the Prime Minister’s Science and Engineering and Innovation Council Working Group in Australia:

> Water supplies to Australia’s cities need to move from reliance of traditional sources to an efficient portfolio of water sources which can provide security through diversity. Like a share portfolio, flexible and cost effective access will be underpinned by diversity, including centralised and decentralised infrastructure. Like a share portfolio, the composition of water source portfolios also needs to reassessed as new information on costs, prices, climate, environmental objectives and impacts, and risks becomes available (PMSEIC 2007).

A strategy built around a diversity of water sources and a diversity of water infrastructure will allow cities the flexibility to access a ‘portfolio’ of water sources at least cost and with least impact on rural and environmental water needs. Each of the alternative water sources have unique reliability, environmental risk and cost profiles with the tendency for sources of high reliability to also have associated high cost and environmental risk profiles and vice versa. In a future water sensitive city, access to these alternative sources can be optimised dynamically (even on a short term basis) through the availability of diverse infrastructures associated with the harvesting, treatment, storage and delivery of the water sources. This would include both centralised and decentralised water supply schemes, ranging from the simple rainwater tank for non-potable use to city-scale indirect potable reuse schemes and the ‘pipeline grid’ linking regional reservoirs. Optimisation will ensure preferential access of sources of low cost and environmental risk ahead of options with higher cost and environmental risk.

Building a diversity of infrastructure throughout a built-up area takes time and therefore does not address the immediate short-term water crises currently facing many Australian cities. Governments have tended to focussed on large centralised infrastructure such as desalination plants, indirect potable substitution scheme (i.e. treated recycled water returned to water supply storages) to address this. These schemes are important elements of a diverse water portfolio but there is a risk that governments would overlook the importance of building the diversity of sources once these centralised schemes are commissioned.

An important component underpinning a diversity of infrastructure is the secondary supply pipeline for non-potable water (sometimes referred to as the third pipe system or dual supply). Water delivered via a secondary supply system provides a sound basis for promoting a ‘fit-for-purpose’ approach to water use. Non-potable water from a variety of local sources (eg. stormwater, groundwater, recycled wastewater) can replace the use of potable water for such uses as toilet flushing, laundry, garden watering and open space irrigation.

The provision of a second water supply pipeline for non-potable water is a fundamental basis for preserving future opportunities for accessing recycled water. In greenfield developments, the cost of providing the secondary supply pipe is low compared to retrofitting existing developments. This opportunity is often not taken up for lack of a suitably cheap alternative water source for non-potable demands. However recycled wastewater is often the alternative water source considered and financial assessment is largely based on the present cost of water recycling technology without recognising the significant reduction in the cost of water recycling technologies observed in the past five years and the likely future extension of this trend. Furthermore, assessments of the feasibility of current projects often do not consider stormwater as a suitable alternative source because of its perceived lower reliability rather than considering stormwater as one of a future interchangable suite of alternative water sources of varying costs and reliabilities delivered by the second water supply pipeline.

Cities providing ecosystem services

As a result of the combined pressures of population growth and climate change, new urban communities face a new and critical urban design challenge. These include ensuring that future urban landscapes encapsulate opportunities and technologies for resilience to the impacts of climate change, to face future uncertainties in urban water supplies and climatic extremes, and provide ecosystem services to protect/buffer downstream aquatic environments and other ecological habitats from these impacts.

Designing cities for climate change, particularly the sustainable management of water resources, requires a reversal in the conventional philosophical approach of urban communities drawing on their depleting ecosystems and natural environments. Spaces in the public domain are essential features of public amenities. However, these urban landscapes must be functional beyond providing spatial amenities. Our knowledge of the traditional 'values' of open spaces and landscape features needs to be bolstered with an understanding of the 'ecological functioning' of the urban landscapes that capture the essences of sustainable water management, micro-climate influences, facilitation of carbon sinks and use for food production. While many of these ecological functions may have little to do with the improvement of stormwater quality and its management as an important resource, the emerging importance of green infrastructure in urban design is consistent and synergistic with the philosophical basis for WSUD.

Protecting the environment from stormwater pollution is a key objective of sustainable water resource management. The transition to WSUD in stormwater management over the last 15 years has been quite remarkable, especially considering that in this short timeframe, we have seen the philosophy, technology and language of WSUD developed to industry standards and referenced in policies across all levels of government in Australia (Wong 2006*b*). Stormwater treatment technologies such as constructed wetlands and bioretention systems (commonly referred to as rain gardens) are implemented at a range of spatial scales, from building and allotment scales to regional public open space and multiple use corridors. Research studies have been able to define key design procedures that ensure these systems can generally be scalable. Through close collaboration with landscape architects and urban designers, it has been possible to incorporate many of these technologies into the urban form as illustrated in the images below. While on-going field research to study long term operational, maintenance and performance of WSUD elements remains essential, many of these elements are becoming mainstream features for stormwater quality management as an adaptive approach is adopted in our effort to build more water sensitive neighbourhoods.

An emerging issue in WSUD is that of rehabilitation of degraded urban waterways. There are many factors that influence waterway health, and these have been categorised by Breen and Lawrence (2006). Waterway health management initiatives would typically consist of a mixture of catchment-wide initiatives (based on WSUD) and on-site works (such as channel stabilisation, creation of in-stream and riparian habitats, etc). Catchment management initiatives provide the underpinning basis for protection or improving waterway health and improving water quality underpins all waterway health improvement or protection initiatives.

Cities comprising water sensitive communities

WSUD as a framework for sustainable urban water management is well-founded and ongoing research can be expected to progressively improve WSUD technologies for improving stormwater quality. However essential, technology based on physical science research alone will not deliver the desired outcome. Institutional capacity for advancing sustainable urban water management is only now being recognised as an important underpinning element of many technological solutions. Brown (2008) argues that unless new technologies are socially embedded into the local institutional context, their development in isolation is insufficient to ensure their successful implementation in practice.

Institutional reform for integrated urban water cycle management remains elusive. Like most reform agendas, this is an area that requires consideration of options that are not immediately intuitive, technically or otherwise. The socio-institutional dimension of WSUD, while instrumental to effective policy development and technology diffusion efforts, still remains a largely underdeveloped area of research. However, Brown & Clarke (2007) recently undertook a historical socio-technical transition analysis of the drivers that underpinned the development of WSUD across Melbourne. Melbourne was selected as a case study because it is often informally identified as a leading city, both nationally and internationally, in the fields of urban stormwater management and WSUD. Additionally, this work has drawn on contemporary social science thinking in relation to technology diffusion in a range of fields.

The outcomes of this research revealed that the development of WSUD across Melbourne has been the result of a complex and sophisticated interplay between key champions (or change agents) and important local context variables. In particular, the champions represent a small and informally connected group of individuals across government, academia and the development industry that have pursued change from a best practice management ideology which was consistently underpinned by local science and technology development. However, the existence of champions alone was insufficient to explain the development of WSUD as there were a number of instrumental context variables that represent a mixture of 'historical accidents' and advocacy outcomes. Over the last 20 years these included the social rise of environmentalism, strategic external funding points, establishment of a number of industry-focus cooperative research centres to bring researchers and industry practitioners together. These associations and networks led to the formalising of stormwater quality objectives, market receptivity with large developers and the development of capacity building tools.

Reference to WSUD as a framework for sustainable urban water management now features in various state and federal government policies, notable in the inter-governmental agreement on a National Water Initiative (Clause 92), the recent amendment to the Victorian Planning Provision and various other state planning blueprints. Amendments to the planning provision for residential subdivision in Victoria have result in mandatory water quality targets. In addition to this, references to potable water conservation and wastewater minimisation have been made. It should be noted that reference to stormwater quality objectives was made, but not stipulated as mandatory, since 1999 and the six years leading to this amendment may be seen as a period of industry engagement and demonstration to refine the practical implementation of such legislation in Victoria. This was facilitated by demonstration projects, capacity building of local government and the industry on WSUD, and the development of tools for demonstrating compliance to the stated water management objectives. It is envisaged that a similar process may precede the implementation of diversity of water sources and infrastructure and an overall water sensitive approach.

Community acceptance and enabling broad scale political support for the water sensitive city is fundamental for enhanced implementation rates and improving industry's technical capacity and ingenuity in complex urban environments. There has been a significant increase in the focus on the role of communities in both defining the urban water 'problem' and participating in developing water sensitive strategies. For example, public art can highlight communities' relationship with water and the general 'intrinsic values of water' and help bring community awareness and participation in decision making on urban water management. Further, recent projects in developing city-wide WSUD strategies have focused on profiling community attitudes and receptivity to water reuse and pollution prevention activities to inform local WSUD policy development. Other such projects have focused on implementing community participatory action models, including scenario workshops for jointly envisaging sustainable water futures, and different types of community-based deliberative forums designed to deliver jointly developed strategies and local WSUD plans.

Water sensitive developments in Australia and Singapore

Water sensitive initiatives are progressing rapidly throughout Australia and Singapore, which can be illustrative for other places as both of these countries experience urban water issues that are relatively representative of major urban water issues faced by other regions in the world. For example, Australian cities are confronted with increasing urban populations and single occupancy households (Birrell *et al.* 2005), aging and degraded water infrastructure (Engineers Australia 2005), climate change implications (Howe *et al.* 2005), and ongoing waterway degradation. These issues are in addition to the current vulnerabilities of Australian cities and Singapore requiring reliable water supply sources, given the ongoing water scarcity conditions in Australia, and the need for Singapore to secure a higher degree of self-reliance in water supplies.

There are many applications of WSUD in Australian developments. One example of an integrated urban water management strategy for building a diversity of water sources is that developed by Gold Coast Water (Queensland) for the 7,000 ha Pimpama-Coomera greenfield development, planned and progressively being built for 130,000 inhabitants. The strategy involves the integration of three sources of water supplies to attain a diversity of water sources in accordance to the first of the three pillars of practice. Treated wastewater is reticulated to households for non-potable use, supplemented by harvested roofwater for use in bathrooms, laundry and hot water system. The estimated reduction in mains (potable) water consumption is in excess of 80%. The strategy also included the incorporation of swales, bioretention systems and constructed wetlands for the treatment of stormwater prior to their discharge to the receiving waters, addressing the second of the three pillars of practice outlined earlier for a water sensitive city. Gold Coast Water was awarded the 2006 International Water Association Global Grand Prize for Planning.

Internationally, the city of Singapore is building its diversity of water sources through their NEWater recycled wastewater scheme, a desalination plant, the transfer of water from neighbouring Malaysia and the harvesting of urban stormwater in a substantial manner. The closure of the Marina Barrage in 2008 commences the conversion of Marina Bay from an estuarine environment, created through land reclamation, into a freshwater reservoir that is supplied by a fully urbanised catchment, equating to almost half of the metropolitan Singapore catchment. The community in Singapore is already a sophisticated community keenly aware of the scarcity of water and the significance of building resilience through diversity of water sources. A rapid roll out of WSUD initiatives in the urban catchment is now planned, in conjunction with a strong community engagement programme to promote active participation in the use and management of Singapore waterways. Professional capacity building for WSUD is underway together with implementation of stormwater treatment technologies at a range of local, precinct and regional scales throughout the metropolitan area of Singapore to protect the water quality of the future Marina Bay reservoir. The Public Utilities Board of Singapore was recognised for its initiatives in securing a diversity of water sources by the award of the 2007 Stockholm Industry Water Award.

CONCLUDING REMARKS

As we begin to realise the significance of global warming and climate change, new urban communities will need to strive for carbon neutrality and also have in-built resilience to face future uncertainties and challenges. They require a significant paradigm shift in urban design.

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. A trans-disciplinary approach to design with active community engagement and participation is an essential process in contextualising global principles of sustainability in urban design to accommodate local opportunities and constraints from both a physical and socio-economic perspectives. A water sensitive city is a fundamental building block towards a sustainable city.

Key principles underpinning the design of a water sensitive city is based on considerations of minimizing the import of potable water, and the export of wastewater, from and to areas outside of the boundaries of the city, and optimizing the use of water resources within a city. Buffering the impacts of climate change on natural aquatic environments and preserving, and/or re-establishing, ecosystem services are also espoused as essential elements in building ecological landscapes in urban communities.

A water sensitive city may be characterised by three key attributes (i) access to a diversity of water sources underpinned by a diversity of centralised and decentralised infrastructure; (ii) provision of ecosystem services for the built and natural environment; and (iii) socio-political capital for sustainability and water sensitive behaviours.

Cities can have access to a diverse range of water sources, many of which are available within city (metropolitan) boundaries. These include groundwater, urban stormwater, rainwater (roof runoff), recycled wastewater and desalinated water. A strategy built around a diversity of water sources and a diversity of water infrastructure will allow cities the flexibility to access a 'portfolio' of water sources at least cost and with least impact on rural and environmental water needs.

Ecological landscapes in urban communities is essential to buffer the impact of climate change on natural aquatic environments and preserve, and/or re-establish, ecosystem services that reverses the conventional philosophical approach of urban communities drawing on ecosystem services of neighbouring upstream and downstream natural environments. New cities will contain landscapes that will have intrinsic ecological functions related to the community and the environment.

Institutional capacity for advancing sustainable urban water management is only now being recognised as an important underpinning element of many technological solutions. It is argued that unless new technologies are socially embedded into the local institutional context, their development in isolation is insufficient to ensure their successful implementation in practice. Future communities will be receptive to an ecological sustainable lifestyle, with an industry skilled at sustainable urban water management and government policies that underpins inter-agency collaboration, public/private engagement and innovation.

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