CHAPTER 3
Sustainable urban stormwater management: water sensitive urban design perceptions, drivers and barriers

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Abstract: *Stormwater has been recognised as one of the main culprits of aquatic ecosystem pollution and as a significant threat to the goal of ecological sustainable development. Water sensitive urban design is one of the key responses to the need to better manage urban stormwater runoff, the objectives of which go beyond rapid and efficient conveyance. Underpinned by the concepts of sustainable urban development, water sensitive urban design has proven to be an efficient and environmentally-friendly approach to urban stormwater management, with the necessary technical know-how and skills already available. However, large-scale implementation of water sensitive urban design is still lacking in Australia due to significant impediments and negative perceptions. Identification of the issues, barriers and drivers that affect sustainability outcomes of urban stormwater management is one of the first steps towards encouraging the wide-scale uptake of water sensitive urban design features which integrate sustainable urban stormwater management. This chapter investigates key water sensitive urban design perceptions, drivers and barriers in order to improve sustainable urban stormwater management efforts.*

Keywords: Sustainable urban development, sustainable urban water management, urban stormwater quality, water sensitive development, water sensitive urban design, low impact urban design, sustainable urban drainage systems.

Introduction

Due to increasing environmental and social pressures stemming from the adverse impacts of urbanisation and other anthropogenic activities, it is now widely accepted that a new paradigm in urban water management must be found in order to transition to the more sustainable use and management of urban water (Brown, 2005). Sustainable development demands that water resources are preserved and protected from urban development (Carmon, 1997). Stormwater, in particular, has been recognised as one of the main culprits of aquatic ecosystem pollution in Australia (Roy et al., 2008), and is a significant threat to achieving the goal of ecological sustainable development. Increasing urbanisation, population growth, aging infrastructure, and extreme weather events such as droughts and bushfires have pushed urban water managers into exploring more innovative ways to tackle increasingly complex traditional problems. Water sensitive urban design (WSUD) is one of the more popular ways in which urban stormwater is now managed.

The WSUD model was initially promoted in the last decade due to a focus on merging land use planning with water management (Gardiner & Hardy, 2005); today, it has grown to incorporate the promotion of sustainable urban development. It does this by featuring opportunities to enhance urban design, while at the same time playing important roles in stormwater drainage and water quality improvements, as well as enabling stormwater harvesting to augment existing supplies–- an important feature in a world with an unstable climate (Victorian Stormwater Committee, 1999; Lloyd et al., 2002, Rahman & Webber, 2003). Furthermore, WSUD is a response to traditional stormwater management goals that do not go beyond flood prevention and rapid conveyance of runoff in order to pursue more inclusive objectives such as preservation of environmental integrity and the recognition of stormwater as a resource rather than

a nuisance (Wong, 2001). In other words, WSUD is deemed 'holistic' because it is concerned with both quantitative and qualitative issues of urban stormwater. Features of WSUD includes the use of natural channel designs, porous pavements, grassed swales and rainwater tanks to reach the target of implementing a total urban water cycle (Rahman & Webber, 2003). The protection of the receiving water bodies will ensure that freshwater sources stay as unpolluted as possible, so as to be fit for both ecological use and human consumption. Reduction of runoff also has the additional benefit of reducing the size and costs of stormwater systems (Carmon et al., 1997).

Implementing WSUD strategies consists of integrating best planning practices (BPP) – concerned with site assessment, planning and design–with the elements of best management practices (BPM): the structural and non-structural elements that perform its prevention, collection, treatment, conveyance, storage and reuse functions (Lloyd, 2001). These best planning and management approaches attempt to achieve objectives of sustainable urban water management and include the assessment of the best physical and natural attributes of the sites, such as climate, geology, vegetation and drainage patterns (Lloyd, 2001).

On the surface, holistic management of urban stormwater in Australia appears to have 'evolved beyond conceptual, investigational and demonstrational stages linked with government and academic partners' (Gardiner & Hardy, 2005). In reality, however, uptake has been slow and sporadic at best, as urban water agencies, policymakers and developers are still reluctant to take the risk of attempting a different and innovative approach (See Wong, 2001; Brown, 2005). Traditional water management strategies still dominate the majority of water institutions and agencies (Brown, 2007). Most of these are frequently fragmented, with operations that do not take into account the multi-dimensional aspects of urban water management, focusing instead on the technological aspects (Farrelly et al., 2007). For policies and practices to be efficient and specific to local scenarios, current settings need to be evaluated in order to specifically identify the problems and issues involved. The first step towards this would be identifying the WSUD perceptions of key stakeholders, and what they deem to be the drivers and barriers to its widespread uptake.

Water sensitive urban design issues, drivers and barriers

Fowler (1999, cited in Arisz & Burrell, 2006) identifies four steps that need to be undertaken in order to evaluate climate change impacts: the projection of the future climate, the transformation of climate change effects into environmental impacts, the transformation of environmental impacts into community impacts, and the response of the community towards these impacts. WSUD falls into the last step: the response of decision makers and planners to the challenge of climate change impacts upon urban stormwater management and infrastructure. However, the uptake of WSUD features in the quest to achieving sustainable urban water management (SUWM) has only occurred in drips and drabs, as mentioned above. Figure 1 details the relationship between the drivers, barriers and perceptions of WSUD.

Figure 1: Relationship between the perceptions, drivers and barriers of WSUD

Drivers and barriers affect the implementation of WSUD, whist simultaneously feeding the perceptions of all stakeholders, including policymakers, decision makers, planners, developers, engineers and the community. Drivers are often external, such as environmental factors and community pressure for decision makers to respond to external events, or encouragement from influential change agents ('champions') who push for more innovative responses to increasingly complicated problems (see Taylor, 2008). WSUD features such as rainwater tanks, stormwater treatment trains and other stormwater quality treatment technologies are seen by internal stakeholders to have the benefits of positive community receptivity as well as good environmental and public health outcomes. However, there are doubts about the ability and technical skills of stakeholders to implement and maintain these features (Brown et al., 2007).

Drivers of water sensitive urban design

Urban growth and consolidation have placed increasing pressure on existing infrastructure and its receiving waters (SOE 2001). Aging infrastructure that needs upgrading or replacement and a high proportion of impervious surfaces in urban areas also cause runoffs and discharges that are known to contain vast amounts of pollutants, including heavy metals, hydrocarbons and microbiological organisms that affect the quality of receiving aquatic environments, sometimes permanently (Goonetilleke et al., 2005; Burian, 2006). Increasing climate change impacts are also expected to stress the system further by bringing significant challenges for urban stormwater management through increase in extreme events such as heavier rainfall periods and drought; for example, the water shortage experienced by the east coast of Australia in the past decade has done much to raise public awareness of sustainable water supply issues (Roach & Sargent, 2007). These external pressures have lead decision makers to explore innovative solutions to traditional problems, and WSUD is touted as a new approach to sustainable urban development practices that aims to integrate urban stormwater management with the natural hydrological cycles.

A study conducted by Brown & Farrelly (2007) found that most urban water managers are highly concerned about maintaining the integrity of aquatic environments into which stormwater discharges. Respondents considered this concern, as well as community perceptions, social amenity and public health outcomes as the main drivers of WSUD implementation (Brown & Farrelly, 2007). Successful examples of WSUD are often also good examples of multi-disciplinary collaboration. This is because efficient stormwater management practices require appropriate amalgamation of elements from the fields of infrastructure planning, urban hydrology, landscape architecture and asset life-cycle economics to determine the appropriate positioning of WSUD strategies (Wong, 2001). The commitment and cooperation of all key stakeholders through a multi-disciplinary approach is essential to ensure that decisions for stormwater management are made with complete comprehension of environmental, social and economic dimensions (Wong, 2001).

Technical expertise and knowledge in WSUD is not lacking or new; in fact, WSUD has been implemented in many locations around the world and is known by other monikers such as Low Impact Urban Design and Development (LIUDD) in New Zealand (e.g. van Roon et al., 2006), Low Impact Development (LID) in the United States (e.g. Roy et al., 2008) or as Sustainable Urban Drainage Systems (SUDS) in the United Kingdom (e.g. Roach & Sargent, 2007). Increased awareness of WSUD benefits has prompted local

governments to revamp their urban stormwater management practices to include WSUD in their policies, or as a requirement for development approval. Examples include the Brisbane City Council rewriting its planning policy to specify WSUD as its preferred option in land development, while the Gold Coast City Council (GCCC) not only released its WSUD guidelines this year, but has also specified that WSUD is a legally required component under its planning scheme (GCCC, 2007). Wong (2001) stresses that this change in government policy is important in the creation of fertile environments that will lead to new and innovative urban stormwater management strategies. Absorbing WSUD into planning documents and setting standards and guidelines will encourage its wide-spread uptake; however, it is not enough. A key issue of concern amongst stakeholders is that the skills and technical knowledge of planners, engineers and policymakers need to be adequate in order for the features to function properly and efficiently (e.g. Lloyd et al., 2001; Brown, 2005; Wong, 2006).

White (2007) and Taylor (2008) both identify change agents, or 'champions', as one of the key drivers in achieving sustainable urban stormwater management. They state that the attainment of sustainable urban stormwater outcomes depends not only on technical knowledge but also on the development of individuals (White 2007; Taylor, 2008). These champions have the ability to influence how principles found in policy and guidelines ('concepts') are translated into concrete examples on the ground ('implementation') (White, 2007). Although these policies and guidelines already exist, the translation of these intangible elements into real practices hinges upon agents who understand the interpersonal and organisation perspectives needed (Cullen, 2007). Cullen (2007) states that these agents are particularly important in local governments as they act as 'brokers' of new scientific knowledge, and are able to present this knowledge in the context of urban stormwater management in a manner that is easily understood and absorbed. Champions can not only push through innovations, they can also foster a culture of employing ground-breaking solutions when feasible, and are able to create momentum to establish widespread organisational commitment to sustainable solutions (Brown, 2005, in White, 2007). The agency is then more likely to try new approaches, while at the same time encouraging innovation and experimentation to build knowledge, which are traits which are uncommon, according to Cullen (2007),

General consensus of practitioners is that users in WSUD developments influence community support (Lloyd et al., 2001). Support and heightened awareness of WSUD in the general community is, of course, important before implementation of any WSUD features. These can be marketed as 'soft' urban design features that retain natural vegetation, and are able to increase community marketing acceptance. Developers were also appreciative of this, stating that clients usually understood the costs involved but also realised that they had the potential to raise the sale prices of the properties in the future (Gardiner & Hardy, 2005). With the increasing environmental awareness amongst the community, developments with WSUD features are being marketed as 'more environmentally' friendly homes and properties, and are potentially able to command a premium price (Gardiner & Hardy, 2005).

Barriers to water sensitive urban design

Barriers to a wider acceptance of WSUD features as a solution are now not merely technical, but also social and institutional. One of the main barriers is that WSUD is because of the lack of understanding of WSUD features and their potential benefits.

Another is the confusion about the meaning of WSUD. Stakeholders have no shared vision or definition: to some, it is confined to stormwater management; to others, it is a fully integrated urban water management system (Gardiner & Hardy, 2005; Cullen, 2007). Understanding these perceptions of, the drivers for, and the barriers to WSUD will therefore help promote a more integrated form of thinking in order to form a consistent and coherent framework of more cohesive strategies (Brown, 2005).

A study of perceptions of WSUD conducted in 2007 (Brown et al.) discovered that industry insiders rated their institutional arrangements for WSUD as 'poor' or 'neutral', while commitment to the implementation of WSUD was also perceived as 'low' in both Perth and Melbourne. Table 1 summarises the opportunities for, and constraints affecting, wide-scale WSUD implementation discussed.

Table 1: Constraints, but opportunities in WSUD implementation

CONSTRAINTS	OPPORTUNITIES
Lack of understanding amongst stakeholders	• Increase awareness programs • Increase circulation of research & information amongst stakeholders
Lack of common standards, guidelines & technical skill-sets	• Agencies to provide & set standards • Workshops & seminars to increase skill levels • Formation of diverse, multi-disciplinary teams
Limited research & knowledge	• Industry partnerships with research facilities • Formation of diverse, multi-disciplinary teams • Design, assessment & maintenance of features based upon specific considerations
Fragmented stormwater management agencies	• Formation of effective regulatory framework linking local & regional levels • Efficient communication amongst different agencies
Lack of institutional provision	• Agencies to confront issues of traditional urban stormwater management • Absorption of WSUD into planning documents • Making WSUD a mandatory feature for new developments
Economic cost	• Increasing awareness that long term benefits outweigh short term costs • Locality-specific modelling • Integration of all aspects of urban water management

Current urban stormwater management frameworks are more geared towards the status quo, and are mainly confined to engineering solutions that have been in place for a lengthy period of time (Wong, 2001). Because these methods are tried and true, most governmental institutions are reluctant to take the risks involved in adopting alternative approaches that they feel they lack expertise in (Lloyd et al., 2001). The uncertainty as to who bears these risks as well as the responsibility for the maintenance of features is also a matter of concern (Cullen, 2007).

Also, some stakeholders are yet to be convinced of the extent of effectiveness of WSUD methods in practice. Ponds and wetlands have been incorporated into development for the better part of the last decade, and efforts such as stormwater trains have proven to be highly effective in the preservation of the quality of receiving waters as well as the alleviation of flooding (Wong, 2001). However, inappropriate implementation such as

not properly linking them to stormwater management considerations has lead to instances whereby they have been inefficient or even harmful to the local community, thus defeating the purpose of the strategy (Lloyd et al., 2001; Wong, 2001). Wong (2001) also points out that inadequate levels of technical skills and knowledge within the industry to design, assess and maintain water sensitive development schemes has created uncertainty about their merits in the minds of stakeholders.

While the GCCC has adopted WSUD practices as their standard policy, they have admitted that its strong technical capacity is marred by asset owner concern about long term maintenance (Alam et al., 2008). One way of combating this is to hold regular stakeholder awareness programs, as carried out by the GCCC and by the Municipal Association of Victoria in collaboration with the Stormwater Industry Association of Victoria (See White & Lloyd, 2005; Alam, 2008). By conducting workshops and organising fieldtrips to showcase successful implementation examples, GCCC has successfully generated awareness and increased technical abilities, as well as allowed stakeholders to associate on-site inefficiencies with design deficiencies (Alam, 2008). The Victorian awareness program has also pointed out that, in addition to raising awareness, it has also managed to emphasise the importance of collaborative management in the implementation of WSUD, a point that was previously overlooked by many stakeholders (White & Lloyd, 2005).

Technical principles and skills are available; however, more often than not, these information and skill-sets are only available to a certain department or are scattered amongst different professions that are involved in urban water management, but do not necessarily work together (Lloyd et al., 2001). Also, information may not be freely available to stakeholders of different disciplines; for example, GCCC (Alam, 2008) states that WSUD design drawings and management plans are available mainly to the engineering department but not readily accessible to staff of other departments, such as to staff in charge of maintenance. It is up to the local governments to provide a decision making guide for best planning practices associated with urban development such as site feasibility, council requirements for site-based stormwater management plans, recommended processes for undertaking a WSUD plan, detailed design process for common WSUD features and so on. A Brisbane City Council (BCC) audit of Water Sensitive Road Design in 2005 noted that recurring deficiencies in swales occurred at all stages of development, and suggested that the release of universal guidelines and education programs would be useful in minimising inadequacies and inefficiencies as well as in informing developers and other stakeholders of the importance of both design and maintenance.

Lack of standardised best practice and differing requirements can cause confusion amongst local authorities and developers (Cullen, 2007). Kay et al. (2004), Gardiner & Hardy (2005), Roy et al. (2008) are some of the researchers who state that lack of consistent standards and knowledge amongst stakeholders are the biggest impediments to implementing WSUD strategies. The ability of staff, especially those who were working in Development Assessment, to evaluate the efficacy of these strategies was suspect in some cases (Gardiner & Hardy, 2005). Standardised guidelines are important to ensure that common standards are maintained in management plans and implementation. These can also have the additional benefits of cost cutting and ease of inspection, and can enable the harvesting and documentation of emerging knowledge

and best practice–an important factor in capacity building in WSUD, and when dealing with high turn-over in staff (Cullen, 2007).

The linkage between concept and construction is also often not well established, and results in poorly translated works on the ground, therefore affecting their efficacy (Wong, 2001). One of the solutions to this could be the formation of more diverse, multi-disciplinary teams to design, assess and maintain WSUD features based upon the specific considerations of local sites. However, integration is made more difficult by the fact that urban water management in most states in Australia is fragmented, and conducted by different institutions (Lloyd et al., 2001; Brown 2005; Wong, 2006; Cullen, 2007). Lloyd et al. (2001) point out that an effective regulatory framework that links local, precinct and regional levels and enables integration of urban stormwater management is important in order for the different agencies to communicate efficiently and to have common goals and understandings. A highly fragmented arrangement only adds to the confusion of both agencies and developers (Cullen, 2007); local councils and management agencies need to work together in order to develop plans that help build linkages between strategic directions of regional water managers and local WSUD initiatives.

A major concern of WSUD is the perception of high initial economic costs, or an inadequate economic assessment of particular elements. In actuality, WSUD features are not substantially different from conventional 'end of pipe' treatment systems; however, due to the effort needed in its design and approval, WSUD is often perceived as being more expensive (Gardiner & Hardy, 2005). While costs may be higher in the short term, potential benefits of the features, such as better environmental outcomes and preservation of quality of life for urban communities are often the benefits in the longer term. WSUD potentially provides a higher level of environmental and community protection compared to traditional urban stormwater features, especially the ability to weather the uncertain impacts of climate change. Proper research and site-specific considerations of WSUD features, alongside scenario modelling and integration of all aspects of urban water management (that is, water supply, waste and stormwater management), have the potential to significantly reduce costs and provide more specific and accurate cost assessment (Lloyd et al., 2001).

Future research directions

Further research on receptivity needs to be conducted in order to aid the success of wide-scale WSUD implementation. Despite heightened awareness of the need to implement WSUD as a part of SUWM for a plethora of reasons, the number of significant barriers outweighs the drivers for its wide-scale implementation. Recent research has identified major barriers as institutionally systemic and social rather than technical (Farrelly & Brown, 2008). There is hope, however. In the past 15 years significant reform of urban water management has occurred in Australia, most recently with the launch of the National Water Initiative (NWI), implying that Australian cities are moving in the right direction in order to achieve water sensitive cities. NWI stresses the importance of efficient water use, of understanding the sustainability of the water resource and of identifying future demands in order to meet the current and future water needs of communities (Cullen, 2007). To achieve these objectives, NWI has committed governments to specific actions in urban water management, one of which is the evaluation of existing WSUDs by fostering 'innovation and capacity building to

create water sensitive cities' (COAG, 2004, in Farrelly et al., 2007). The journey towards these 'water sensitive cities', however, is still a matter of ongoing research; for example, there is no actual definition of what a 'water sensitive city' is, and much study still needs to be done in order to establish and support learning mechanisms that promote policy and the management changes associated with them (Farrelly et al., 2007).

The level of support for, and association with, the benefits of WSUD is also strong amongst industry, management agencies and the community in general (Brown et al., 2007). Stormwater management agencies need to build on this momentum and make firm commitments to take WSUD beyond the 'concept' stage and translate it into implementation by making it a condition of development, and providing them with legislative powers (Lloyd et al., 2001). This is a move which several local councils have already undertaken. While institutional and social elements are recognised as barriers, there are few empirical studies that have been conducted on these significant impediments. Future research therefore needs to be conducted to not only identify these barriers, but also to advance the knowledge of all stakeholders involved in urban stormwater management.

One of the more under-studied factors in sustainable urban stormwater management is the role and capacity of change agents and how to develop them. Whilst their attributes and achievements, especially in local governments, are increasingly recognised and valued, the way in which these agencies can facilitate their development is still vague. It is assumed that these change agents can be created by providing required skills, training and exposure to situations that develop leadership capabilities; however, exactly what skills, training and exposure is needed is still unclear. Taylor (2008) has written extensively on this, and more needs to be done to build on his work to understand and encourage this phenomenon.

Wong (2001) also suggests that the current methods of knowledge transfer such as publication and conference discussion need to be augmented by comprehensive community engagement. Technical guidelines based on best available practice also need to be developed, with collaboration between industry and researchers (Wong, 2001). Dialogue between these two parties will not only help identify gaps in knowledge and determine subsequent research and policy direction, it will also uncover and exchange the knowledge and technical expertise which is available in both spheres (Wong, 2001). However, WSUD strategies are highly site-specific; this means that generic guidelines will only offer a certain amount of guidance (Gardiner & Hardy, 2005). While there is clearly a need for more specific guidance, Gardiner & Hardy (2005) lament the fact that few developers are willing to share experiences with agencies or academics due to commercial responsibility, and that knowledge transfer via publication is not an important factor in their line of work. Having said that, it is encouraging that local councils (for example, the Municipal Association of Victoria and GCCC) are willing to hold workshops, and run programs and field trips to impart knowledge and experience. These also have the valuable role of developing skill levels and fostering dialogue not only between industry and researchers, but also amongst disciplines that may have never worked closely before. Feedback from participants has been overwhelmingly positive, showing that these initiatives are badly needed in the industry.

Conclusion

It is only in the past decade that significant change in urban water management in Australia has occurred. One of the responses to the increasing degradation of the aquatic environment has been WSUD, which challenges the traditional manner of managing urban stormwater. Instead of an 'out of sight, out of mind' approach, WSUD represents a changing paradigm in urban stormwater management in Australia, where objectives go beyond rapid conveyance of runoff and include the protection of environmental quality, the promotion of stormwater as a resource, and the integration of stormwater facilities into the natural hydrological cycle. While its implementation in Australia has been rather slow and sporadic, rising awareness of impacts of urbanisation and other anthropogenic activities, impacts of climate change and increasing engagement between researchers and industry have prompted local authorities and land developers to adopt the WSUD philosophy, and to confront traditional issues regarding urban stormwater management (White & Lloyd, 2005). Funding and interest from government agencies which result in introduction of WSUD in planning schemes and the emergence of demonstration sites and other large-scale showcase projects also reflect this rapidly changing model from traditional to more holistic stormwater management. However, there is still a need for significant research to recognising core barriers and drivers in this area, such as considerable institutional fragmentation as well as gaps in knowledge and awareness; these need to be identified and overcome. For the widespread uptake of WSUD strategies, all stakeholders–from stormwater management agencies to developers and the community–need the benefits of additional planning, clearer legislation and deeper knowledge.

Improving stormwater quality not only benefits the water bodies it discharges to, but also creates an opportunity whereby stormwater can be used to augment potable water supplies. There are already significant drivers in replacing traditional stormwater management with innovative, sustainable measures such as WSUD, and the current situation is ripe for change agents to conduct further research in the area, to revolutionise traditional methods, and to build a new paradigm in urban stormwater management.

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