Literature review summary
Sustainable Drainage Systems (SDS)

Background

'Sustainable Drainage Systems' (SDS) refer to integrated systems for managing throughputs of water through an urban system (e.g. through swales and retention ponds). SDS are referred to variously in different contexts, for instance: as SUDS (Sustainable Urban Drainage Systems[1]) in the UK; as 'Water-Sensitive Urban Design[2]' in Australia; as 'Low Impact Development[3]' in North America; in, Brazil[4], 'urban drainage', 'sanitation' and other aspects of water management may be dealt with separately.

Literature review

Academic research on SDS remains relatively small in terms of the number of studies. The following summary is based upon a review of new, peer-reviewed, research-based, English- and Portuguese-language research papers which contain the above and related terms in title/abstract, published between 2000-15. 220 research papers met these criteria. Those studies were narrowed down through analysis of citations and an emphasis on review-style papers.

Key findings

Although diverse in terms of methodology, discipline, location and focus, the papers under review tend to: (i) explore environmental management and the design/optimization of SDS systems (the largest area of research); (ii) evaluate society-environment interactions within SDS; or (iii) analyse the role of communities and education in ensuring the successful operation of SDS. Key, recurring findings are as follows.

i. Environmental management and SDS design

- Many scholars agree that SDS offer a key tool for addressing the effects of climate change[5]. The largest mitigation benefits come from attenuating extreme run-off and peak flow[6]. Generally, there is agreement that SDS should operate at the scale of large watersheds rather than at the level of neighbourhoods or urban districts[7].
- Despite global advances in SDS research/technologies, there remain many obstacles to their implementation. Notable challenges include: the reliability of modelling systems for predicting the real-world effectiveness of SDS at a given site[8]; lack of understanding around the interaction between SDS and other water bodies/courses; tensions between increasing urban populations and costs of SDS[9]; lack of funding and legislative mechanisms to realise SDS at large scales[10].

- Despite the increase in use of SDS, there is little evidence on the role of such systems in attenuating baseflow. Recent research has sought to address this, analysing physiographic and anthropogenic effects of baseflow and calling for source-control technologies that could mitigate the effects of urbanisation on baseflow.[11]

- There is considerable debate about appropriate methods for modelling and evaluating SDS effectiveness. Most authors agree that extant modelling methods are not sophisticated enough to understand the complexities of large-scale watersheds, especially when societal factors are incorporated (see below)[12].

ii. Society-environment interactions within SDS systems

- Conceptual work has been devoted to examining how SDS-related research can *both* operate at larger scales *and* account for the complexities of dynamic social-ecological systems. Much of this work has centered on the idea of 'adaptive management', positing that much of what we know about such systems is currently 'wrong' because it is based on research at smaller scales[13].

- Several recent studies have sought to extend a discussion of adaptation towards notions of 'resilience' – how systems may recover from disturbance and may be 'safe to fail' rather than 'failsafe'[14] – thereby questioning the 'over-engineering' of SDS in some contexts.

- Some studies advocate the use of modelling *with* community groups – for instance, comparing the relative effectiveness of Global Positioning Systems (GPS) devices and Smartphones for community mapping of urban stormwater management. Both technologies have been shown to be effective given their accessibility and low cost[15].

- Some studies offer critical policy analyses of SDS. For instance, a recent UK-based study[16] used SDS as an example of how governments have sought to masterplan as many elements of life-itself in new sustainable developments as possible – from the micro-scale properties of porous surfaces to the design of 'amenity spaces' through swales and ponds.

- Most reviews conclude that single-discipline studies are not sufficient; indeed, they call for research combining the human and physical sciences, especially in efforts to model and evaluate the effectiveness of SDS in large-scale, complex urban watersheds[17].

iii. The role of communities and education in SDS success

- The role of governance in respect of (local) urban communities is contentious. The logic (globally) has been a shift from top-down to bottom-up governance, involving both communities and local policy-makers[18]. Therefore, several scholars argue that *local/municipal* governments have a key role to play in initiating and managing SDS[19].

- Social acceptance for SDS is key. A number of important factors have been identified, including: ensuring that the visible components of SDS are aesthetically pleasing; acknowledging that positive community

dispositions to SDS do not lead to take-up (e.g. where residents must make changes to their properties); mitigating the transfer of increased financial costs (e.g. for water/sewerage supply) to consumers[20].

- Several scholars advocate participatory modes of dialogue and planning to ensure that diverse community groups are included in SDS planning. However, some authors caution against seeing participation as a panacea, because of the complexity of urban water management issues and the pressure this can put on communities[21].

- In order to engage urban communities, work must be done to (radically) re-frame the terms of the debate. For instance, urban storm water could be seen a public good provision issue (i.e. as a positive resource that could be harvested and distributed) – rather than seeing it as a waste product to be disposed of through a system[22].

Recommendations for future research and practice

- A starting point for future research should be discussion and resolution of key definitions (e.g. variability of SDS/WSUD/LID globally). Researchers should grapple with a growing recognition that previous knowledge about urban water is potentially inaccurate, leading to a re-framing of some 'problems' – like storm water – as 'resources'.

- Discussions of temporal and spatial scale are paramount. There is a tension in the literature between acknowledging complexity and scaling-up (e.g. to entire cities/watershed systems), and emphasising the local, especially in terms of governance and participation. Researchers could focus on these tensions in future work.

- In terms of methods (in both research and practice), more participatory, and novel (e.g. GPS/app-based) methods might be introduced to better engage urban communities. However, these methods are not a panacea. Moreover, given the dominance of the physical sciences in SDS research, there is a need for much greater interdisciplinary working to assess the complexities and dynamism of urban watersheds.

- The UK, Australia and the USA dominate studies and practical attempts to introduce SDS; the lack of work in the Majority Global South should be addressed. Important work in countries like Brazil has called for specialised Federal Funds for managing urban water systems[23].

- Cross-party, cross-government and cross-sector agreement and leadership is important in countries with strong regional governmental legislative systems (like Australia and Brazil).

- Climate models tend only to assess anthropogenic impacts on climate (and hence water systems), not natural changes. Thus, future SDS will likely require high and low tech solutions that balance investment cost and performance against the limitations of any human intervention into

complex and dynamic watershed systems.

The Sharing Futures partnership

Sharing Futures is a major ESRC-funded collaboration between engineering scientists in Brazil and social scientists in the UK. The partnership addresses key challenges in planning for sustainable urban environments, with a particular focus upon water and energy resources. For further information and resources, including a range of summary literature reviews, please visit the partnership website: http://www.sharing-futures.com/

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