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Research article

From conventional drainage to sustainable stormwater management: Beyond the technical challenges

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ABSTRACT

Countries and cities are increasingly recognizing the value of adopting Sustainable Stormwater Management (SSWM) goals and measures. SSWM serves multiple hydrological, ecological, social and economic goals and can replace substantial parts of conventional drainage infrastructure. Following international experience in the socio-technical nature of transitions in stormwater management, this research investigates how socio-institutional factors enable the transition from conventional to sustainable stormwater management over time. The research is based on analysing available relevant documents, semi-structured interviews and focus groups, all in a single country case study (Israel). We found significant changes in professional awareness and discourse, some advances in professional standards of work and changes to the regulative system, supporting infiltration practices in particular. We concluded that the three-pillared socio-institutional framework, composed of cultural-cognitive, normative and regulative changes, was insightful for mapping factors supporting transition from conventional drainage to SSWM. Elements within the three pillars can work simultaneously and synergistically to achieve widespread change. At the same time, while SSWM always strives to achieve multiple goals, the order of priority of the various goals may differ from place to place and may change over time. Thus the transition process across the socio-institutional pillars should be renewed if and when the priority of goals changes. The urban and regional planning system can play a crucial role in enhancing the transition process from conventional to sustainable stormwater management. These conclusions may be relevant to other localities and countries that are struggling with such transitions to sustainability.

1. Introduction

In the past few decades there has been growing awareness of the value of stormwater as a resource to be factored into urban development. This has been driven by various trends including rising populations and increased water demand, increased environmental awareness, risk of storm damage exacerbated by climate change, and growth in urban areas and related impervious surfaces. There has been a parallel emergence in many countries of more sustainable paradigms for urban stormwater management including Water-Sensitive Urban Design (WSUD) in Australia, Sustainable Urban Drainage Systems (SUDS) in Britain, and Low-Impact Development (LID) in North America (Fletcher et al., 2015). As opposed to conventional drainage approaches, which treat stormwater as a nuisance to be removed from the urban area as quickly as possible, the sustainable management of stormwater sees it as a multifunctional resource (Mitchell, 2006) with many potential benefits for society and the environment if managed wisely (Barbosa et al., 2012; Fletcher et al., 2015; Hering and Ingold, 2012; Makropoulos et al., 2008; Mitchell, 2006; Roy et al., 2008).

The implementation of Sustainable Stormwater Management involves measures at different scales, from urban and regional planning, where siting of different land uses can be determined according to topographical and hydrological conditions, down to construction of individual installations or best management practices (BMPs) (Carmon and Shamir, 2010). The latter are designed to retain, detain, convey and preserve stormwater flow, to encourage groundwater recharge, provide water for irrigation, reduce topsoil loss, and filter unwanted pollutants and sediments (Barbosa et al., 2012; Roy et al., 2008). Rainwater harvesting can also directly supplement domestic water supply for reuse and provide other

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benefits such as reducing pressure on downstream drainage and sewer systems and reducing the need to transport water (Han and Mun, 2011; Nguyen and Han, 2017).

Sustainable Stormwater Management is closely related to urban planning and landscape design. As Karvonen (2011) notes, "Where conventional stormwater management focuses on the symptoms of large stormwater volumes, source control goes to the root of the problem to address development patterns and impervious cover that create these large volumes of polluted water in the first place" (p.18). Connecting between integrated urban water management and spatial planning has been described as a means of providing a statutory basis for spatial water management, overcoming fragmented water governance (Mitchell, 2005) and shifting the field of water management from a largely technical domain to an issue with broader professional and social considerations (Wiering and Immink, 2006).

In this paper we use the term Sustainable Stormwater Management (hereafter SSWM) to denote an approach that incorporates these changes and departs from reliance on conventional urban drainage. The main elements of these different approaches are summarized in Table 1.

In many parts of the world there is evidence of a gradual transition from conventional to SSWM practice (Chouli et al., 2007; Dhakal and Chevalier, 2016; Ellis and Lundy, 2016; Ferguson et al., 2013; Han and Mun, 2011; Nguyen and Han, 2017) and reasons to increase and accelerate this shift. Yet, existing research has acknowledged that in addition to technical knowhow, widespread change towards SSWM requires social shifts in awareness, professional norms, and forms of governance (Bos and Brown, 2013; Brown and Farrelly, 2009; Carmon and Shamir, 2010; Dhakal and Chevalier, 2016; Sharma et al., 2016; Taylor and Fletcher, 2007; van de Meene et al., 2011). Examples of social changes contributing to SSWM have included the creation of new professional communities (Ferguson et al., 2013), inclusion of more actors and approaches in governance (van de Meene et al., 2011) and new public discourse and terminologies (Morison and Brown, 2011). The changes required for implementing SSWM have therefore been framed as socio-technical (Bos and Brown, 2013; Rogers et al., 2015), in line with approaches described within socio-technical transitions (Geels, 2011) and specifically sustainability transitions studies (Markard et al., 2012). As with the detailed transitions framework presented by Brown et al. (2009), this conceptualization emphasizes that water management includes social and cultural elements that change in tandem with technical developments as new practices take hold. Without social changes, new technologies and practices are unlikely to be widely introduced, as the existing social systems tend to privilege existing technologies. The existence, or absence, of various social parameters are therefore an indication as to whether conditions exist to bring about new approaches to stormwater management in practice (Rogers et al., 2015).

With a view to understanding how the uptake of Sustainable Stormwater Management may be increased, this paper places the transition to SSWM in the context of a broad socio-institutional framework (Ferguson et al., 2013) to consider the complex factors that may increase the adoption of SSWM goals and practices by practitioners. The analysis is carried out in a case study of a single country, the State of Israel. The research derives recommendations on how to encourage further uptake which may be relevant to other countries at various stages of a similar paradigm shift.

The goals of the research presented in this paper were:

(i) to study and understand the socio-institutional context affecting a transition from conventional drainage to Sustainable Stormwater Management (SSWM) in the case study of Israel;
(ii) to draw conclusions and provide recommendations on supporting greater implementation of SSWM for countries interested in sustainable development, including Israel.

2. Materials and methods

2.1. Study area

The case of Israel is of interest given that it has a history of awareness of drought, centralized water management and high capacity for control of water resources (Feitelson, 2005), yet management of stormwater as a resource is still an emerging field, which highlights the complexity of approaches to this water resource. In particular the case study depicts changing and varied approaches to stormwater use within a policy context that prioritizes water management and efficiency.

Awareness of SSWM has grown in Israel since the 1990s, with the development of the field of Water-sensitive Planning (Carmon and Shamir, 1997, 2010). Water-sensitive Planning emphasizes the multiple objectives of stormwater management and the benefits of integrating water considerations into urban and regional planning to achieve these (Carmon and Shamir, 2010). This approach was developed in response to Israel's decreasing natural water replenishment (OECD, 2011; Weinberger et al., 2011) that has been exacerbated by intensive development and increased impervious surface area, particularly in the coastal plain (Goldshleger et al., 2015; Shoshany and Goldshleger, 2002). Shamir and Carmon

Table 1
Characteristics of conventional urban drainage and SSWM – Sustainable Stormwater Management.

	Conventional urban drainage	Sustainable Stormwater Management (SSWM)
Attitude towards stormwater	to be controlled and removed; designed to handle extreme stormwater events	a valued resource for humans and nature; handling all stormwater events; living with water
Goals	avoid flooding; avoid sanitation risks, in cases with combined sewage infrastructure; reduce topsoil erosion	multiple goals: (i) water-related – increasing quantity, improving quality, flood mitigation and adaptation. (ii) ecological – protecting water-based ecosystems, reduced topsoil loss (iii) social – improving urban quality of life by supporting urban nature and water-based urban landscapes, reducing urban heat islands and creating recreational and educational opportunities (iv) economic – reducing infrastructure costs, increasing land value due to blue-green landscapes and attracting tourists
Measures	rapid removal of runoff (in urban areas) by constructed channels	slowed runoff conveyance; detention, retention and infiltration of runoff; biological and mechanical quality treatment; dynamic management of flood plains; integration with conventional drainage as needed
Professional roles and work process	drainage engineers work alone post land-use planning and architectural design	cooperation from initial stages between the various relevant professionals: urban planners, architects, drainage engineers, landscape architects, ecologists.