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The role of monitoring sustainable drainage systems for promoting transition towards regenerative urban built environments: a case study in the Valencian region, Spain

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ABSTRACT

Sustainable drainage systems are an alternative and holistic approach to conventional urban stormwater management that use and enhance natural processes to mimic pre-development hydrology, adding a number of well-recognized, although not so often quantified benefits. However, transitions towards regenerative urban built environments that widely incorporate sustainable drainage systems are "per se" innovative journeys that encounter barriers which include the limited evidence on the performance of these systems which, in many countries, are still unknown to professionals and decision makers. A further important barrier is the frequently poor interaction among stakeholders; key items such as sustainable drainage systems provide collective benefits which also demand collective efforts. With the aim of overcoming such innovation-driven barriers, six showcase projects (including rain gardens acting as infiltration basins, swales and a green roof) to demonstrate the feasibility and suitability of sustainable drainage systems were developed and/or retrofitted in two cities of the Valencian region of Spain as a part of an European project, and their performance was monitored for a year. The data acquired, after being fully analyzed and presented to a group of key regional stakeholders, is proving to be a valuable promoter of the desired transition (for instance in influencing the support to SuDS in recent regional legislation). This paper presents detailed data on how these urban ecological drainage infrastructure elements reduce runoff (peak flows and volumes) and improve its quality, contributing to the goal of healthier and livable cities. The data show that the pilots have good hydraulic performance under a typical Mediterranean climate and also provided water quality benefits. Furthermore, it shows how engagement can contribute to smarter governance in the sense of smoothing the difficulties faced by innovation when being presented, understood, and endorsed by professionals and decision-makers in the field of stormwater management. Finally, activities undertaken in the demonstration sites monitored, show how they have been drivers of innovation and transition towards a new stormwater paradigm in Spain, serving as a reference to other urban areas in the Mediterranean.

1. Introduction

Cities around the world face multiple challenges including expansion of paved areas, loss of vegetation cover and the effects of climate change. Conventional drainage systems are particularly impacted since normally their initial design was based on rapidly conveying stormwater runoff to receiving waters. All too often their capacity is now compromised by the increase of impermeable areas that produce larger amounts of runoff which is expected to increase

Abbreviations: BOD_5, five day biological oxygen demand; CFU, colony-forming unit; COD, chemical oxygen demand; DO, dissolved oxygen; SuDS, sustainable drainage systems; TN, total nitrogen; TP, total phosphorus; TSS, total suspended solids; VSS, volatile suspended solids; WWTP, waste water treatment plant.

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further in many parts of the world due to climate change. This will also cause environmental damage not only because of changes to the flow regime but also to the increased loads of pollutants (Arnbjerg-Nielsen et al., 2013; Barbosa et al., 2012; Brown et al., 2009; Burns et al., 2012).

Sustainable Drainage Systems (SuDS) are an alternative and holistic approach to conventional stormwater management that use and enhance natural processes to mimic predevelopment hydrology. SuDS contribute to the mitigation of urban flooding and water pollution (Burns et al., 2012; Novotny et al., 2010) while saving energy in the urban water cycle and providing a non-conventional water resource, amenity, wildlife, carbon sequestration and storage, urban cooling, human-health and well-being (Charlesworth, 2010; Norton et al., 2015). Hence, SuDS are part of the urban ecological infrastructure (Xu et al., 2012) that can be considered in broader greener plans (Li et al., 2005) as part of the transition towards regenerative urban built environments (du Plessis, 2012), a need highlighted by EU Ministers responsible for Urban Development (European Commission, 2010). However, such a journey encounters barriers including insufficient demonstration projects and a lack of interaction between stakeholders (Winz et al., 2014).

The complexity of such a transition process requires transition management (Jefferies and Duffy, 2011; van der Brugge and Rotmans, 2007), a governance approach that has the potential to overcome the inherent tension between the open-ended and uncertain process of sustainability transitions and the ambition for governing such a process through selective participatory activities of envisioning, negotiating, learning and experimenting (Frantzeskaki et al., 2012).

Sustainable transitions can be led by government (Loorbach and Rotmans, 2010), business (Loorbach et al., 2010), science, or civil society (Radywyl and Biggs, 2013; Woolthuis et al., 2013). In all cases it is crucial that, in order to enhance the quality of environmental decisions, stakeholder participation should emphasize empowerment, equity, trust and learning (Pahl-Wostl et al., 2008; Reed, 2008; Smith and Raven, 2012). This requires the involvement of governmental and non-governmental multidisciplinary professionals (Jim, 2004; Potter et al., 2011), ever more important in a changing climate where the design and optimization of urban drainage infrastructure needs to be co-optimized with other objectives to keep cities habitable into the future (Arnbjerg-Nielsen et al., 2013).

The lack of available demonstration projects with appropriate monitoring is an important barrier (Brown and Farrelly, 2009; Hunt and Rogers, 2005) that challenges the implementation of novel systems. Indeed, both government and industry require clear evidence about their benefits and costs, customized for the region of study, to be willing to invest. Furthermore, there is evidence that demonstration sites have facilitated the development of mature understanding of innovative approaches such as integrated urban water management (Mitchell, 2006). Demo sites help in the identification of opportunities and substantial cost savings for local communities that are not apparent when separate strategies are developed for each service (Anderson and Iyaduri, 2003).

Although SuDS have been implemented in many parts of the globe (Novotny et al., 2010), experience is limited in the Mediterranean region (Castro-Fresno et al., 2013; Charlesworth et al., 2013; Chouli et al., 2007) in particular characterizing the response of SuDS in the region, with its long dry periods and torrential rain (Millán et al., 2013; Perales-Momparler et al., 2014; Terzakis et al., 2008). Hence, there is a need for 'learning by doing' experiments which can demonstrate the effectiveness of this new approach (Barbosa et al., 2012; Binney et al., 2010; Casal-Campos et al., 2012; Lamera et al., 2014; Tukker and Butter, 2007) since, according to Nevens et al. (2013), experiments can be major triggers for the take-off and acceleration of transitions (van der Brugge and Rotmans, 2007).

As Willke (2007) affirms, the creation of new knowledge becomes paramount for smart forms of governance. However, new knowledge has to fight for acceptance against conservatism and a host of difficulties, because knowledge is part of, and embedded in, social relationships. More specifically, new knowledge in civil engineering does not move easily into practice when professionals do not have codes, guidelines and/or evidence of proper performance that they can reference to justify due diligence in design and construction.

This paper aims to enhance smart governance in this context by providing information about the successful implementation and monitoring of SuDS showcase sites in Mediterranean Spain. These showcase sites are promoting the transition towards

Fig. 1. Showcase sites after SuDS development/retrofitting in Xàtiva (upper row) and Benaguasil (lower row).