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Adaptation Planning Support Toolbox: Measurable performance information based tools for co-creation of resilient, ecosystem-based urban plans with urban designers, decision-makers and stakeholders

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ABSTRACT

Currently, most tools, guidelines and benchmarks for urban adaptation raise awareness on climate change impacts, assess the city's vulnerability and/or address the need for adaptation on a policy-level. However, tools that have the ability to implement adaptation solutions in the actual urban planning and design practice seem to be missing. We developed and tested the Adaptation Planning Support Toolbox (APST) to fill this gap. This toolbox supports local policymakers, planners, designers and practitioners in defining the program of demands, in setting adaptation targets, in selecting from more than 60 blue, green and grey adaptation measures and with informed co-creation of conceptual adaptation plans. The APST provides quantitative, evidence-based performance information on (cost)effectiveness of adaptation measures regarding climate resilience and co-benefits. The APST can be used design workshops, to feed dialogues among stakeholders on where and how which ecosystem-based adaptation measures can be applied. Applications of the AST in various settings and context in cities on different continents have illustrated the added value of the toolbox in bringing policy and practice together with help of science. With more and more cities worldwide that will make the step from policymaking to actual adaptation-inclusive urban (re)development practice we foresee a growing demand for such tools.

1. Introduction

1.1. Adaptation of urban areas

The need for adaptation of urban areas to changing climatic conditions is widely recognized (Deltaprogramma, 2015; IPCC, 2007, 2012; PROVIA, 2013). Flooding, drought, heat stress and related problems with water quality, water supply and land subsidence, aggravated by the UHI effect, are increasing hazards threatening the liveability of our urban areas as well as our social and economic urban systems (Albers et al., 2015; Jha et al., 2012; Rovers et al., 2014; World Bank, 2010; Zevenbergen et al., 2010). Risks are further increased by on-going urbanization (Nichols et al., 2007; UN DESA, 2014) and by intensification of urban land use; the invested capital and the asset value of buildings, infrastructure and industrial facilities has increased drastically over the past decades (Kind, 2013). Although the need for adapting our urban environments is clear, in practice adaption is difficult. Opportunities for adaptation are often limited to new development projects, to large infrastructural renovation and renewal projects or to initiatives from individual residents (Van der Brugge and De Graaf, 2010).

Adaptation requires the construction of structural or "hard" adaptation measures (Hallegatte, 2009; Pelling, 2011). Such measures are physical or technological interventions, constructed facilities that require space and therefore are subject of spatial planning and design (Taylor and Wong, 2002). This article will focus on the right design of structural adaptation measures, as embedded in a planning process that leads to a decision on a spatial adaptation plan.

The pallet of adaptation measures has extended dramatically over the past decades. Earlier, Sustainable Urban Drainage Systems (SUDS) (CIRIA, 1998; Svenske Vatten- och Aflopsverksföreningen,

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1983) and Water Sensitive Urban Design(WSUD) for urban drainage (Brown et al., 2008; Engineers Australia, 2006), nowadays also known as green or blue-green infrastructure, were introduced. Maksimovic et al. (2014) recently argue that a new concept of Multiple-Use Water Services (MUS) is emerging. MUS solutions enhance the synergy of urban water (blue) infrastructure with green assets and ecosystem services, are economically viable and climate (environmental) adaptive.

Ecosystem-based Adaptation (EbA) is at the heart of this MUS development. EbA- measures integrate the use of biodiversity and ecosystem services into an overall strategy for helping people adapt to climate change (Munroe et al., 2012). In addition to flood control, drought mitigation and heat stress reduction they provide e.g. aesthetic quality, recreational and restorative capacity and health benefits (Opdam et al., 2009; Van den Berg et al., 2007; Van den Berg et al., 2015). This article shows how planning 'blue-green' EbA measures is used to advance climate resiliency, while maximizing their co-benefits.

1.2. Adaptation planning

Urban planning exists of a series of more or less consecutive phases starting from system analysis and program development (initiative phase), via conceptual, preliminary and final design (design phase) up to implementation (Fig. 1). The process ends with a final decision on an adaptation or (re)development plan. Although shown as a straightforward, stepwise process in theory, the process in practice often reiterates to an earlier stage to investigate alternative adaptation pathways.

Many guidelines on climate resilient urban planning provide procedures for hazard, exposure and vulnerability analysis and an overview of potential solutions and/or best practices (Challenge for Sustainability; Climate-ADAPT; Deltaprogramma N&H, 2014; EPA; Great Lakes and St. Lawrence Cities Initiative; PROVIA, 2013). They however lack guidance where it comes to the selection of appropriate packages of adaptation measures during the initiative and design phases (Voskamp and Van de Ven, 2015). For these phases tools seems unavailable to support stakeholders to make hard choices which adaptation measures are attractive and effective for the project area (Bours et al., 2014; PROVIA, 2013); this while complex simulation models to evaluate the expected hydraulic and hydrological performance of the final plan are readily available (Lerer et al., 2015)

In the initiative phase, urban planners are often in the lead of the process. Eliasson (2000) showed that climatology so far has a low impact on the planning process; urban planners' use of climatic information is unsystematic as the urban climatologists fail to provide them with good arguments, suitable methods and tools. This underlines the need for a planning support system that bridges the gap between urban planners and engineers; she makes a plea for a "communicative approach" to the planning process.

1.3. Adaptation support tools for collaborative planning

Involvement of local stakeholders, land & water engineers, experts from other disciplines and decision-makers is considered essential in particular in planning reconstruction of existing urban areas. Each of them not only has different interests, agendas and roles in the process. They differ in their sense of urgency of the problem, their approach to the problem, their language and knowledge level, and their rationality regarding potential solutions (Van Stigt et al., 2015). Design workshops during the initiative phase are meant to get to know each other, to share each other's knowledge and understanding of the problems and to collectively identify interesting adaptation solutions.

Question is how to support the planners, stakeholders and decision-makers in this analysis – dialogue – design-engineering process with knowledge and information, in order to get a converging learning process that leads to a final positive decision on an adaptation plan? Such planning support tools should raise awareness, present the broad range of adaptation options, let participants explore the impact of different design choices on the climate resiliency of their project area (Pelzer et al., 2013) and maximize the co-benefits of adaptation measures.

Goal of our study was to develop a toolbox that supports the incorporation of climate adaptation in the actual planning and design practice in cities. This Adaptation Planning Support Toolbox was developed to provide urban planners, landscape architects, civil engineers and local stakeholders and decision makers with quantified, evidence-based information on the climate resilience of their ideas in early phases of the planning process and to facilitate decision-making during conceptual design workshops. In design workshops the toolbox should supports them in how to share their knowledge and discuss alternative measures, including location, size, costs and (co)benefits.

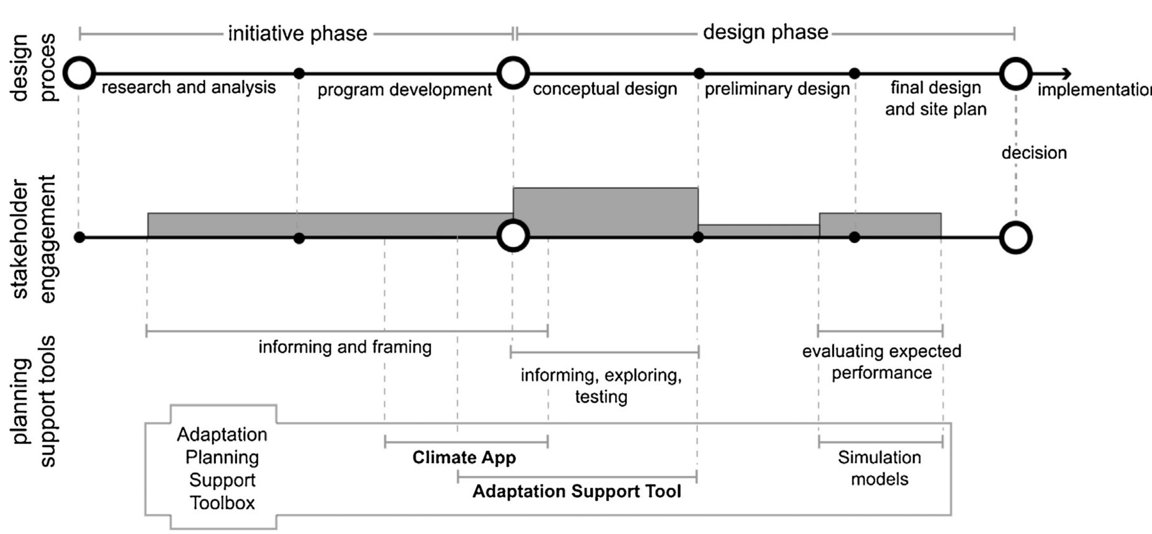

Fig. 1. Adaptation planning process, stakeholder engagement and planning support tools. Both tools (**bold**) in the Adaptation Planning Support Toolbox will be discussed in this article.

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