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Cascades of green: A review of ecosystem-based adaptation in urban areas

Ebba Brink[a,b,1,*], Theodor Aalders[a,1], Dóra Ádám[a,1], Robert Feller[c,1], Yuki Henselek[d,1], Alexander Hoffmann[a,1], Karin Ibe[e,1], Aude Matthey-Doret[a,1], Moritz Meyer[f,1], N. Lucian Negrut[a,1], Anna-Lena Rau[c,1], Bente Riewerts[e,1], Lukas von Schuckmann[a,1], Sara Törnros[a,1], Henrik von Wehrden[c,e,g], David J. Abson[g], Christine Wamsler[a,h,*]

[a] Lund University Centre for Sustainability Studies (LUCSUS), P.O. Box 170, SE-221 00 Lund, Sweden
[b] Lund University Centre of Excellence for Integration of Social and Natural Dimensions of Sustainability (LUCID), P.O. Box 170, SE-221 00 Lund, Sweden
[c] Center for Methods, Faculty of Sustainability, Leuphana University Lüneburg, Scharnhorststr.1, 21335 Lüneburg, Germany
[d] Chair of Environmental Economics and Resource Management, University of Freiburg, Tennenbacher Str. 4, 79104 Freiburg, Germany
[e] Institute of Ecology, Faculty of Sustainability, Leuphana University Lüneburg, Scharnhorststr.1, 21335 Lüneburg, Germany
[f] Sustainability Economics Group, Faculty of Sustainability, Leuphana University Lüneburg, Scharnhorststraße 1, 21335 Lüneburg, Germany
[g] FuturES Research Center, Leuphana University, Scharnhorststr.1, 21335 Lüneburg, Germany
[h] Centre for Societal Resilience, Lund University, P.O. Box 118, SE-221 00 Lund, Sweden

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ABSTRACT

Climate change impacts increase pressure on challenges to sustainability and the developmental needs of cities. Conventional, "hard" adaptation measures are often associated with high costs, inflexibility and conflicting interests related to the dense urban fabric, and ecosystem-based adaptation (EbA) has emerged as a potentially cost-efficient, comprehensive, and multifunctional approach. This paper reviews and systematises research on urban EbA. We propose an analytical framework that draws on theory from ecosystem services, climate change adaptation and sustainability science. It conceptualises EbA in terms of five linked components: ecological structures, ecological functions, adaptation benefits, valuation, and ecosystem management practices.

Our review identified 110 articles, reporting on 112 cities, and analysed them using both quantitative statistical and qualitative content analysis. We found that EbA research in an urban context is fragmented due to different disciplinary approaches and concepts. Most articles focus on heat or flooding, and the most studied ecological structures for reducing the risk of such hazards are green space, wetlands, trees and parks. EbA is usually evaluated in bio-geophysical terms and the use of economic or social valuations are rare. While most articles do not mention specific practices for managing ecological structures, those that do imply that urban EbA strategies are increasingly being integrated into institutional structures. Few articles considered issues of equity or stakeholder participation in EbA.

We identified the following challenges for future EbA research. First, while the large amount of data generated by isolated case studies contributes to systems knowledge, there is a lack of systems perspectives that position EbA in relation to the wider socio-economic and bio-geophysical context. Second, normative and ethical aspects of EbA require more thought, such as who are the winners and losers, especially in relation to processes that put people at risk from climate-related hazards. Third, there is room for more forward-looking EbA research, including consideration of future scenarios, experimentation in the creation of new ecological structures and the role of EbA in transformative adaptation.

1. Introduction

There is an urgent need for urban areas to adapt to climate change (Revi et al., 2014). More than half of the world's population lives in urban areas; they hold most of its economic assets, and are responsible for most economic and institutional activity

* Corresponding author at: Lund University Centre for Sustainability Studies (LUCSUS), P.O. Box 170, SE-221 00 Lund, Sweden. Fax: +46 46 222 0475.
E-mail addresses: ebba.brink@lucsus.lu.se (E. Brink), christine.wamsler@lucsus.lu.se (C. Wamsler).
[1] First author.

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(Revi et al., 2014). However, climate-related hazards (e.g. storm surges and extreme temperatures) increase pressure on existing challenges to sustainability, such as achieving intra- and inter-generationally equitable urban development. Moreover, urbanisation itself is often a driver of risks (e.g. flooding and heat islands due to soil sealing) (Wamsler, 2014).

There are some fundamental barriers to urban climate change adaptation. Traditional, "hard"[1] adaptation measures (e.g. sea walls, levees and irrigation systems) are often expensive and inflexible (Jones et al., 2012; Kithiia and Lyth, 2011), while the dense urban fabric and competition for land makes it difficult to introduce infrastructure that only serves the function of risk reduction (Revi et al., 2014). More recently, "ecosystem-based" adaptation (EbA) has emerged as a comprehensive, multifunctional and potentially cost-efficient form of climate change adaptation. It uses biodiversity and ecosystem services "as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change" (CBD, 2009, p. 41). Its focus on societal welfare rather than conservation for nature's own sake is argued to be a powerful catalyst in increasing the commitment of governments (Chong, 2014).

EbA research takes a problem-focused, rather than a traditional disciplinary approach and in doing so draws upon multiple academic fields and concepts, including ecology, nature conservation, development, risk management, ecosystem services and climate change adaptation. While the pluralism of problem-focused research is often beneficial in terms of generating new ideas, there is a pressing need to ensure that urban-focused EbA research is synthesised, in order to reduce duplication of research efforts, increase the opportunities for synergetic research and identify research gaps in this rapidly-expanding field. However, to date, reviews of EbA research have either not focused on the urban context (Campbell et al., 2008; Doswald et al., 2014) or looked at other aspects, such as mangrove coasts (Sierra-Correa and Cantera Kintz, 2015), forests (Pramova et al., 2012) or particular geographical regions (Laros et al., 2013; Mercer et al., 2012; Munang et al., 2014).

In this context, this paper develops a conceptual and analytical framework that provides the background for a systematic review of EbA research in urban environments. The review addresses the following questions: What hazards and ecological structures are the focus of research into urban EbA? What concepts do researchers link their EbA work to? How are stakeholders integrated into urban EbA research and planning? What type of knowledge is generated and where are the gaps in the wider discussion of urban EbA?

2. Conceptual framework

2.1. Key concepts for EbA: climate change adaptation and ecosystem services

Even with the most stringent mitigation measures, climate change adaptation is necessary, or even "unavoidable" (Burkett et al., 2014, p. 184). Climate change adaptation (or in short adaptation) is defined by the IPCC (2014, p. 1758) as "the process of adjustment to actual or expected climate and its effects [which] in human systems [. . .] seeks to moderate harm or exploit beneficial opportunities". Thus, it includes both long-term, forward-looking activities and those that address risks and hazards

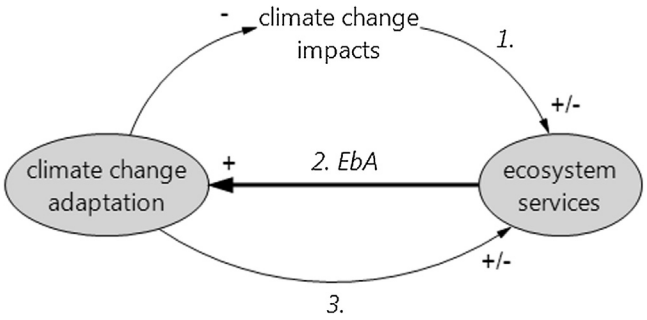

Fig. 1. Connections between climate change adaptation and ecosystems services.

arising from the current climate. The latter is also key in the field of disaster risk reduction (UNISDR, 2009), which has, until recently, developed separately from climate change adaptation.[2] Hazard refers here to the potential occurrence of a (natural or human-induced) physical event, trend or impact that may negatively affect human life, health, or things that humans value (cf. IPCC, 2014). Risk, in turn, is often conceptualised as the interaction between hazards and societies that are vulnerable to their impact (UNISDR, 2009; Wisner et al., 2004).

An addition to the definition of climate change adaptation given in the earlier IPCC Assessment Report (IPCC, 2007) acknowledges the potential to harness ecosystem services for this purpose: "In natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2014, p. 1758). Ecosystem services are "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily, 1997 p. 3) and their use in urban planning has attracted increasing attention in recent years (e.g. Ahern et al., 2014; Gómez-Baggethun and Barton, 2013; Niemelä et al., 2010). Relevant examples in urban areas include water regulation, air filtration and recreation (Bolund and Hunhammar, 1999).

Three points link climate change adaptation and ecosystem services (see Fig. 1 and Campbell et al., 2008): (1) how ecosystem services are affected by climate change; (2) how ecosystem services can be used for climate change adaptation; and (3) how ecosystem services are affected by human adaptation actions. This paper focuses on the second point: the use of ecosystem services for climate change adaptation, known as ecosystem-based adaptation (EbA).[3]

EbA first emerged as a concept around 2008 (Mercer et al., 2012; Wertz-Kanounnikoff et al., 2011) and was initially discussed in a Global South context, often with the rationale that poor communities in developing countries are more directly, and even predominantly, dependent on the environment (Forsyth, 2014; Jones et al., 2012; Vignola et al., 2009). More recently, matching the "boom" in EbA in policy and practice, the concept has been applied more generally to climate change adaptation using ecosystem services in the Global North (e.g. Jones et al., 2012; McCarthy, 2013; Wamsler et al., 2014).

The community focus is, however, still inherent in much EbA research. According to the International Union for Conservation of

[1] "Hard" measures are also referred to as "technical" or "engineering" measures, while "soft" measures refer to institutional, capacity-building and awareness-raising approaches and "green" measures refer to ecosystem-based approaches (Jones et al., 2012).

[2] While there is increasing overlap, a key difference between climate change adaptation and disaster risk reduction is that the former is more future-oriented and focuses on all potential risks and opportunities related to climate change, while the latter is more event-based and focuses also on non-climate related risks and disasters (Wamsler, 2014).

[3] This paper uses the term ecosystem-based adaptation (EbA) for all activities that fit the description of using ecosystem services for climate change adaptation, also those that do not explicitly employ this term. In the few cases where we deem it necessary to distinguish the explicit reference to EbA from the implicit, the term EbA concept is used.