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An integrated method for assessing climate-related risks and adaptation alternatives in urban areas

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ABSTRACT

The urban environment is a complex structure with interlinked social, ecological and technical structures. Global warming is expected to have a broad variety of impacts, which will add to the complexity. Climate changes will force adaptation, to reduce climate-related risks. Adaptation measures can address one aspect at the time, or aim for a holistic approach to avoid maladaptation. This paper presents a systematic, integrated approach for assessing alternatives for reducing the risks of heat waves, flooding and air pollution in urban settings, with the aim of reducing the risk of maladaptation. The study includes strategies covering different spatial scales, and both the current climate situation and the climate predicted under climate change scenarios. The adaptation strategies investigated included increasing vegetation; selecting density, height and colour of buildings; and retreat or resist (defend) against sea-level rise. Their effectiveness was assessed with regard to not only flooding, heat stress and air quality but also with regard to resource use, emissions to air (incl. GHG), soil and water, and people's perceptions and vulnerability. The effectiveness of the strategies were ranked on a common scale (from −3 to 3) in an integrated assessment. Integrated assessments are recommended, as they help identify the most sustainable solutions, but to reduce the risk of maladaptation they require experts from a variety of disciplines. The most generally applicable recommendation, derived from the integrated assessment here, taking into account both expertise from different municipal departments, literature surveys, life cycle assessments and publics perceptions, is to increase the urban greenery, as it contributes to several positive aspects such as heat stress mitigation, air quality improvement, effective storm-water and flood-risk management, and it has several positive social impacts. The most favourable alternative was compact, mid-rise, light coloured building design with large parks/green areas and trees near buildings.

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Introduction

The urban environment is a complex structure of interlinked social, ecological and technical systems (Bulkeley et al., 2014; Castán Broto and Bulkeley, 2013; Hodson and Marvin, 2012; Rosenzweig et al., 2011). Global warming is projected to have a broad variety of impacts on societies and ecosystems in combination with other environmental, economic and political stresses and this, of course, adds to the complexity (Granberg and Glover, 2014; Leichenko, 2011). Likely temperature increases will lead to increased sea level and changes in precipitation patterns with impacts on infrastructure, environment and health (IPCC, 2013). The increased temperature will also affect human-health through increased morbidity and mortality during the warmer seasons (Oudin Åström et al., 2011; Reid et al., 2009).

It is clear that changed climatic conditions impact society and drive demands for adaptation to reduce climate-related risks (Adger et al., 2013; Bauer et al., 2012; Granberg and Glover, 2014; Moser and Boykoff, 2013; Palutikof, 2013; Pelling, 2011). In a longer, historic perspective, the development of society has entailed constant adaptation to changing weather conditions (Bauer et al., 2012). Adaptation to climate change, however, addresses risks outside the range of experience (cf. Adger et al., 2007). Climate change impacts always manifests themselves at the local level and the urban setting thus becomes a crucial site for adaptation to climate change impacts (van den Berg and Coenen, 2012; Castán Broto and Bulkeley, 2013; Fünfgeld, 2015; Storbjörk, 2010). Cities have to adapt to contemporary and future impacts of climate change, despite the uncertainty surrounding climate change and its local impacts (IPCC, 2012; Pelling, 2011).

Adaptation measures can range from local to the regional scales (Füssel, 2007), and their time horizons from the short to long-term. They can be tactical or strategic; can seek immediate, delayed, or cumulative effects; and can encompass widely differing outcomes (such as retreat, accommodation, protection, prevention, toleration, change, and restoration) (Barnett and O'Neill, 2010; Granberg and Glover, 2014). There are examples in the literature where one aspect of adaptation, for example measures to reduce heat stress, have been tested and assessed (Barnett and O'Neill, 2013; Lee et al., 2013). Maladaptation, however, may occur. For example, when a measure to reduce climate-change induced risks contributes to increased emissions of greenhouse gases, thereby exacerbating the cause. Maladaptation also covers adaptation actions that increase disproportionately the burdens of already vulnerable people, or result in high economic, social or environmental costs (Barnett and O'Neill, 2010). Identifying the occurrence of maladaptation is difficult for there are no widely accepted criteria to define its occurrence (cf. Turner et al., 2014).

We know of no study that investigates how a strategy to reduce one climate related risk interacts with other climate related risks in potentially positive or negative ways, simultaneously taking into account maladaptation from a broader perspective. We therefore see a need for integrated assessment methods that can be applied within existing planning processes.

Aim of paper

This paper presents a systematic, integrated approach for assessing different alternatives for reducing the risks of heat stress, flooding and air pollution in urban settings, with the aim of reducing the potential for maladaptation. The study includes strategies covering different spatial scales, and both the current climate situation and the climate predicted under climate change scenarios. There are three major objectives with the study:

- Rank the effectiveness of the investigated alternatives.
- Apply the individual rankings in an integrated evaluation system, taking into account environmental and social impacts with short and long-term perspectives, under both current and future climate conditions.
- Provide recommendations that can be used in physical planning, management and design, limiting the risks of maladaptation.

The individual ranking system is generically applicable for integrated assessments and easy to use in, for example, existing planning process.

Background

Climate related risks and adaptation measures in urban environments – today and in a future climate

The costs related to extreme weather events and urban air pollution are severe already today, and expected to increase with future climate change (e.g. EEA, 2011; IPCC, 2013). The risks are expected to increase as a consequence of both climate change, increasing urbanisation and increased demands for resources in urban areas (DePaul, 2012; Grimm et al., 2008; IPCC, 2013; While and Whitehead, 2013). Adapting to tangible climate impacts and trying to mitigate risks today also includes the potential risk of maladaptation in the future (Barnett and O'Neill, 2010; Granberg and Glover, 2014; IPCC, 2012).

Flooding

Already today, there are high costs and consequences due to flooding in urban areas with land being eroded away, fatalities, construction, infrastructure failures and disease (e.g. IPCC, 2013; McBean, 2004). Higher sea level and changes in precipitation patterns will not only increase the risk of flooding but also of erosion and landslides (e.g. Andersson-Sköld et al., 2013, 2014a).