Introduction

Climate change may be seen as the largest economic, political, developmental and environmental challenge the world has ever faced. IPCC reports have shown that human activities are altering the atmosphere, and that it is crucial now for decision-makers at all levels to take urgent action.

At the same time, urbanization is creating a growing challenge for cities and urban population centers both as engines of economic activity and as sources of greenhouse gas emissions. According to the United Nations Population Fund the number of people living in cities exceeds the world's rural population since 2008 and this trend is expected to continue. The way in which we build and operate cities strongly affects energy use and emissions. For example, the so-called 'urban heat island effect' affects energy use for space conditioning and greenhouse gas emissions, whereas simple measures can be applied to control this effect. Cities are also vulnerable to climate change, since many are located in coastal areas or depend on imported resources such as water and food. Urban centers are also important users of resources, and potential future stocks. Climate proofing cities will hence affect resource use globally. Many cities are in the forefront of initiatives for mitigating and adapting to climate change and try to develop creative solutions.

The Symposium 'Climate Proofing Cities', organized December 1st 2009 by 'SENSE' (the Netherlands Research School for Socio-Economic and Natural Sciences of the Environment, <http://www.sense.nl>), provided a platform to discuss key developments for cities in the climate debate. The SENSE network is not only a researcher's network for promoting the integrated and interdisciplinary environmental sciences, but also a graduate school for some 500 PhD students in the socio-economic and natural sciences of the environment. Organizing an exploring symposium on 'Climate Proofing Cities' fits well in SENSE's mission of developing bridges between science and society for sustainable solutions around the globe.

This Special Issue presents highlights from the presentations. While most articles relate to the Dutch situation: an affluent, urbanized society in a coastal area, with a moderate climate at present and with a well developed water management system, lessons learned may be applicable to similar (delta) areas around the world.

Under the heading of *Balancing adaptation and mitigation*, symposium participants discussed conceptual approaches to urban climate management. Bergsma et al. (2012) focus on adaptive capacity to water stress of different Dutch localities. What should be handled publicly, what can be handled individually? Using an 'Adaptive Capacity Wheel', the article compares strengths and weaknesses of adaptive capacity in two urban areas and one rural area. In general, they conclude that cities require a more

top-down approach, while rural areas require a more group-centred approach. Leadership should fit these different requirements. For effective policies, the article lists generic accountability demands and information needs.

Under the heading of *Future City Design*, symposium participants discussed design challenges for Climate Proofing Cities. Agudelo-Vera et al. (2012) present the Urban Harvest approach, a novel design tool that maps resource potentials of urban areas. Based on urban metabolism, Urban Harvest aims for better resource management by closing urban cycles and harvesting urban resources. The 'urban tissue' concept is used to map harvesting potentials for energy and water for an average Dutch city hectare. At neighbourhood level, 'urban tissues' are applied to develop harvesting scenarios. The article concludes that urban design should focus on synergies of urban functions and facilities to cascade and recycle resources within the same area.

Three articles discuss the Urban Heat Island Effect, warmer temperatures within urban settlements compared to surrounding rural areas. A first step is to measure and monitor this effect. Klok et al. (2012) used satellite images to quantify the surface heat island of Rotterdam. They find that temperature differences between Rotterdam and non-urban areas can be as large as 10 °C. The data also show the influence of urban vegetation on city district temperatures, urban materials and building density. How to use such measurements for urban design? Lenzholzer (2012) presents a 'research for design/research by design' project that generated guidelines for thermally comfortable squares in Dutch cities. The project combined people's microclimate perceptions with microclimate simulation tests. Urban shelterbelts of trees offer optimal wind and sun protection. A challenging conclusion is that 'the man in the street' intuitively knows more about microclimate than Dutch city planners. Kleerekoper et al. (2012) discuss tools and strategies to combat heat in outdoor spaces. Next to vegetation and surface water (ponds, fountains, flowing water), they stress the importance of material use (permeable materials, colours) and built form (optimal density, green walls). Applying these principles to city districts in Den Haag and Utrecht, the article shows that renovation of existing neighbourhoods offers sufficient opportunities to combat the accumulation of heat.

Greening the city can be seen as a specific design challenge. Two articles discuss the possibilities to combine climate policies with biodiversity conservation. Metselaar (2012) discuss options and dilemmas of green roofs. Increasing biodiversity requires matching natural vegetation types to growing conditions on roofs. They contrast water demands of vegetation types with

construction requirements, which determine roof costs. Vermonden et al. (2012) start with the notion that more extreme rainfall demands an increase in storage and discharge capacity of surface water systems. What opportunities does this provide to increase biodiversity in urban areas? Urban surface water systems can sustain a biodiversity comparable to that of man-made ditches and (semi)natural streams in rural areas and can even be a habitat for several endangered species. Ecology of urban drainage systems shows that key factors for biological diversity are nutrients, sediment composition, transparency and habitat structure. Reducing the nutrient load appears to be the overarching requirement for increased biodiversity, while difficult to achieve in delta areas with high nutrient load of rivers by communal discharges and agriculture.

The Climate Proofing Cities Symposium showed promising tools to develop and assess sustainable cities. At the same time, practical applications are in their infancy. There is an urgent need to collect experience based evidence. This is even more pressing because the reconstruction of our existing urban fabrics will be more complicated and more time consuming than construction of new, climate proof, urban areas.

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