Climate Risk Management 16 (2017) 73–92

Contents lists available at ScienceDirect

Climate Risk Management

journal homepage: www.elsevier.com/locate/crm

Development and appraisal of long-term adaptation pathways for managing heat-risk in London

Ashley Kingsborough *, Katie Jenkins, Jim W. Hall

Environmental Change Institute, University of Oxford, South Parks Road, Oxford OX1 3QY, United Kingdom

ARTICLE INFO

Article history:
Received 9 March 2016
Revised 22 December 2016
Accepted 11 January 2017
Available online 19 January 2017

Keywords:
Urban climate change adaptation
Adaptation pathways
Decision-making under uncertainty
Heat-risk

ABSTRACT

The risk of residential overheating and mortality is increasing due to the effects of global warming and the urban heat island effect and needs to be addressed through climate change adaptation. 'Adaptation pathways' have become widely recognised as an adaptation planning approach, but they have not been utilised for long-term planning for city-scale urban heat risk management. This paper applies adaptation pathway methodology to urban heat risk management. We use spatially coherent downscaled probabilistic climate change projections that account for changes in urban-land cover and the urban heat island to appraise adaptation pathways and inform long-term adaptation planning. We demonstrate that adaptation strategies focusing solely on urban greening or building level adaptation based on current best practice are unlikely to cope with the increasing levels of risk. Air-conditioning may play a growing role in managing heat-risk; however, increasing air-conditioning will exacerbate the urban heat island and further increase the risks of overheating.

1. Introduction

Adapting to increasing mean and maximum temperatures, and heatwaves that are projected to increase in both frequency and severity is a significant challenge for urban authorities globally (Hunt and Watkiss, 2010; IPCC, 2014). Without proportionate adaptation, increasing heat-risk is likely to result in increasing heat-related mortality (Gasparrini et al., 2015; Hajat et al., 2014; Stone et al., 2014; Taylor et al., 2015); additional residential overheating (Porritt et al., 2012; Taylor et al., 2015; ZCH, 2015); reduced infrastructure performance (Jenkins et al., 2014a); and, in extreme cases, it may exceed the threshold for human adaptability and threaten the viability of cities (Pal and Eltahir, 2015).

In addition to climate change, the implementation and effectiveness of urban adaptation strategies will be strongly influenced by socio-economic changes including population, demographic, land-use and technological change (IPCC, 2014). Adaptation pathways have demonstrated significant potential as an adaptation planning approach under such conditions of deep uncertainty (Haasnoot et al., 2012; Siebentritt et al., 2014; Barnett et al., 2014; Rosenzweig and Solecki, 2014; Lawrence et al., 2013; Wise et al., 2014; Haasnoot et al., 2013; Kingsborough et al., 2016). A pathways approach that sequences the implementation of actions over time, to ensure the system adapts to the changing social, environmental and economic conditions, will build flexibility into the overall adaptation strategy (Ranger et al., 2010; Haasnoot et al., 2012).

* Corresponding author.
E-mail addresses: ashley.kingsborough@ouce.ox.ac.uk (A. Kingsborough), katie.jenkins@eci.ox.ac.uk (K. Jenkins), jim.hall@eci.ox.ac.uk (J.W. Hall).

http://dx.doi.org/10.1016/j.crm.2017.01.001
2212-0963/

The combined effects of the urban heat island (UHI) and climate change are projected to significantly increase summer temperatures and the number of heatwaves[1] in London (McCarthy et al., 2010; Mavrogianni et al., 2011; Murphy et al., 2009). A heatwave equivalent to the 2003 heatwave – which resulted in 650–1000 excess deaths in London (D'Ippoliti et al., 2010) – is projected to have a return period of 1 in 2 years in the 2080s, under a medium emissions scenario at the 50% probability level (Murphy et al., 2009; LCCP, 2012a).

While the risk of mortality due to heat in London remains lower than that due to cold (Gasparrini et al., 2015), heat-risk is expected to increase as the climate warms and extreme heatwave events become more common (Jenkins et al., 2014b; Taylor et al., 2015; Wolf and McGregor, 2013). Heat-risk associated with increased mortality and overheating of people, buildings, infrastructure and urban environments is increasing and needs to be addressed through adaptation (Nickson et al., 2011; LCCP, 2012b,a; Hajat et al., 2014; Jenkins et al., 2014a; Jenkins et al., 2014b; ZCH, 2015; Taylor et al., 2015).

Limited research exists that estimates the vulnerability of populations to heat-risk based on a combination of population and environmental variables at the city scale (Taylor et al., 2015). Wolf and McGregor (2013) used principal components analysis to create a heat vulnerability index for London that accounted for UHI, living in a flat, population density, age, illness, socio-economic status, social isolation, and ethnic minority status. They found spatial clustering of areas of high heat vulnerability in Central and East London that coincide with areas of potentially high heat exposure. Taylor et al. (2015) examined the risk of mortality in London during hot weather events by combining data on population age and distribution, UHI, and dwelling characteristics to calculate the spatial variation in heat-related mortality risk across London. Spatial variation of heat-related mortality was found to reflect background mortality rates due to population age, while dwelling characteristics were found to cause a larger variation in risk than the UHI. This research, however, did not consider future climate, socio-demographic or adaptation scenarios.

Jenkins et al. (2014b) utilised high spatial resolution probabilistic projections of urban temperatures with projections of demographic change as part of a risk assessment at the ward scale in London. They found that reducing indoor temperatures by 1–2 °C reduced both annual heat-related mortality and residential overheating compared to no-adaptation in future scenarios, however limited consideration was given to the nature and feasibility of potential adaptation actions.

A range of actions including land-use planning, building design, community resilience, and emergency planning and response must be considered together for cities to manage long term heat-risk. Research on the effectiveness of localised adaptation actions in London is growing, including solar shading; building insulation and ventilation (Porritt et al., 2012); roof insulation and window upgrades (Mavrogianni et al., 2012); green roofs (Virk et al., 2015, 2014); and occupant behaviour (Mavrogianni et al., 2014). However, evidence on the effectiveness of adaptation actions in lowering heat-related mortality is limited (Frontier Economics, 2013), and quantifying the effectiveness of specific adaptation options into an associated temperature based increase in resilience at the city scale remains a significant challenge (Jenkins et al., 2014b). There is limited research on existing and future heat-risk that actively considers the effectiveness of specific adaptation actions in managing that risk through time at the city scale (Stone et al., 2014).

There is a need to continue developing, trialling, critiquing and demonstrating how pathways approaches can be utilised in informing and motivating adaptation planning (Wise et al., 2014; Haasnoot et al., 2012; Barnett et al., 2015; Kingsborough et al., 2016).

Adaptation pathways have not been applied to long-term planning for urban heat-risk at the city scale, and a lack of demonstration in this context limits decision-makers' confidence in their utility. This paper explores the potential for adaptation strategies to manage future heat risk under a long-term population growth and climate change scenarios.

This research adopts a framework for adaptation planning and the development of adaptation pathways developed by Kingsborough et al. (2016); generates quantified estimates for the effectiveness of a range of adaptation options; and utilises an updated probabilistic spatial heat-risk assessment model developed by Jenkins et al. (2014b) to demonstrate how adaptation pathways in response may manage long-term heat-risk in London. We present a quantified assessment of how heat-risk in London is projected to vary depending on the choice of adaptation pathway under a medium greenhouse gas emissions and population scenario. This research focuses on Greater London: assessing mortality risk, thermal discomfort in residential buildings, and adaptation pathways.

2. Methodology

The adaptation planning framework developed by Kingsborough et al. (2016) is a risk -based and iterative approach that prioritises management of existing risks, and guides the development of long-term adaptation pathways. Within our adaptation planning framework (Fig. 1), the key steps in the development of adaptation pathways include: a review of the potential usefulness of adaptation pathways; the identification of an adaptation canvas; selection of adaptation portfolios; the development of adaptation pathways; and an appraisal and visualisation of adaptation pathways. This section outlines their application to the development of adaptation pathways for heat-risk.

[1] Two heatwave definitions are commonly used in London: Public Health England define a heatwave (Level 3) as two consecutive days above 32 °C with an overnight minimum above 18 °C (2015), while the London Resilience Partnership define it as five days above 32 °C with overnight minimums above 15 degrees (2014).