Applied Geography 89 (2017) 52–60

Contents lists available at ScienceDirect

Applied Geography

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

Cultivating climate justice: Green infrastructure and suburban disadvantage in Australia

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ARTICLE INFO

Keywords:
Green infrastructure
Inequality
Climate justice
Adaptation
Planning
Social disadvantage

ABSTRACT

Green infrastructure has recently risen to international prominence for its purported capacity to enhance urban sustainability, and particularly to modulate ambient temperatures in the context of climate change. We assess whether residents in a sub-tropical Australian city perceive green infrastructure as an effective climate adaptation response for reducing vulnerability to heat stress. Gold Coast City has pursued urban densification policies, such as reducing block sizes and increasing building heights, to accommodate rapid population growth. Little attention has been given to the combined impact of local heat island effects and global climate change upon lower-income residents in the city's suburban fringe, including rising energy costs associated with cooling homes. The study has three aims: to assess whether social disadvantage is associated with (1) concern about climate change impacts; (2) perceptions about the potential of green infrastructure to offer potential climate-adaptive benefits; and (3) the desire for more urban greening in a working class suburb. We used a mail-back survey to elicit information related to cooling dwellings, awareness of, and concern about, climate change impacts, perceptions of the benefits of green infrastructure, and desire for more urban greening. Results indicate that despite their vulnerability to heat stress, comparatively disadvantaged residents are no more concerned about climate change; nor are they any more inclined to encourage local government to enhance neighbourhood greenery. These residents are, if anything, *less* likely to perceive benefits of urban greening. Our findings indicate that cultivating support for green infrastructure in disadvantaged neighbourhoods will require parallel efforts to redress inequality.

1. Introduction

Green infrastructure is receiving growing international attention as a way to improve the environmental performance and liveability of cities. Increasingly, green infrastructure is regarded as a potential intervention to help adapt built environments to increased heat associated with climate change (Gaffin, Rosenzweig, & Kong, 2012). Green infrastructure refers to vegetation that is intentionally managed to benefit humans (e.g. open spaces, parks, street trees, green roofs and walls) (Beer, 2010; Byrne, Lo, & Jianjun, 2015). Green infrastructure is said to provide a range of biogenic services including: modulating ambient temperatures (Alexandri & Jones, 2008; Hall, Handley, & Ennos, 2012; Hamada & Ohta, 2010), lessening stormwater runoff, intercepting particulate pollution (Byrne et al., 2015), sequestering carbon, attenuating noise pollution (Tiwary et al., 2016), and fostering biological diversity (Tzoulas et al., 2007). These services have been linked to a range of positive social outcomes, such as reduced energy consumption (Akbari, Pomerantz, & Taha, 2001), improved public health (Wolch, Byrne, & Newell, 2014), enhanced economic productivity (Matthews, Lo, & Byrne, 2015) and improved neighbourhood amenity (Watkins, Palmer, & Kolokotroni, 2007).

Urban greening initiatives may offer the capability to adapt some built environments to heat-related impacts of anthropogenic climate change (Moser, 2010). Green infrastructure can potentially also remedy some of the unintended consequences of urban densification (hereafter urban consolidation). Specifically, increased residential densities often

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http://dx.doi.org/10.1016/j.apgeog.2017.10.002
Received 23 February 2017; Received in revised form 24 September 2017; Accepted 1 October 2017

mean less vegetation, more impervious surfaces and higher temperatures (e.g., from transportation, building cooling and heat absorption). These elements combine to increase the frequency and intensity of extreme heat events and exacerbate the vulnerabilities of urban dwellers in a warming climate, with deleterious consequences for human health and wellbeing (Lee & Maheswaran, 2011; Weber, Sadoff, Zell, & de Sherbinin, 2015).

The cooling potential of green infrastructure is promising. Evidence suggests that increasing tree canopy cover by up to 5% may reduce diurnal temperatures by as much as 2.3 °C (Hall et al., 2012; Hamada & Ohta, 2010). Some studies report that densely greening parking lots could achieve in-situ cooling of up to 7 °C (Onishi, Cao, Ito, Shi, & Imura, 2010). Green walls and roofs have been reported to potentially cool built environments by up to 8 °C (Alexandri & Jones, 2008). And greenspaces as small as 0.24 ha are reportedly able to reduce temperatures by as much as 6.9 °C (Oliveira, Andrade, & Vaz, 2011). Such cooling may translate into reduced energy consumption, especially for cities in hotter climates. Akbari et al. (2001, p. 296) for example, have noted that: "electricity demand in cities increases by 2–4% for each 1 °C increase in temperature". Moreover, urban greening may reduce mortality during heatwaves. Researchers have reported health impacts from heatwaves across different cities in different climates. For example, for every 1 °C increase in temperature above 21.5 °C in London, Kovats, Hajat, and Wilkinson (2004) reported an associated increase mortality up to 3% among very young and elderly. Similarly Gouveia, Hajat, and Armstrong (2003) reported a 2.6% increase in mortality above 20 °C in São Paulo; and Son, Lee, Anderson, and Bell (2012) note a 3.5% increase in heatwave-related mortality for every 1 °C increase in temperature above daily averages for several Asian cities, including Seoul. Green infrastructure may thus potentially reduce health-care and energy expenses.

However, for the benefits of green infrastructure to be distributed equitably, it is vital that urban greening be planned with social justice outcomes in mind. There is a longstanding environmental justice literature documenting how marginalised and vulnerable communities (e.g. ethno-racial groups and low-income earners) are disproportionately exposed to greater environmental harms (e.g. landfills, polluting factories and contaminated sites) and have reduced access to environmental benefits, including greenspaces (Byrne, 2017). The concept of climate justice has been used to trace global spatial dynamics in the distribution of environmental goods and harms (Adger, 2001). In the urban context, the unequal distribution of greenspace can exacerbate the vulnerability of already disadvantaged residents (Steele, Maccallum, Byrne, & Houston, 2012). Following Weber et al. (2015), we conceptualise vulnerability to heat stress as a function of residents' exposure to high temperatures combined with their sensitivity to such temperatures, in the absence of adaptive capacity (i.e. the their ability to prepare for, respond to, and cope with extreme heat (see Fig. 1)).

A concern with socially just outcomes from green infrastructure also directs attention to potential problems arising with urban greening activities. For a start, some of the recognised services of urban greening may have paradoxical effects. For example, the ability of urban greening to lower wind speeds may reduce pollution dispersal (Salmond et al., 2016). Green infrastructure may also create a range of disservices, such as vegetation-related hazards. These range from human health and safety (e.g. pollen allergies and tree limb fall), to engineering and design (e.g. traffic hazards, damage to buildings and soil desiccation) to environment (e.g. fire risk, wildlife behaviours and obstruction of views) to legal (e.g. conflict between neighbours, jurisdictional disputes and public liability) concerns (Davison & Kirkpatrick, 2014; Mortimer & Kane, 2004; Roy, Byrne, & Pickering, 2012). The provision, apportioning and opportunity-cost associated with economic and other resources invested in green infrastructure may also have social justice implications (Braverman, 2008). Furthermore, deprivation may actually accentuate one's perception of the disamenities associated with urban trees and other vegetation (Kirkpatrick, Davison, & Daniels, 2013; Kitchen, 2013; Lohr, Pearson-Mims, Tarnai, & Dillman, 2004).

Although a growing body of green infrastructure research has focused on inner-city locales, less research has examined suburban environments. This knowledge gap is particularly acute for Australian suburbs, where most Australians live – but also for North American, some South American cities, and South African cities with proportionally higher suburban populations. Over the past two decades, many Australian suburbs have been transformed by urban consolidation, with backyards subdivided for new housing, leaving little or no yard space (Hall, 2010). Scant attention has been given to the combined effects of urban consolidation and climate change on lower-income residents in the suburban fringe, including heat island impacts and rising energy prices (associated with cooling homes) due to reduced tree canopy cover (Mitchell & Chakraborty, 2015). This paper speaks to these knowledge gaps through a place-based analysis of a working class suburb in Australia, where urban consolidation priorities and reduced greenery combine to shape and condition suburban design and thermal comfort.

The study has three aims: to assess whether social disadvantage[1] is associated with (1) concern about climate change impacts; (2) perceptions about the potential of green infrastructure to offer potential climate-adaptive benefits; and (3) the desire for more urban greening in a working class suburb. The findings of our study offer new evidence about the capacity of green infrastructure policy and practice to create climate-just cities. In what follows, we overview the findings from studies assessing thermal inequity (Section 1.1), present our hypotheses (Section 1.2), outline the materials and methods employed (Section 2), and report the results of our study (Section 3). In Sections 4 and 5 we discuss these results, offer policy suggestions, and identify questions in need of further research, particularly within geography.

1.1. Green infrastructure and thermal inequity

A now considerable environmental justice literature suggests that greenspaces in many cities are unequally distributed. This has implications for urban heat (Mitchell & Chakraborty, 2014, 2015). While a detailed review of that literature is beyond the scope of this paper, a comprehensive review by Byrne (2018) concluded that, aside from a few notable exceptions, patterns in the inequitable socio-spatial distribution of urban greenspace – including green infrastructure – are internationally consistent. Greenspace disparities have been observed in the United States, Canada, China, South Africa, India and Australia – among other countries (Wolch et al., 2014). A growing literature on energy poverty and thermal inequity points to similar disparities. Byrne and Portanger (2014, p. 315) for example, found that: '[h]igher electricity costs associated with 'climate proofing' energy network infrastructure may exacerbate 'fuel poverty''. Similarly, Bickerstaff, Walker, and Bulkeley (2013) observed that climate change and energy generation produce spatially uneven impacts that disproportionately harm marginalised and vulnerable populations (also see Fuller & McCauley, 2016). And Steffen, Hughes, and Perkins (2014, p. 20) have observed that climate change is increasing the frequency and intensity of heatwaves, heightening their 'impacts on people, property, communities and the environment', in turn driving increased energy use for thermal comfort.

Surprisingly, less research has investigated the nexus between

[1] Throughout this study the expression 'comparatively disadvantaged residents' is a measure of socio-economic disadvantage related to fuel poverty and captures an energy cost-induced burden, which is very relevant for the study. It is used to refer to residents who spend a higher percentage of their income on energy. This is operationalized using the variable 'Resident's percentage of household income spent on energy' (0.23%–26.96%) described in Table 1. Pairwise correlations are included as additional supplementary material to provide interested readers with more information on the characteristics that correspond to being comparatively disadvantaged.