Urban Transformations

PERSPECTIVE

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Nature can cool cities, but proceed with caution

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Abstract

Increased extreme heat events draw attention to the potential of urban nature as a heat adaptation strategy for cities. This is reflected in multiple scientific perspective pieces, policy documents and science media publications advocating for urban greening as a cooling approach. Although attention to the dangers of heat and the benefits of urban nature is welcomed, it is vital that nature-based approaches to cooling are underpinned by diverse knowledge and a sound understanding of what nature in cities can and cannot do. We explain why an evidence-driven and cautious approach to heat adaptation through urban greening is so important, and propose three actions that urban actors can take towards effective and equitable long-term cooling through urban nature: enabling dialogue between different sectors with multiple remits; including diverse knowledge systems in planning and governance processes; and investing in long-term stewardship for the climatological and societal conditions of the coming decades.

Policy and practice recommendation

- Create fora for dialogue between governments, residents, civil society and developers from planning stage for green cooling;
- Cooling through nature must be driven by expertise spanning diverse knowledge systems, combined with local knowledge and community needs;
- Consider future climates and stewardship when planning urban cooling via nature.

Science highlights

- Understanding link between urban thermal environment and nature is an inter- and transdisciplinary task;
- Critical need for evidence of how greening reduces heat impacts across different social and cultural contexts;
- Evidence of how species perform under future climates required for stewardship of urban nature.

Keywords: Climate change adaptation, Nature-based solutions, Urban greening, Urban heat, Urban planning

Rising interest in cooling through urban greening

Along with annual summer heat events in the Northern Hemisphere comes growing societal attention to the potential of trees, parks and other greenery to mitigate heat island effects. This was well illustrated during the extreme heat events in North America and Europe in summer 2021 and 2022. At this time, the science and environment sections of outlets such as the New York Times (New York Times 2021) and Reuters (Reuters 2022), as well as specialist scientific press such as *Nature* (Nature 2021), advocated for the proliferation of urban greenery as a cooling strategy for cities. Attention to the cooling potential of trees is leading to policy proposals aimed at urban planners and governors. This is seen in calls in Vancouver and London for rapid tree-planting targeted at the most vulnerable areas (Greater London Authority, 2022; Vancouver City Planning Commission 2021) and the inclusion of cool shelters and targeted greening in Barcelona's climate plan (Barcelona City Council 2018). Funders of applied and transdisciplinary research are also showing interest, with funding schemes and projects at the interface between human wellbeing, urban nature, and cooling (e.g. JPI Urban Europe 2022; Wellcome Trust 2023).

Rising science-policy interest and funding priority has led to significant enthusiasm for inter- and transdisciplinary research and experimentation into urban greening for cooling. Such activity is welcome, and brings fresh perspectives on how urban nature can help to reduce harm under extreme heat. Nonetheless, it is vital that actors and institutions who are new to engaging with urban cooling through nature temper their enthusiasm with acknowledgement of what is already known – and what is not known – across scholarly literature, professional knowledge and expertise, and local experiences and knowledge. It is also crucial that interest in nature-based cooling recognises the limitations imposed by local climatic and ecological conditions, social and political structures, and urban planning processes. In this Perspective, we offer several reasons for caution over the cooling potential of urban greenery, and suggest avenues of enquiry that city planners, governors, developers, researchers and residents working together for the first time or engaging in new approaches to keeping their cities cool through urban greening can take to support an evidence-informed approach.

Grounds for caution

Urban greening can undoubtedly offer cooling benefits (Iungman et al. 2023). However, as we now outline, a range of social and environmental factors can limit the effectiveness of nature-based cooling if not fully considered at the planning and implementation stage.

Paying attention to multiple knowledge systems and experiences matters

Plans for cooling through urban greenery must be informed by scholarly evidence and professional expertise spanning a breadth of academic disciplines, as well deep understanding of residents' local knowledge of the neighbourhoods they live in. Different approaches, species and greenspace configurations may deliver different cooling effects (Yu et al. 2020). Effective cooling requires integrated consideration of insights from landscape architecture, arboriculture, spatial planning and many more areas of knowledge.

Trade-offs may be required between cooling benefits and other ecosystem services that landscape features are expected to provide, such as rainfall retention or biodiversity enhancement (Meerow 2019). In a conceptual study focusing on irrigation of urban greening for cooling, Cheung et al. (2022) argue that effective management requires consideration of soil properties, flora and fauna ecology, and types of amenity use. For irrigation alone, expertise from at least three diverse fields – social science, ecology, and behavioural studies – is thus required to develop a technically appropriate management strategy for nature-based cooling. Likewise, in empirical research in Melbourne, Australia, Sanusi and Livesley (2020) find a tree species selected for its hardiness and ability to survive in harsh urban environments – the London Plane – loses its leaves quickly in heatwave conditions. Sanusi and Livesley hence hold that a research evidence base spanning tree species selection, soil water availability, irrigation and street orientation among others is important if trees are to deliver cooling to residents.

Moreover, greening for cooling can even bring 'ecosystem disservices' such as allergens, reduction in pollution dispersion, or safety concerns at night (Roman et al. 2021). Engaging the knowledge and experience of residents is important if local concerns or preferences are to be embedded within planning and implementation, and can help to identify species and configurations that may be appropriate to the local environment (Barron et al. 2021). Indeed, in Vilnius, Lithuania, Misiune et al. (2021) find that although residents value the regulating services that green spaces provide, concerns over safety discourage some groups from visiting parks. Initiatives to cool the urban environment which do not pay attention to the technical complexities of nature-based cooling, or fail to recognise how residents experience their own urban green spaces, may thus stand a lower chance of reducing heat risk.

City-wide visions need to be implemented and not fragmented

City-wide greening visions will not necessarily lead to effective cooling if their implementation is fragmented. Effective cooling requires coordinated practical actions at the city scale, thinking not only about immediate cooling from nearby parks and trees, but also the effects of wind corridors and greenspace connectivity. Linear greenspaces can provide ventilation passages to allow cooling air to flow through the city; parks and open spaces can aid wind flow; and trees and smaller greenery can cool neighbourhoods (Hebbert 2014). A city-wide approach also entails understanding how different species and ecosystems may be affected under a changing climate, and planning and planting species that will be suited to local climatic conditions in the coming decades (Esperon-Rodriguez et al. 2022).

A good example of whole-city thinking is Stuttgart in Germany, which coordinated planning to strategically conserve and connect green spaces across the city to rehabilitate natural ventilation for channelling air pollutants and heat from the city (Hebbert 2014). Conversely, although Tokyo in Japan engaged with urban climatological planning through the mid-2000s, the relaxation of rules on constructing tall buildings meant sea breezes were blocked and urban temperatures increased (Webb 2016). This shows how city-wide visions for cooling may not reach their full effectiveness if implemented in a partial or fragmented way – especially if, like Tokyo, implementation requires economically difficult decisions to be taken that could restrict urban development. Indeed, the

fact that few cities beyond exemplars like Stuttgart have implemented urban climatological planning or city-wide cooling programmes (Pedersen Zari et al. 2022) illustrates the difficulty of attaining such strategies in practice. City plans for land use, green- and open space plans, and climate change adaptation are often produced by different government departments. Opportunities for dialogue and collaboration may be limited (Mabon and Shih 2021). As Hebbert (2014) notes, a good scientific understanding of the urban climate and the creation of a spatial urban climate plan alone will not deliver urban cooling if issues such as regulation of property rights for environmental ends and giving plans regulatory effect are not taken into account.

What works varies from place to place

The components of an effective cooling strategy vary from place to place (Keith et al. 2021). In comparison to the literature on European and North American city contexts, the English-language peer-reviewed evidence base for the effects of greening on urban thermal environments – and urban climate risk more broadly – is limited in low-to-middle-income countries and at lower latitude contexts. This evidence gap is especially concerning for international city-to-city learning given that high urbanisation rates, income inequalities, informal settlements and lack of state capacity may pose challenges for nature-based adaptation in lower-latitude contexts (Kato-Huerta and Geneletti 2023; Lin et al. 2021). This lack of contextual knowledge may mean that recommendations of how to adapt to heat through urban greening are not appropriate to different contexts globally. For instance, public green spaces are often promoted in temperate cities as green refuges from extreme events such as heat (UNEP 2020). However, Saw et al. (2015) argue in the case of Singapore that heat and humidity forces urban dwellers away from green spaces and into air-conditioned spaces; and Claris Fisher et al. (2021) find for Georgetown in Guyana that residents may be more likely to use private green spaces rather than visiting public green spaces. Both cases illustrate the importance of in-depth and context specific knowledge for understanding how practices that are advocated in Western-focused research may not be appropriate to different climatic and urban development contexts. This lack of context-specific evidence is especially acute for smaller cities in which many people globally will experience climate extremes such as heat. Moves to promote nature-based cooling as a low-cost or no-regrets heat adaptation strategy for low-latitude or less wealthy cities must therefore be set against the recognition that there is still a paucity of peer-reviewed evidence in these settings.

Cooling benefits are not always distributed or planned equitably

The ultimate objective of cooling is to cool people rather than places. Benefit from nature-based cooling may differ across sections of society due to social and political factors; or due to the physical characteristics of green spaces. It has been demonstrated across different geographical contexts that disempowered or less well-off urban dwellers may be less likely to benefit from climate risk-reducing ecosystem services such as cooling (see e.g. Kim et al. (2021) on Seoul, Korea; Langemeyer and Connolly (2020) on Barcelona in Spain; and Venter et al. (2020) on sub-Saharan Africa). Explaining why this is requires us to look to the broader historical and political context, which the social sciences and humanities can help us to understand more fully. For instance, Lopez et al.

(2021) find for New York City at the height of the COVID-19 pandemic that safety and accessibility concerns discouraged residents from visiting green spaces, disproportionately affecting often marginalised groups such as Black and Latinx populations. Lopez et al. also argue, however, that redressing such inequalities requires attention to historical and structural factors – such as police presence and procedural justice issues—that lead to some groups of people feeling excluded or unsafe in green and open spaces in the first instance. Effective and equitable greening hence requires fairness in process (procedural justice) and recognition (recognitional justice) as well as outcome (distributional justice). Yet explicit consideration of equity and inclusion in planning strategies for urban greening, whilst improving, is still in cases limited (Grabowski et al. 2023; Gradinaru et al. 2023).

Moreover, design of green spaces does not always allow those most vulnerable to heat – older people, those with long-term conditions, disabilities and mobility impairments, and children (UK Health Security Agency 2022) – to be able to benefit from cooling. Wet or piled up fallen leaves can become a slip hazard for older people in autumn and winter (Sarkissian and Stenberg 2013). Urban planning and design processes do not always account for the longer walking times – and associated need for more shade and rest stops en route – that older people need when accessing green spaces (Baldwin et al. 2020).

Urban greening does not replace broad-based adaptation strategies and emissions reduction

Lastly, it is important not to place too much expectation on what urban nature can deliver. In line with the principles of the Nature-based Solutions Initiative (2021), urban greening for heat adaptation must be considered an addition to, and not a replacement for, rapid and sustained emissions reduction. Urban greening is only one of several strategies that ought to be used to reduce heat risk in cities, alongside engineering interventions in the built environment and public policy actions such as housing design, early warning systems for heatwaves, and cool-sharing spots. Urban greening helps to reduce exposure to heat but not vulnerability. It is hence important that 'community-led' urban greening initiatives in the name of societal resilience and climate risk reduction do not become a substitute for sustained and properly funded public health and social welfare programmes. Likewise, government-led urban greening initiatives do not negate the need for measures that reduce underlying drivers of vulnerability to heat, such as inability to afford electricity to power mechanical cooling, or geographical distance from and lack of transportation to cool spaces (Shih 2022; Thomson et al. 2019).

Towards effective and evidence-driven cooling via urban greening

The previous section illustrates why caution is required when considering urban greening as a cooling strategy. However, there are actions that those responsible for designing, implementing, managing and maintaining cooling interventions – local governments, researchers, developers, and residents themselves—can take towards a more evidence-informed and strategic approach to heat adaptation through urban greening.

Identify boundary concepts and focal points that allow different sectors to work together

Our first recommendation is identifying focal points that allow integration of remits and expertise within urban planning processes. In the previous section, we noted that effective cooling via urban greening requires a coordinated city-wide approach, but that this often proves difficult to realise. As it may be years if not decades before cooling benefits from new greenery planted today are realised, dialogue and coordination between sectors and integration of policies and plans to link urban, open space and climate adaptation plans is critical now to realise city-scale benefits in future.

An example of how this may be implemented in practice is Durban and the wider eThekwini Municipality in South Africa, where adaptation actions have connected sectors including (but not limited to) environmental planning and climate protection, land use, disaster prevention and management, and civil engineering (Leck and Roberts 2015). Durban's open space governance has had an important role in this process. Through a system known as D'MOSS (Durban Metropolitan Open Space System), the municipality enlarged its open space system to incorporate the concept of green infrastructure and ecosystem services. This means the city can use the urban planning system to protect a green network within the city, drawing on expert assessment to identify and protect natural spaces which bring a range of resilience benefits, including not only cooling but also water regulation, erosion control, nutrient cycling, waste treatment, food production, and raw materials (eThekwini Municipality 2017). Durban's climate action plan refers to the adaptation and ecosystem service values provided by D'MOSS, including cooling, and in turn has actions to identify green spaces that provide cooling services and to implement cooling pilots via strategic greening in vulnerable areas (eThekwini Municipality 2019).

eThekwini Municipality has hence been able to use ecosystem services as a boundary concept to frame D'MOSS and associated green infrastructure initiatives in terms of the economic contributions they provide to city finances, and also their role in social and economic development (Davids et al. 2022). This has helped to bring different sectors on-board to protect important green infrastructure and ecosystem services from loss and fragmentation. Conceptual approaches that make room for broad-based yet evidence-driven rationales for nature-based urban cooling may thus stand a heightened chance of success, especially if they can be embedded within focal points like urban planning systems that allow different sectors to build a common understanding of what the creation and protection of a city-wide green network looks like 'on the ground.'

As an extension of this, it is also possible to link city-wide data on green spaces with spatial data on the urban thermal environment and neighbourhood socio-economic characteristics. Doing so can help to identify heat-vulnerable neighbourhoods, and to identify specific locations where existing greenspaces require protection or where additional greening is required to ensure equitable cooling benefits from urban greening across the whole city. Indeed, local authorities in Durban have already carried out such heat vulnerability mapping (C40 Cities 2019); and adaptation planners in other urban areas such as Glasgow City Region have linked data on green coverage, thermal environments and socio-economics to identify heat-vulnerable areas for targeted greening interventions (Climate Ready Clyde 2021). As long as subsequent greening interventions are developed in consultation with communities and are not forced on neighbourhoods in

a way that is patronising or unwelcome, city-wide green network planning underpinned by a rigorous understanding of what specifically drives vulnerability in the local context (Shih and Mabon 2021) can be a useful tool for identifying locations where greening actions can most effectively be targeted to address uneven vulnerabilities to heat.

Guide planning and implementation processes with a blend of knowledge systems

Our second, related, recommendation is to ensure that expert-driven planning and implementation processes for nature-based cooling are guided by a blend of knowledge systems. This entails engaging not only the natural and social sciences, but also the arts and humanities as well as local knowledge and community engagement and co-design practices. In the previous section, we highlighted the limitations of cooling strategies that do not reflect residents' experiences of the green spaces around them, and of overlooking the societal context that can make some people more vulnerable to heat than others in the first instance. It is therefore vital that calls for city 'heat officers' (Keith et al. 2021) or chief scientists (City of Edmonton 2018) reflect the breadth of knowledge systems that contribute to an effective response to heat risk, and also reflect locally-produced knowledge.

A good example of how participatory approaches grounded in the arts and humanities can aid with urban greening for cooling is the cooperation of the city of Ghent in Belgium with an embedded artist and with local arts organisations in the management of urban greenspaces for heat risk reduction and wider climate adaptation. The value of bringing arts-based approaches into adaptation action in the Ghent case came through the ability of the embedded artist to bring technically-driven urban planners out walking in urban green spaces, and to facilitate conversations with residents in ways that traditional consultation processes did not allow. In practice, this led to new ideas for how to change paving surfaces in one of the city's parks, and gave urban planners and environmental managers a chance to experience the spaces they were managing 'on the ground' for the first time (Cultural Adaptations 2021). Arts, humanities and social science expertise can thus act as a conduit for linking techno-scientific knowledge with residents' local knowledges and lived experience, and can help to create different fora for making decisions that flattens power hierarchies.

When it comes to international learning and understanding what effective nature-based cooling may look like in parts of the world for which limited evidence exists, it is important to remember that rigorous studies and evidence may exist in languages other than English, or may lie outside of the peer-reviewed international literature. Evidence libraries ought to be expanded to include non-English sources (Callaghan et al. 2021), and academic editors and authors in more empowered nations can provide support to enable researchers in different global contexts to navigate the peer review process (e.g. helping to source peer reviewers familiar with local contexts). Doing so will enrichen and diversify the global evidence base for nature-based cooling by providing locally-produced and contextually appropriate evidence for regions of the world that are under-represented in English-language scholarly literature. There is also value in looking beyond 'exemplars' or 'success stories'. Projects that have faced multiple challenges during their delivery, or which may have failed completely, can equally provide valuable insights for different locations globally.

Taking a long-term view for stewardship and green jobs

The third action that actors responsible for implementing and maintaining urban greening for cooling can take is to adopt a long-term vision. In the previous section, we cautioned against expecting too much of urban nature for cooling, and of ensuring that actions are guided by the best available evidence. At a global level, the various texts produced by the IPCC's Sixth Assessment Cycle have made clear the dangers of maladaptation, which refers to actions that may – often unintentionally – increase or shift vulnerability or lead to more inequitable outcomes (IPCC 2022). These ideas are relevant too when we think about nature-based approaches to cooling at a neighbourhood and city level. Avoiding maladaptation in nature-based cooling means paying cognisance to the climate and also the society and economy of the future. Trees and greenery planted today need to be able to thrive and deliver cooling benefits under the changing climates we will see in coming decades, which means considering not only species but also factors such as water use and retention (Esperon-Rodriguez et al. 2022).

Creating opportunities for residents to get involved in the creation and management of green spaces, such as forming local user groups, can help to foster a sense of stewardship and ensure that ecosystem functions are sustained long-term (Andersson et al. 2014). There is also a role for more formal and structured investment and training. For example, developing training courses and qualifications with local educational establishments can provide a future skilled workforce to manage green infrastructure and ensure it retains its functions in the face of a changing climate. However, it is vital that measures for both formal maintenance job creation and local stewardship follow the principles of a just transition, and take into account differences in capabilities, resources and structural inequalities which lower income communities may be faced with (ILO/UNEP/IUCN, 2022). Studies have shown, for example, that coal sector workers in India (Majumdar et al. 2023) or former heavy industry workers in Glasgow (Mabon 2023) could find fair and decent work in urban nature-based solutions for climate adaptation if support to allow less well-off workers to participate in appropriate retraining was put in place.

There is also need to develop business models that support ongoing revenue funding for the maintenance of green infrastructure beyond short-term capital investment (Mell 2020). Finally, population dynamics change over time. Urban greening interventions designed now will, in many Western countries at least, be providing for an increasingly ageing and in cases declining population (Baldwin et al. 2020). Thinking about how our cities will change over the coming decades, and embedding this in planning and decision-making, will help to ensure the heat risk reduction contributions of urban nature in future are appropriate to the characteristics and requirements of future populations.

In sum: retain a cautious and evidence-driven approach, and manage expectations

Nature-based approaches to cooling cities are not a silver bullet, but one strategy among a range of technical and social interventions that can be used to adapt to rising heat. Cooling is potentially only one of a number of ways in which urban dwellers may see value in the green spaces around them, and these multiple benefits may need to be balanced and considered holistically. Thinking systemically about the contributions urban

greening brings to people is especially important if we consider that some of these other benefits aside from cooling – such as health, wellbeing and societal interaction – can also help to build neighbourhoods' resilience to extreme heat events. Amidst growing enthusiasm for urban greenery as a strategy to counter heat in cities and an influx of new perspectives and insights from both research and practice on how nature can support cooling, it is vital to retain a cautious and evidence-driven approach and to manage expectations about the extent to which extreme heat events can be mitigated by urban greening.

Acknowledgements
Not applicable.

Authors' contributions
LM: Conceptualization; Investigation; Project Administration; Resources (references and examples); Writing—Original Draft; Writing—Review & Editing. BC: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. AM: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. CP: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. EP: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. WYS: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. MCT: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. JV: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. RW: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing. VW: Conceptualization; Investigation; Resources (references and examples); Writing—Review & Editing.

Funding
The research on which this contribution is based is funded by the British Academy (KF6220287) and the Economic and Social Research Council (ES/W000172/1).

Availability of data and materials
There is no data on which this Perspective is based.

Declarations

Competing interests
The authors have no competing interests to declare and do not stand to benefit financially or otherwise from the content of the paper.

Received: 17 April 2023 Accepted: 6 September 2023
Published online: 21 September 2023

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