Urban design and planning for extreme heat: an empirical study of built environment professionals' perceptions in South East Queensland, Australia

Article *in* Cities & Health · December 2023

DOI: 10.1080/23748834.2023.2290901

CITATIONS
2

READS
62

3 authors, including:

Ryan McNeilly Smith
University of the Sunshine Coast
1 PUBLICATION **1** CITATION
SEE PROFILE

Silvia Tavares
University of the Sunshine Coast
51 PUBLICATIONS **262** CITATIONS
SEE PROFILE

Cities & Health

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rcah20

Urban design and planning for extreme heat: an empirical study of built environment professionals' perceptions in South East Queensland, Australia

Ryan McNeilly Smith, Silvia Tavares & Nicholas Stevens

To cite this article: Ryan McNeilly Smith, Silvia Tavares & Nicholas Stevens (22 Dec 2023): Urban design and planning for extreme heat: an empirical study of built environment professionals' perceptions in South East Queensland, Australia, Cities & Health, DOI: 10.1080/23748834.2023.2290901

To link to this article: https://doi.org/10.1080/23748834.2023.2290901

Published online: 22 Dec 2023.

CITIES & HEALTH
https://doi.org/10.1080/23748834.2023.2290901

Routledge
Taylor & Francis Group

ORIGINAL SCHOLARSHIP

Urban design and planning for extreme heat: an empirical study of built environment professionals' perceptions in South East Queensland, Australia

Ryan McNeilly Smith, Silvia Tavares and Nicholas Stevens

Bioclimatic and Sociotechnical Cities Lab, University of the Sunshine Coast, Sippy Downs, Australia

ABSTRACT

Extreme heat is currently Australia's deadliest natural hazard. The intensity of heat events is increasing due to climate change, and further exacerbated by urban heat islands. Urban design and planning solutions can assist in reducing heat-health risks, but they are rarely implemented. Through semi-structured interviews and an online survey, we investigated the role of such solutions in planning and urban design practice in South-East Queensland, Australia. The results showed planning professionals had lower awareness of the role urban design and planning played in heat mitigation and adaptation strategies compared to urban designers and architects. Continued professional development and a greater inclusion of heat mitigation design provisions in Queensland's planning system and Australian planning education are outlined as future requirements.

ARTICLE HISTORY
Received 6 April 2023
Accepted 29 November 2023

KEYWORDS
Urban heat Island; heatwaves; urban climate; climate adaptation; urban design; Queensland

Introduction

Often referred to as a 'silent killer' (Queensland Government 2019), extreme heat and heatwaves can have severe human health effects (Ebi *et al.* 2021) and cause 55% of all natural hazard-related fatalities in Australia (Coates *et al.* 2014). The impacts of these events are only expected to increase (IPCC 2022), and government jurisdictions at all levels understand the need to address the urban impacts of climate change. Other research has investigated the levels of urban climate awareness and adaptation between different professions (Lenzholzer et al. 2020a, 2020b). This work focuses on the South East Queensland region in Australia and explores built environment professionals' perceptions of their own roles in mitigating these heat-health risks. For the purposes of this work, built environment professionals includes urban planners, urban designers, landscape architects and architects.

We refer in this work to urban design as the profession responsible for designing public spaces to impact upon human experience and use of these urban areas considering their arrangement, appearance, and function (McMahon 2018); and urban planning as the profession focused on strategically shaping and managing cities, land use, spatial morphologies, resource distribution, and economic and social interactions (Huxley 2009). In its essence, urban design is technical, while urban planning is strategic. Urban design can reduce risks associated with heatwaves, including health risks, as the design solutions relate to surfaces' albedo, urban canopy cover, optimisation of air flow and reduction of solar exposure, however, such approaches are rarely a priority for implementation (Fernandez Milan and Creutzig 2015). Urban planning is responsible for ensuring that the built form is conducive to urban cooling, particularly through building heights, setbacks, and breeze corridors (Ng *et al.* 2011).Whereas, climate-responsive design in the building scale is well-understood (Oke 2006, Erell *et al.* 2011), there is less focus on climate-responsive urban design and planning, focusing on the public realm. In this context, this work investigates awareness levels of urban heat, extreme heat and heat-mitigation techniques, in addition to how these topics are being addressed in urban design and planning practice by built environment professionals within South East Queensland. In doing so, we explore the resources and policy guiding the work of built environment professionals in South East Queensland and the policies required to further the uptake and implementation of evidence-based responses to heat hazards in a growing region.

Background

Heatwaves and health

Heatwaves can present serious risk to human health and public and private infrastructure, and their increasing intensity and frequency places populations

CONTACT Ryan McNeilly Smith Ryan.McNeillySmith@research.usc.edu.au Bioclimatic and Sociotechnical Cities Lab, School of Law and Society, University of the Sunshine Coast, Sippy Downs, QLD 4556, Australia

at risk (IPCC 2022). In Australia, the Bureau of Meteorology defines a heatwave as three or more days of high maximum and minimum temperatures that are unusual for a given location (Bureau of Meteorology 2016). Urban heat island (UHI) effect (Oke 1973) amplifies heatwaves (Rogers *et al.* 2018) and exacerbates heat-health risks (Campbell *et al.* 2018).

Health impacts of heatwaves include heat-related illnesses ranging from mild dehydration to potentially fatal severe heatstroke (Campbell *et al.* 2018). Very young and elderly have lower thermoregulatory capabilities, increasing risk of death. Individuals with mental health conditions may have reduced physiological and behavioural thermoregulatory capabilities, and other health factors affecting heat strain include alcohol consumption and certain medications (Ebi *et al.* 2021).

Culturally and linguistically diverse individuals may lack social networks and access to information about extreme heat events (Hansen *et al.* 2014); similarly for the elderly (Zografos *et al.* 2016), which compounds their risk as they are also likely to have comorbidities (Loughnan *et al.* 2015). Compounding many factors mentioned above, communities with low-socioeconomic status may also live in houses of poor quality (Zografos *et al.* 2016) and in warmer neighbourhoods (Harlan *et al.* 2006).

The extent to which someone's health is ultimately impacted by heat is dependent upon the environment they are in. On a local scale, this is influenced by microclimatic factors, such as temperature, light, wind speed and moisture (Naiman *et al.* 2005). There are a range of microclimate variables contributing to urban heating, including solar radiation, wind and evapotranspiration (Brown 2010, Chatzidimitriou and Yannas 2016). These microclimate factors and variables can be affected by urban planning and amended by design.

Urban design, planning and heat mitigation

Urban design interventions are important in mitigating these risks and reducing urban heat. Layout and form of urban spaces – their geometry – can influence temperature and airflow. Building orientation and street geometry influence microclimate, with certain solutions more suitable than others in cooling urban environments (Lobaccaro *et al.* 2019, Zhang *et al.* 2019, Miao *et al.* 2020). Urban greening also provides benefits under certain conditions, as vegetation provides thermal relief via evapotranspiration and shading (Speak *et al.* 2020). Denser plantings with large canopies offer greater thermal performance (Sharifi and Boland 2017, Macleod *et al.* 2019). Cooling benefits beyond the immediate area are dependent on airflow, typically being felt downwind of green spaces like parks (Motazedian *et al.* 2020), however, under low wind conditions, this type of cooling is limited (Clay and Guan 2020). Green roofs require extensive plantings and appropriate irrigation (Razzaghmanesh *et al.* 2016) to have significant cooling impact (Peng and Jim 2013, Zhang *et al.* 2019). Emerging data on green walls found correlation between decreased urban heat and green wall vegetation (Palermo and Turco 2020), however, this may be limited to short distances (1 metre) from the wall itself (Shafiee *et al.* 2020).

Winds and breezes can assist in regulating temperatures (He *et al.* 2020a), however their cooling mechanics is dependent upon built form geometry and climate conditions (He *et al.* 2020b). Careful usage of surface albedo can contribute to lowering temperatures, while ensuring built objects do not become heated (Lobaccaro *et al.* 2019). Water bodies have historically been used as a heat mitigation solution in urban environments (Steeneveld *et al.* 2014). However, their ability to cool spaces is dependent on variables such as size, water movement, shading and spatial-relation to surrounding built form, and may be negligible or even contribute to heating spaces during the night and under certain climatic conditions (Steeneveld *et al.* 2014, Jacobs *et al.* 2020). Urban design and planning outcomes can be achieved via regulatory or discretionary measures (Punter 2007, White 2015).

Urban design and planning for an improved microclimate in South East Queensland

In South East Queensland, regulatory measures which can influence microclimate outcomes include statutory policies and codes, like state planning policies and planning schemes. The primary regulatory measure in Queensland is the state's land-use planning framework, established by the Planning Act 2016 (Qld). The State Planning Policy (SPP) is one piece of subordinate regulation sitting under the Planning Act. This policy expresses the Queensland Government's interests in land use planning and development through state interests. Under this performance-based planning system, local planning schemes have the most influence on the resulting microclimate, as they allow local and site-specific matters to be addressed. The design and implementation of the aforementioned state planning framework is the responsibility of the State Government's planning department and officers, while local government planning officers are responsible for the development of local planning schemes and assessment of developments lodged under these schemes. While any landholder can make a development application, it is most often done by private planning consultants who operate on behalf of a landholder.

Beyond the statutory planning functions, discretionary measures include principled or place-based design guidelines. They outline principles and strategies seeking to achieve high-quality design outcomes based on climatic, environmental, and social considerations important to a place. In South East Queensland, these are found in documents such as *Sunshine Coast Design Book* (Sunshine Coast Council 2020) and *Buildings that Breathe* (Brisbane City Council 2016). A consistent theme within these documents is designing for local climate and climate-responsive design. However, a common critique is that they are too abstract and aspirational for professionals to achieve the desired outcomes (White 2015).

Research design

This work was based on a multi-method research design (Schoonenboom and Johnson 2017) which used an online survey targeted to built environment professionals and semi-structured interviews with built environment professionals, all working within South East Queensland.

To understand how built environment professionals perceive the relationships between extreme heat, heat-health risks and urban design, this work covers four overarching themes: 1) extreme heat and professionals' awareness and practice; 2) resources for urban heat-mitigation; 3) the planning system and the Queensland State Government's role; and, 4) urban design solutions.

Built environment professionals' perception of extreme heat has implications for how, or whether, they consider it when creating new policies or assessing a new development. Insights into resource types, such as policies or guidelines, that built environment professionals use in their practice to mitigate heat risks in urban environment assists in understanding levels of awareness and decision-making processes. This is complemented by understanding practitioners' perception of the Queensland State Government's role as the planning regulator and its role in mitigating heat-health risks. There are also several types of urban design solutions which built environment professionals can implement to mitigate heat in the public realm and reduce heat-health risks, and this study sought to understand perception and implementation practices of different solutions. These urban design solutions were geometry, shading, vegetation, winds and breezes, materials/albedo and water (Chatzidimitriou and Yannas 2016).

Methods

The location of South East Queensland, Australia, was chosen as a case study. It is made up of 12 local government areas and is currently planning to accommodate 5.3 million people, an additional 1.9 million over the 25 years to 2041 (Queensland Government 2017). The region has a diversity of urban and peri-urban landscapes, such as metropolitan locations, coastal towns, agricultural townships, and rural villages. This diversity is also reflected in the region's heat vulnerability. The VHHEDA Index (Vulnerability to heat, poor Health, Hot spots, Economic Disadvantage, and Access to green space) (Amati *et al.* 2017) scores local governments on heat urban heat vulnerability, with a rank given out of five (0 being most vulnerable; 5 being least vulnerable). For instance, Brisbane received a score five, Moreton Bay and Sunshine Coast a scores of three and Toowoomba and Ipswich scores of two.

An online survey and semi-structured interviews were undertaken, targeted at built environment professionals who have worked in South East Queensland region for longer than six months. The survey received 38 eligible responses. Key respondent demographics are provided in Table 1. For the analysis, town and environmental planners are considered 'planners', while architects, landscape architects and urban designers are considered 'design centric professionals'. Three respondents listed their location as 'Other', stating they worked across multiple jurisdictions in South East Queensland. As they are still within the focus region, their responses were included in the analysis.

Questions for both methods were designed with these participants in mind and informed by current literature and planning and urban design policy in South East Queensland. Likert scale (1-5) questions and supporting

Table 1. Survey respondent professional and organisational affiliation.

	Affiliation	%	*n*
Profession	Architecture	4.88	2
	Landscape architecture	14.63	6
	Town planning	48.78	20
	Urban design	29.27	12
	Other[a]	2.44	1
Organisation type[b]	Public sector – Local government	52.63	20
	Public sector – State government	13.16	5
	Private sector	18.42	7
	Academia	15.79	6

[a]Environmental planning.
[b]Other possible responses included the following but received zero responses: 'Public sector – Federal government'; 'Not-for-profit', and 'Other'.

open-ended questions were used in the online survey. Recruitment occurred on social media (LinkedIn) and via direct emails to various organisations, including local councils, state government, and private consultancies operating in South East Queensland.

Recruitment for semi-structured interviews occurred initially through the authors' own professional networks, followed by snowball sampling (Johnson 2005). Ten built environment professionals were interviewed, with backgrounds in town planning ($n = 8$), architecture ($n = 1$) and landscape architecture ($n = 1$) from across levels of government, private sector, and academia. Questions contained in the semi-structured interviews were open ended, designed to draw on the professional's expertise.

NVivo was used to code written survey results and interview transcripts. The coding process described in Baldwin *et al.* (2020) was used, which produced a set of inductive and deductive codes refined through selective reduction. Open ended survey responses and interview transcripts were coded to deductive codes, which were based upon the literature reviewed, as well as inductive codes which emerged during the analysis process (Patton 1990). A subset of data was reviewed and coded to validate the initial set of deductive codes selected, and to establish emergent inductive codes. Once this first pass was complete, the entirety of the data was coded using both sets of codes.

Themes and quotes from the open ended survey questions and interviews were extracted and reported. Quantitative survey data (Likert scale) was cross-tabulated in Qualtrics and exported to Excel for data visualisation. To ensure anonymity, a code was attributed to each participant. Each code is constituted by letters and a number representing survey or interview, followed by profession initials and a numerical value within the total subset population. Survey and interview results are presented together as they followed a multi-method integrated analysis (Schoonenboom and Johnson 2017).

Results

The key themes identified in the survey and semi-structured interviews are summarised in Table 2. These key themes are presented in the next sections. Table

Extreme heat and professionals' awareness and practice

Respondents were asked questions related to their professional practice and how aware they are of the role design[1] has in mitigating the health risks of extreme heat; if they consider that extreme heat is a natural hazard that built environment professionals need to consider in their practice; and if heat mitigation design is an important part of their practice as a built environment professional. The following results therefore regard to professional's awareness of both their own role and the role of design strategies in addressing this issue.

Survey respondents were asked about their awareness of extreme heat, whether they consider extreme heat in their practice and whether they use heat mitigation measures in their practice. All design-centric professionals (n=20) reported they were aware of extreme heat and that they consider it in their practice, while only under two-thirds (63%) applied heat mitigation measures in their practice. While planners'(n = 20) awareness is lower and their perception of the need is almost the same, their usage in practice is considerably less (35%). Despite a uniformly high rate of reported awareness across all professions surveyed, reported implementation is lower among planners compared to design-centric professionals (Figure 1).

This was further emphasised by planners reporting low usage of heat mitigation techniques in practice. The results indicate that design-centric professionals had a better understanding of design's role in mitigating heat, *'UHI effect is all about being a good*

Table 2. Survey and interview focus and themes.

Overarching themes (Aims)	Sub-themes
Extreme heat and professional's awareness and practice	Increased awareness due to other climate-related planning and policy development
	Education and professional development
Resources for heat-mitigation	Existing statutory material
	Best practice heat-mitigation material
The planning system and the Queensland State Government's role	Limitations of statutory instruments
	Building code-imposed limitations
	Professional experience in subtropical and tropical settings
	Innovation at odds with regulation
	Lack of strategic policy position
	Inadequate implementation of heat-mitigation strategies
	Model policy examples
	Place-based design guidelines
	Data to support decision making
Urban design solutions	Climate-responsive urban design as business as usual
	Constraints – Vegetation
	Constraints – Shading
	Constraints – Material selection and albedo
	Constraints – Winds and breezes
	Constraints – Water

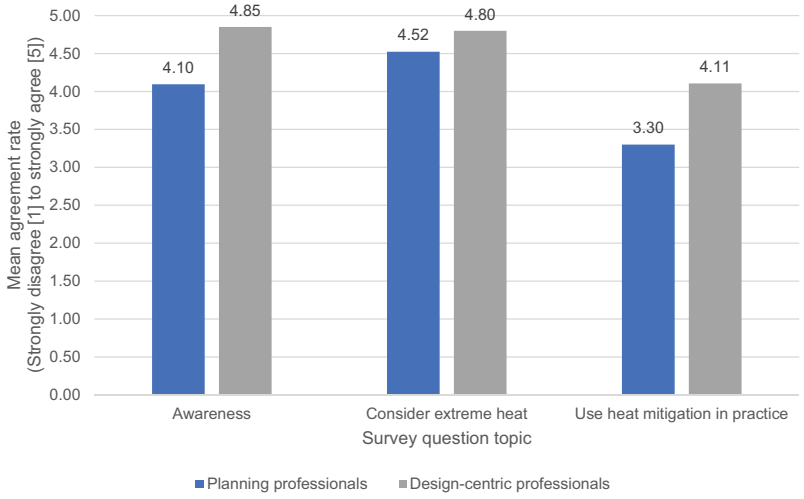

Figure 1. Practiced-related questions by profession group.

neighbour' (IA1), and during the interviews they were able to discuss a wide range of heat-mitigation techniques – unprompted – along with passive climatic design and UHI, noting these *'[have] always been a key consideration'* (ILA1). They expressed a drive to implement these techniques and find solutions to some of the impediments they face in implementation. This was contrasted by planners interviewed who spoke to heat-mitigation strategies, but many struggled to identify avenues for efficient implementation; one planner noting that heat is not something they consider in their practice day-to-day: *'not that I can think of (. . .) [not] in our daily work anyway'* (IP3).

Another theme to emerge from interviews related to increased awareness of climate change risks due to emergent climate mitigation and adaptation work, including Coastal Hazard Adaptation Strategies. These strategies enable local governments to gain a greater understanding of the vulnerabilities and risks to communities, infrastructure and the environment from present and future coastal hazards and embed this risk understanding into statutory planning processes (Local Government Association of Queensland & Department of Environment and Science 2023). Three participants (IP3, IP4, IP6) referenced having an increased understanding of climate change adaptation generally because of working on these coastal strategies being developed by many coastal councils in Queensland at the time of this study. For them, working on a Coastal Hazard Adaptation Strategies has brought to the forefront climate change-related hazards, making them reflect on those which are not just related to sea-level rise.

Resources for heat-mitigation

Respondents were asked about the resources (e.g. regulations, documents and literature) they use to mitigate heat risks through their professional practice. Survey respondents reported that the most frequent document they consulted was local government planning schemes, where 67% of respondents agreed or strongly agreed that they frequently used this type of document with the intention of mitigating heat risks in the built environment – mean response of 3.79 out of five (Figure 2). The 'Other' response had the third highest response; examples provided included *'future climate dashboard'* (S44) (Queensland Government 2021), *'international best practice guidelines'* (S42) and *'other state's and city's design guides'* (S7)

Regarding the use frequency of these documents and the types of documents used, planners focused their attention on statutory material, such as local planning schemes and the SPP. Whereas, design-centric fields read more broadly, considering heat-mitigation strategies from other regions, for example.

The planning system and the Queensland State Government's role

The study asked respondents whether they believe their ability to implement heat-mitigation techniques is limited by the current Queensland planning framework. The overall mean response for this question was 2.89 out of five. Architects agreed with this sentiment the most (3.50), followed by planners (3.07). Urban designers (2.64) and landscape architects (2.25) agreed with this the least. Regarding their organisation type, professionals in the private sector agreed with this question the most (3.33), followed by local government professionals (3.06) (Figure 3).

When asked to further explain their responses, differing views and themes emerged. One planner stated that *'heat mitigation is not a strong focus in the legislation and is therefore difficult to enforce'* (SP1). While an architect described the Queensland Development Code as a limiting factor, because *'the Queensland*

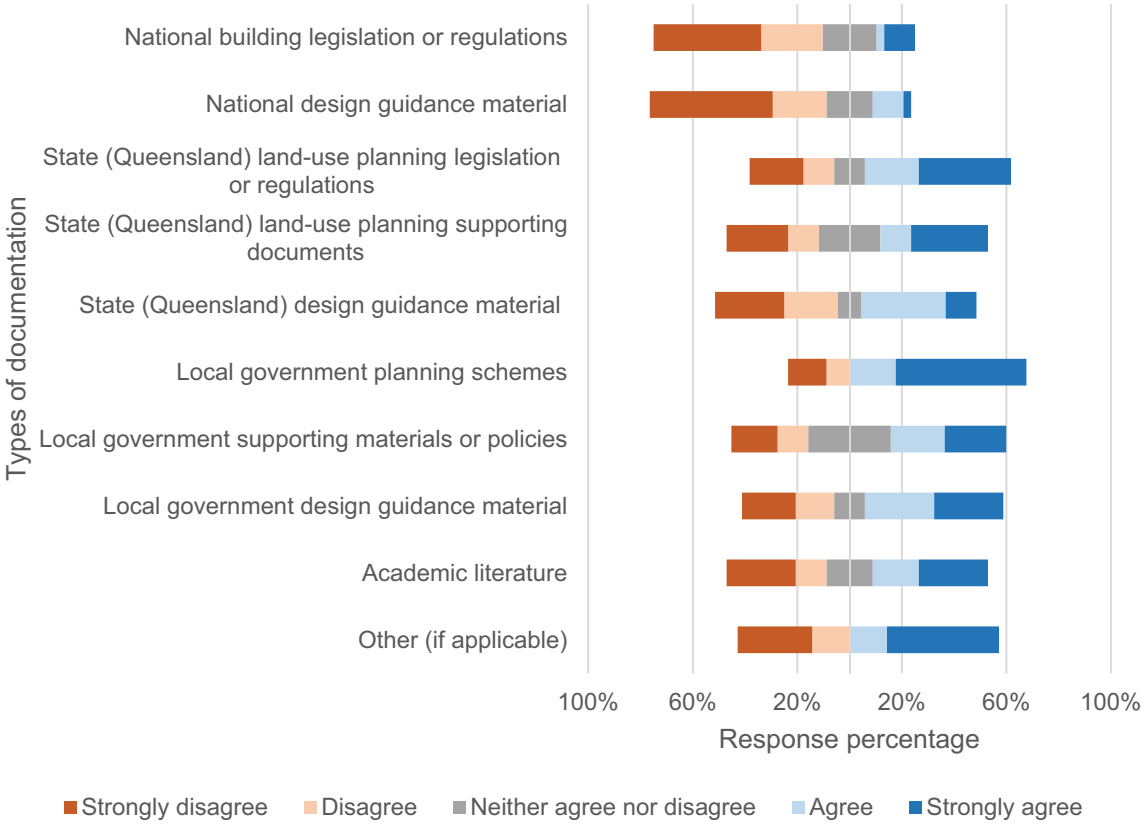

Figure 2. Resources used in practice.

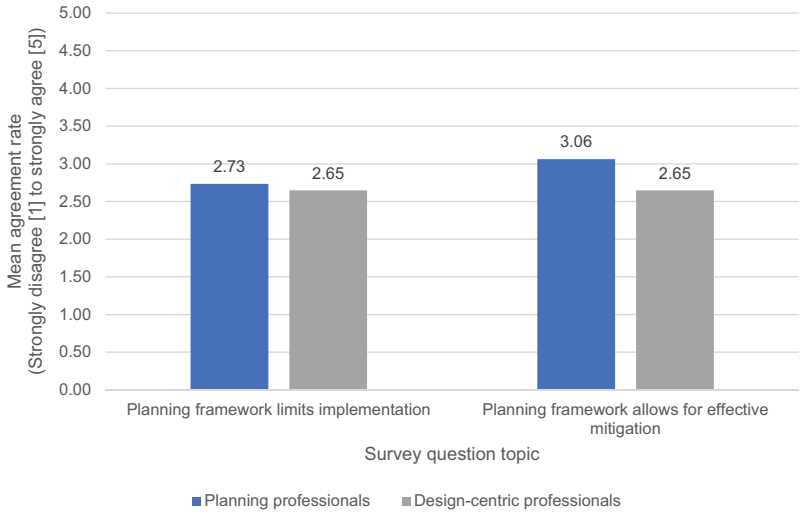

Figure 3. Planning framework questions by profession group.

Development Code does not contain enough [Queensland] specific guidance on design for climate or character or place [sic]' (SA1). They went on to say that it is only through many years of professional practice and knowledge that it is possible to determine outcomes, and *'people who are new to the subtropics, heat and [Queensland] would have no clue'* (SA1). Two respondents considered heat-mitigation techniques as innovative but noted that regulations do not always allow for innovation (SUD2, SUD7), one stating that *'often we use design to push the limits of accepted policy – this is often at odds with regulatory policy'* (SUD7). Limits imposed on planning schemes by building regulations at the state level were also a strong theme, as *'Planning Schemes are not able to prevail over building standards'* (SP8). One respondent stated that heat is not a strong focus of state regulation, noting that *'the current SPP does not include heatwave as a natural hazard'* (SP16). One interviewee (IP3) believed the SPP only deals with heat indirectly, via

the protection of natural areas such as Matters of State Environmental Significance (Queensland Government 2017).

Regarding whether respondents agreed that the current planning framework allows for the effective mitigation of heat-health risks, urban designers (2.91) and town planners (2.79) agreed the most. Landscape architects (2.25), architects (2.00), and 'other' (2.00) disagreed with this statement. Many respondents stated that the implementation of heat-mitigation is not necessarily limited by the current framework. They consider that the '*planning framework is generally adequate, the challenge is implementation (following development approval, into operational works)*' (SUD6), indicating difficulties at the construction phase of a project. Some respondents noted that there is not a mandatory requirement to do so, leading to a lack of implementation. With one specifically saying that implementation is left up to the development industry, and that '*there is a lack of strong regulation. If someone wants to implement best practice – they can – but they generally don't*' (SUD4). This aligns with the intent of Queensland's performance-based planning system.

Seven respondents commented specifically on the lack of regulation or guidance for heat-mitigation design in Queensland. One noting a disconnect between general heat-mitigation policy and the implementation of said policies and mitigation measures at the local and state level (SP9). Another said the planning framework is '*too weak [. . .] and requires straightforward directions on [heat-mitigation]*' (SUD8). Heat not being considered within the SPP was again raised (SP8). Three respondents noted the differences between what is achievable under the planning framework and requirements of building codes (SPUD3, SP8, SP13); with one respondent referring to these differences as a '*frustration*' (SPUD3). Respondents commented on a lack of subtropical design guidance within the framework (SUD6, SA1) and within the Queensland Development Code (SA1), one of them noting, '*examples of simple subtropical design principles and features to influence dwelling design would be beneficial [. . .] in the private sector*' (SUD6).

These sentiments were also reflected in the interviews. All interviewees agreed that the current planning system in Queensland allows for the implementation of heat mitigation strategies, but many did not believe implementation was occurring adequately – from both local governments and the development industry. Some suggested greater leadership from the state government through regional plans and the SPP (IP6).

A cohort of planners who had a seemingly better understanding of urban heat policy was the local government strategic planning professionals. Interviewees highlighted an emerging understanding of urban heat, however, a lack of strategic policy and guidance from the State Government is hindering their efforts. They noted that greater input from the State would be beneficial, '*[The Queensland State Government] have got some broad principles [but] there is not much meat to it. It really is putting the onus on the local government to make sure places are liveable*' (IP3). In response to a question about wind and breeze planning provisions, '*if it could also happen at a State level, that makes our job easier as well, then we aren't asking for something that is well beyond what any other local government would be asking for*' (IP5).

One interviewee (IP3) spoke of model codes as a way in which the State could respond to heat-mitigation in the public realm, referencing the *Model Code for Neighbourhood Design* by the State Government as an example (Queensland Government 2020). This was mirrored by another interviewee (IP1) who mentioned that having the State identify broad level principles, the intended policy position and supporting material for local governments to go away and integrate into their scheme is beneficial; and further reflected by another planner:

> Smaller councils don't necessarily have the money to spend on this stuff. The old 'roads, rates and rubbish' . . . They've got other key responsibilities. I could imagine if a planner stood up in front of [Councillors and the executive] and said we need to do this urban heat island study to come up with practical responses, they wouldn't understand it, [and] it would be a very hard sell. And those councils need ready-made stuff that they can just chuck in their schemes. (IP7)

Six interviewees also discussed tensions between building regulations and planning schemes as a limiting factor in achieving the implementation of heat mitigation techniques, in particular, an existing policy void between these two pieces of regulation in relation to shading elements, climate-responsive design and sustainability measures. For some, this tension is frustrating, '*[Queensland Development Code] currently is hopeless, it is really terrible*' (IA1). Others have long been engaged in advocacy to see limitations of building controls addressed:

> Planners have been trying to focus on that issue for years . . . . I think the first meeting I was on for that issue was in 2004 . . . . It is highly complicated. I don't think I've actually – still to this day – read something [that] very succinctly identifies the jurisdictional conflicts, and how to move forward. (IP7 - 20 plus years' experience)

As a way to respond to this conflict within local government authority, IP7 recommended the creation of place-based design guidelines to their Councillors and executive.

The role of data was another theme raised by four interviewees. One highlighted the importance of

having data to support decision making, *'we need good data on how the products we are building today, or built over the last ten years, [are] going to affect both lifestyle and [. . .] economy. That's things like updated heat mapping'* (IP7) and *'we have the tools that we could be using better, but we do not necessarily have the data'* (IP7). Another suggested a state-level body which reports on urban heat data across local government areas, *'we probably need an environmental heat monitor. Something that should be in every council and then reporting to the state because that would make everyone a little bit interested'* (IA1).

Urban design solutions

Professionals were asked to rate whether they agreed if several urban design solutions – geometry, shading, vegetation, winds and breezes, materials/albedo and water (Chatzidimitriou and Yannas 2016) – are effective at mitigating heat in the built environment. Based on mean average responses, vegetation (4.83) was the highest rated solution, and water (3.86) the lowest. Professionals also rated the frequency at which they use each solution in their practice to mitigate heat; vegetation (4.17) was again the highest rated, and water (2.86) the lowest (Figure 4).

Discussions about each urban design solution arose during interviews. Vegetation as a solution was raised by every interviewee. In doing so, some raised some issues, including maintenance issues (IA1, IP6, ILA1), building control provisions relating to cladding (IP1, IA1) and the use of green walls in-lieu of deep planted shade trees (IP1, ILA1). Building regulation-planning scheme constraints were central to discussions of built shading. An architect (IA1) summarised their approach to albedo, *'We don't want buildings that absorb heat, but we don't want reflective buildings either. We have to find the happy medium between reflective and absorbent. I am not sure where that sits'*. Winds and breezes were discussed as a method to reduce reliance on mechanical ventilation. Capturing breezes for cooling is an intrinsically 'Queensland' way to manage heat, as put by one interviewee (IA1). However, such approaches are only successful if breeze and wind corridors are protected. Water was described as one of the least useful methods of cooling, due to climatic, drought and energy usage factors. Interestingly, conversations about the role of geometry in heat mitigation were limited.

More broadly, two interviewees (IA1, IP7) raised the need for a new perspective on urban design approaches. Their argument being that climate-responsive design needs to be business as usual; currently, some urban design solutions continue to take a perspective solely focused on aesthetics and form, not including a climatic or urban heat considerations.

Discussion

The findings presented in the previous section indicate that extreme heat is not actively considered by town planners on a day-to-day basis, there may be several reasons for this. It may be a confluence of it not being a core requirement in education, professional practice or planning policy. Design-centric professionals reported a higher level of familiarity with extreme heat and heat-mitigation techniques. This difference may be explained by the fact that passive climatic design is more broadly considered in landscape architecture and architecture education, and consequently

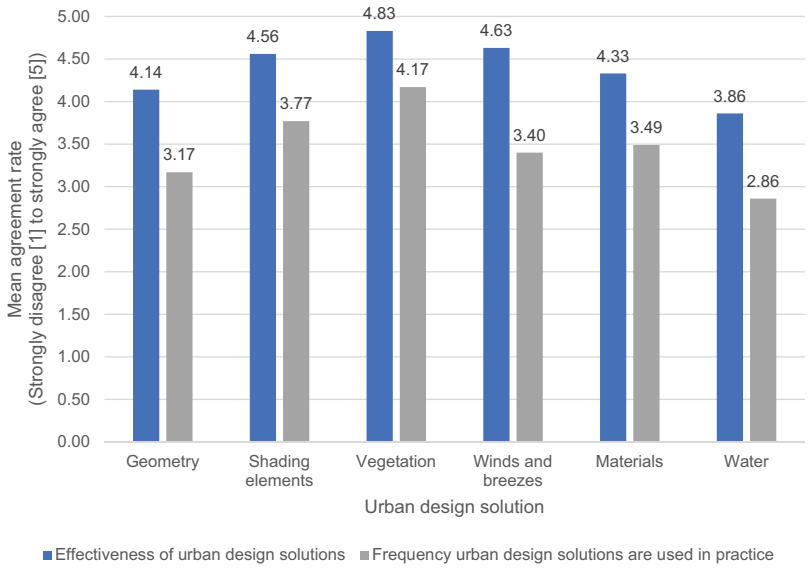

Figure 4. Effectiveness and use of urban design solutions.

practice (Vasiu 2013). The discussion presented next is structured around the key issues raised by survey respondents and interviewees: awareness and application of knowledge; existing policies; design guidance and solutions; advocacy and other matters.

Awareness and application

The awareness level of planners in regard to urban climate outcomes in comparison to other built environment practitioners is concerning, as planners are the primary custodians of the planning system – a system which many other practitioners are statutorily required to interface with. The findings align with Eliasson (2000) who found that climate knowledge had a low impact on the planning process and that urban planners were uncertain about their own urban climate knowledge and role in practice. They identified a need for improved knowledge and communication within the profession and with stakeholders, like the community and political decision-makers. More recently, it was found that planners and designers do not act on their urban climate knowledge 'due to other urban planning priorities or lacking knowledge about climate adaptation measures' (Lenzholzer *et al.* 2020b).

This lack of application may be a consequence of limited requirements for heat mitigation in practice and policies. Increasing awareness could address this by tertiary and professional development education. Elements of heat-mitigation and climate-responsive design go back to core teachings for design-centric professions. However, as one respondent explained, increasingly, architectural students are not gaining these skills during their studies, instead, focusing on the highly aesthetical elements of architectural design practice (IA1). Both these factors are likely at play. Bhoge *et al.* (2019) recommend that passive climatic design be interweaved into all built environment courses, rather than stand-alone course on the matter. This aligns with suggestions from other interviewees; a new 'climate' lens is needed on built environment policy.

Built environment policies

A key emerging theme from the interviews was the need for a clear line of sight between high-level policies, such as the SPP, down to local planning schemes. The *natural hazards, risk and resilience* state interest within the SPP requires that:

> risks associated with natural hazards, including the projected impacts of climate change, are avoided or mitigated to protect people and property and enhance the community's resilience to natural hazards. (Queensland Government 2017)

The natural hazards addressed in the state interest are spatially defined, like bushfire prone areas. At the time of writing, the state interest does not require the consideration of hazards like extreme heat, which does not necessarily occur in predictable geographical areas. This is despite one of the state interest's primary purposes being the avoidance or mitigation of the projected impacts of climate change on people and property (Queensland Government 2017). In its current form, the SPP does not respond directly to extreme heat, only indirectly through vegetation and liveability requirements.

The *Model Code for Neighbourhood Design* (Queensland Government 2020) was raised as an example of a possible approach to support the increase of heat mitigation outcomes in planning schemes. A similar approach of model planning scheme codes applied to heat and heatwaves would provide a method and means for smaller local governments to adopt best practice solutions. In the Queensland context, model codes are developed by the Queensland Government to provide best practice planning guidance to local governments and developers, often times on matters which are technically complex (Queensland Government 2022). Model codes provide other benefits too, even if not integrated; providing the development industry with examples of best practice provisions while also sending a policy signal that the topic is something planning jurisdictions care about (IP7). However, any further work which seeks to standardise planning and urban design heat mitigation measures must be climate-sensitive (Tavares 2020).

A concern raised by many interviewees and survey respondents was a perceived policy void between building codes (National Construction Code and Queensland Development Code) and local government planning schemes. This policy void is a long-standing issue, with one planner reporting that advocacy for changes has been occurring since 2004 (IP7). These concerns are warranted and need to be addressed, however, considering the broad range of heat-mitigation tools available to planners, these concerns may blind professionals from larger issues at play. Aforementioned awareness issues may limit professionals' perspectives to see these macro issues or other avenues for heat-mitigation. Planning and design for urban heat and urban climates, in contrast to climatic design within buildings, is a complex task (De Schiller and Evans 1996). As previously highlighted, planning scale city-wide types of solutions like geometry and winds and breezes feature less in practice – compared to site-specific responses – despite their critical role in managing urban heat at a planning scale. Again, planning for urban heat and urban climates is perhaps not something that planners are currently adequately equipped to undertake (Lenzholzer *et al.* 2020b).

Design guidance and solutions

As one participant explained, the development of their own council's design guideline was, in part, a direct response to the building codes policy void – among other issues. This sentiment may be true for other local governments who have developed these types of guidelines. However, the effectiveness of these documents at delivering best-practice design – where it is not otherwise prescribed in other planning and building requirements – can be limited due to a range of factors (Bhoge *et al.* 2019). In the case of Brisbane's *Buildings that Breathe* design guidance, Bhoge *et al.* (2019) argue it's discretionary nature may not be in the public interest in light of the current climate crisis; suggesting such guidelines should be mandatory. This perception holds true in reflection on this study for other discretionary design guidelines in South East Queensland (e.g. QDesign and the Sunshine Coast Design 'Yellow Book').

Design solutions such as geometry and winds and breezes require city-wide coordination. Geometry for instance, is a consequence of regulating building height, setbacks and ground cover provisions, therefore it is defined by the planning schemes, and largely controlled by it. In the case of winds and breezes, it also requires city-wide policies for effective implementation, as such, provisions need to be contained within non-discretionary (statutory) polices, like a planning scheme. Without such city-wide policies, the result is a piecemeal approach. In both cases, the extent of what effective heat-mitigation can be achieved within a discretionary guide is limited.

Advocacy and alliance building

During 2021, the Planning Institute of Australia began establishing a suite of nationwide advocacy papers on state planning system responses to climate change (Planning Institue of Australia 2021). Queensland's advocacy paper addresses some of the concerns raised in this study, including the inclusion of heat as a hazard in the SPP and climate change guidance for local governments to support their strategic planning activities – among others.

The entirety of this burden does not sit with built environment professionals, as there are other actors who have influence over policy. While survey and interview participants did not discuss political actors extensively, in Australia the creation and management of urban spaces and the policies which govern them is a process with significant state and political connections (Farid Uddin and Piracha 2023). This point was highlighted starkly in New South Wales in 2022, when proposed planning regulations to increase energy efficiency and design requirements to mitigate extreme heat were scrapped. Vocal opposition came from the property industry, whom stated that the proposed policies would 'undermine the economics of delivering housing' (Visontay 2022). Commentary by prominent urban heat experts at the time stated that, 'people may well die of heat because the Planning Minister scrapped a good plan' (Pfautsch 2022). Self-interest and political ideology influence policy preference (Wood *et al.* 2018). Further work needs to engage at all levels, with all stakeholders, to build consensus and coalitions that can stand the test of political cycles.

Other sectors are increasing heat-health risk mitigation and adaptation measures. The Bureau of Meteorology's Heatwave Service issues heatwave forecasts and assessments (Bureau of Meteorology 2016), and has recently begun issuing warnings in the same manner warnings are issued for severe storms (Bureau of Meteorology 2022). State emergency management agencies have begun the roll-out of heatwave alerts under the new nationally consistent Australian Warning System (Logan 2022).

Other matters

Regarding the resources used by professionals, it should be noted that these results may skew towards local planning documents due to many respondents working within local government. It is also important to acknowledge the diverse nature of the work planners and built environment professionals are engaged in. Some respondents, due to their role responsibilities, organisation or interests, may be more or less knowledgeable about heat-health risks and heat mitigation techniques.

The emerging themes and their interconnections showcase the complexity of urban heat and heatwaves, heat-health risks, and urban design and planning policy. Bioclimatic design (responding to the local climate to provide human thermal comfort using freely available and renewable resources) presents a pre-existing principled-framework which can be applied to the public realm. At present, these principles are used widely in the architecture and building professions to provide passive climatic control within buildings (Daemei *et al.* 2019); but this is not necessarily the case in the public realm (Tavares 2020).

To support the application of bioclimatic urban design and planning, further research would benefit from using research methodologies and tools which can organise complexity in urban systems, such as work domain analysis (Stevens 2018). It would enable a framework to develop and test possible policy scenarios, reduce complexity and provide a greater level of clarity for policy and decision-makers working in this space.

Conclusion

Urban design and planning solutions have a clear role in mitigating heat-health risks in urban spaces, however, they are not always implemented (Eliasson 2000, Fernandez Milan and Creutzig 2015). In our warming world, we found that planning practitioners had lower awareness of this growing issue than their design-centric counterparts in the built environment professions. We argue the lower level of awareness, consideration, and use of heat-mitigation techniques in practice among planners presents concerns about the implications this has on planning policy and the resulting urban forms – and in turn, the resulting urban microclimates, and heat-health risks. In response, urban climate knowledge needs to become commonplace in built environment education and professional development, while planning policy-makers and practitioners must work with subject matter experts to embed heat mitigation in planning and urban design processes.

In this study, responses from non-coastal South East Queensland local government areas were limited. Participants' perceptions may vary depending on the location where they work and the existing policies and guidelines available for each region or state. It would be valuable to undertake similar studies in other places to better understand the factors impacting awareness and adoption of heat mitigation strategies. This would help to inform future policy shifts aimed at achieving optimum outcomes.

Future research would benefit from gaining insights from developers, engineers and building designers, surveyors and assessors who fall under the umbrella of 'built environment professionals' but were not targeted within this work, and more private sector professionals. Further investigation of the tensions highlighted here in relation to heat-mitigation techniques would be useful, including inter-jurisdictional (i.e. building code-planning scheme) and inter-professional (i.e. planners and architects). Further collaboration is required with industry to reduce the research-policy gap, supporting greater implementation of heat-mitigation techniques. The work by the Planning Institute of Australia may be a step in the right direction (Planning Institute of Australia 2021), but practitioners still require adequate knowledge, guidance material and data to implement change.

Given the central role planners have in guiding and controlling urban development – which influence heat outcomes – coupled with current and continuing changes to the climate, the profession must play a more active role in achieving climate-responsive design outcomes in response to increasing heat-health risks. Here, we have presented an initial analysis of the challenges built environment professionals in South East Queensland, Australia believe are present in the status quo and the opportunities to begin to shift the dial on how planning and urban design policies can respond to growing heat-health risks.

Note

1. The use of 'design' here is a by-product of the survey questions, which intended to relate to all built environment design-related professions. It is not intended to mean only 'urban design'.

Acknowledgements

The authors wish to thank the built environment practitioners who participated in research surveys and interviews for sharing their knowledge and insights.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

Ryan McNeilly Smith is a PhD Candidate with the University of the Sunshine Coast's BASC Lab (Bioclimatic and Sociotechnical Systems Lab) and Silvia Tavares and Nicholas Stevens are each BASC Lab co-leaders. With a systems perspective that acknowledges the complexity of delivering sustainable urban environments we research, teach and design to optimise urban climate and urban comfort. The BASC Lab collaborates with industry and local communities to achieve real-world project outcomes.

ORCID

Ryan McNeilly Smith http://orcid.org/0000-0002-3738-6045
Silvia Tavares http://orcid.org/0000-0002-8405-9717
Nicholas Stevens http://orcid.org/0000-0003-0046-9362

Ethics

This study was undertaken in accordance with human research ethics requirements set by the University of the Sunshine Coast – Ethics Approval Number S201475.

References

Amati, M., *et al.*, 2017. *Where should all the trees go? Investigating the impact of tree canopy cover on socio-economic status and wellbeing in Lga's* [online]. Horticulture Innovation Australia. Available from: https://apo.org.au/node/112646 [Accessed 29 March 2020].

Anon, *Planning Act 2016 (Qld)*.

Baldwin, C., Matthews, T., and Byrne, J., 2020. Planning for older people in a rapidly warming and ageing world: the role of urban greening. *Urban policy and research*, 38 (3), 199–212. doi:10.1080/08111146.2020.1780424

Bhoge, R., Nolan, H., and Pojani, D., 2019. Designing the subtropical city: an evaluation of climate-sensitive policy

effects in Brisbane, Australia. *Journal of Environmental planning and management*, 63 (10), 1880–1901. doi:10.1080/09640568.2019.1689934

Brisbane City Council, 2016. *New world city design guide - buildings that breath* [online]. Available from: https://www.brisbane.qld.gov.au/planning-and-building/planning-guidelines-and-tools/neighbourhood-planning-and-urban-renewal/new-world-city-design-guide-buildings-that-breathe [Accessed 27 November 2020].

Brown, R.D., 2010. *Design with microclimate: the secret to comfortable outdoor space*. Washington DC: Island Press.

Bureau of Meteorology, 2016. *About the heatwave service* [online]. Available from: http://www.bom.gov.au/australia/heatwave/about.shtml [Accessed 14 March 2020].

Bureau of Meteorology, 2022. New national heatwave warning service to help keep Australians safer this summer.

Campbell, S., *et al.*, 2018. Heatwave and health impact research: a global review. *Health and place*, 53, 210–218. doi:10.1016/j.healthplace.2018.08.017

Chatzidimitriou, A. and Yannas, S., 2016. Microclimate design for open spaces: ranking urban design effects on pedestrian thermal comfort in summer. *Sustainable cities and society*, 26, 27–47. doi:10.1016/j.scs.2016.05.004

Clay, R. and Guan, H., 2020. The urban-parkland nocturnal temperature interface. *Urban climate*, 31, 31. doi:10.1016/j.uclim.2020.100585

Coates, L., *et al.*, 2014. Exploring 167 years of vulnerability: an examination of extreme heat events in Australia 1844–2010. *Environmental science & policy*, 42, 33–44. doi:10.1016/j.envsci.2014.05.003

Daemei, A.B., Eghbali, S.R., and Khotbehsara, E.M., 2019. Bioclimatic design strategies: a guideline to enhance human thermal comfort in Cfa climate zones. *Journal of building engineering*, 25, 100758. doi:10.1016/j.jobe.2019.100758

De Schiller, S. and Evans, J.M., 1996. Training architects and planners to design with urban microclimates. *Atmospheric environment (1994)*, 30 (3), 449–454. doi:10.1016/1352-2310(94)00139-1

Ebi, K.L., *et al.*, 2021. Hot weather and heat extremes: health risks. *The lancet*, 398 (10301), 698–708. doi:10.1016/S0140-6736(21)01208-3

Eliasson, I., 2000. The use of climate knowledge in urban planning. *Landscape and urban planning*, 48 (1–2), 31–44. doi:10.1016/S0169-2046(00)00034-7

Erell, E., Pearlmutter, D., and Williamson, T., 2011. *Urban microclimate – designing the spaces between buildings*. London and Washington: Earthscan.

Farid Uddin, K. and Piracha, A., 2023. Urban planning as a game of power: the case of New South Wales (NSW), Australia. *Habitat international*, 133, 133. doi:10.1016/j.habitatint.2023.102751

Fernandez Milan, B. and Creutzig, F., 2015. Reducing urban heat wave risk in the 21st century. *Current opinion in Environmental sustainability*, 14, 221–231. doi:10.1016/j.cosust.2015.08.002

Hansen, A., *et al.*, 2014. Extreme heat and cultural and linguistic minorities in Australia: perceptions of stakeholders. *BMC public health*, 14 (1), 550. doi:10.1186/1471-2458-14-550

Harlan, S.L., *et al.*, 2006. Neighborhood microclimates and vulnerability to heat stress. *Social science & medicine*, 63 (11), 2847–2863. doi:10.1016/j.socscimed.2006.07.030

He, B.-J., Ding, L., and Prasad, D., 2020a. Outdoor thermal environment of an open space under sea breeze: a mobile experience in a coastal city of Sydney, Australia. *Urban climate*, 31, 100567. doi:10.1016/j.uclim.2019.100567

He, B.-J., Ding, L., and Prasad, D., 2020b. Relationships among local-scale urban morphology, urban ventilation, urban heat island and outdoor thermal comfort under sea breeze influence. *Sustainable cities and society*, 60, 102289. doi:10.1016/j.scs.2020.102289

Huxley, M., 2009. Planning, Urban. *In*: R. Kitchin and N. Thrift, eds. *International encyclopedia of human geography*. Oxford: Elsevier, 193–198.

IPCC, 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. In H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem and B. Rama, eds. Cambridge, UK and New York, NY: Cambridge University Press, 3056. doi:10.1017/9781009325844.

Jacobs, C., *et al.*, 2020. Are urban water bodies really cooling? *Urban climate*, 32, 100607. doi:10.1016/j.uclim.2020.100607

Johnson, T.P., 2005. Snowball sampling. *Encyclopedia of biostatistics*. doi:10.1002/0470011815.b2a16070

Lenzholzer, S., *et al.*, 2020a. Awareness of urban climate adaptation strategies –an international overview. *Urban climate*, 34, 100705. doi:10.1016/j.uclim.2020.100705

Lenzholzer, S., *et al.*, 2020b. Urban climate awareness and urgency to adapt: an international overview. *Urban climate*, 33, 100667. doi:10.1016/j.uclim.2020.100667

Lobaccaro, G., *et al.*, 2019. Effects of orientations, aspect ratios, pavement materials and vegetation elements on thermal stress inside typical urban canyons. *International journal of environmental research and public health*, 16 (19), 3574. doi:10.3390/ijerph16193574

Local Government Association of Queensland & Department of Environment and Science, 2023. *QCoast2100* [online]. Available from: https://www.qcoast2100.com.au/about/home

Logan, T., 2022. New heatwave warning system adopted across Australia, using bushfire-style emergency alerts *ABC News*, 21 Nov.

Loughnan, M., Carroll, M., and Tapper, N.J., 2015. The relationship between housing and heat wave resilience in older people. *International journal of biometeorology*, 59 (9), 1291–1298. doi:10.1007/s00484-014-0939-9

Macleod, T.A., *et al.*, 2019. Balancing fire risk and human thermal comfort in fire-prone urban landscapes. *PLoS One*, 14 (12), e0225981. doi:10.1371/journal.pone.0225981

McMahon, S., 2018. Urban Design. *In*: S. Thompson and P. J. Maginn, eds. *Planning Australia: an overview of urban and regional planning*. 2nd ed. Cambridge: Cambridge University Press, 294–330.

Miao, C., *et al.*, 2020. Review of methods used to estimate the sky view factor in urban street canyons. *Building and environment*, 168, 106497. doi:10.1016/j.buildenv.2019.106497

Motazedian, A., Coutts, A.M., and Tapper, N.J., 2020. The microclimatic interaction of a small urban park in central Melbourne with its surrounding urban environment during heat events. *Urban forestry & urban greening*, 52, 126688. doi:10.1016/j.ufug.2020.126688

Naiman, R.J., *et al.*, 2005. 5 - biotic functions of riparia. *In*: R.J. Naiman, H. Décamps, M.E. Mcclain, and G.E. Likens, eds. *Riparia*. Burlington: Academic Press, 125–158.

Ng, E., *et al.*, 2011. Improving the wind environment in high-density cities by understanding urban morphology and surface roughness: a study in Hong Kong. *Landscape*

and urban planning, 101 (1), 59–74. doi:10.1016/j.landurbplan.2011.01.004

Oke, T.R., 1973. City size and the urban heat island. *Atmospheric environment (1967)*, 7 (8), 769–779. doi:10.1016/0004-6981(73)90140-6

Oke, T.R., 2006. Towards better scientific communication in urban climate. *Theoretical and applied climatology*, 84 (1–3), 179–190. doi:10.1007/s00704-005-0153-0

Palermo, S.A. and Turco, M., 2020. Green Wall systems: where do we stand? *In*: *IOP conference series: Earth and environmental science*. Thessaloniki, Greece: IOP Publishing, 410.

Patton, M.Q., 1990. *Qualitative evaluation and research methods*. 2nd ed. Beverly Hills, CA: Sage Publications, Inc.

Peng, L. and Jim, C., 2013. Green-roof effects on neighborhood microclimate and human thermal sensation. *Energies*, 6 (2), 598–618. doi:10.3390/en6020598

Pfautsch, S., 2022. People may well die of heat because the planning minister scrapped a good plan *The Sydney Morning Herald*, 6 Apr.

Planning Institue of Australia, 2021. *Policy 2021 PIA Climate Series* [online]. Available from: https://www.planning.org.au/policy/current-pia-policy-positions/2021-pia-climate-series

Planning Institute of Australia, 2021. *Planning to tackle climate change. 10 actions for a climate-conscious planning system in Queensland* [Online]. Available from: https://www.planning.org.au/documents/item/11362.

Punter, J., 2007. Developing urban design as public policy: best practice principles for design review and development management. *Journal of urban design*, 12 (2), 167–202. doi:10.1080/13574800701306195

Queensland Government, 2017. *Shaping SEQ: South-East Queensland regional plan 2017* [Online]. Available from: https://dilgpprd.blob.core.windows.net/general/shapingseq.pdf.

Queensland Government, 2017. *State planning policy* [online]. Available from: https://dilgpprd.blob.core.windows.net/general/spp-july-2017.pdf [Accessed 27 November 2020].

Queensland Government, 2019. *Queensland State Heatwave Risk Assessment 2019* [online]. Available from: https://www.disaster.qld.gov.au/dmp/Documents/QFES-Heatwave-Risk-Assessement.pdf [Accessed 27 November 2020].

Queensland Government, 2020. *Model code for neighbourhood design* [online]. Available from: https://dsdmipprd.blob.core.windows.net/general/model-code-for-neighbourhood-design.pdf [Accessed 27 November 2020].

Queensland Government, 2021. *The long paddock* [online]. Available from: https://www.longpaddock.qld.gov.au/ [Accessed 27 November 2020].

Queensland Government, 2022. *Planning code guidance* [online]. Available from: https://planning.statedevelopment.qld.gov.au/planning-framework/plan-making/state-planning/planning-code-guidance

Razzaghmanesh, M., Beecham, S., and Salemi, T., 2016. The role of green roofs in mitigating urban heat island effects in the metropolitan area of Adelaide, South Australia. *Urban forestry & urban greening*, 15, 89–102. doi:10.1016/j.ufug.2015.11.013

Rogers, C.D.W., Gallant, A.J.E., and Tapper, N.J., 2018. Is the urban heat island exacerbated during heatwaves in southern Australian cities? *Theoretical and applied climatology*, 137 (1–2), 441–457. doi:10.1007/s00704-018-2599-x

Schoonenboom, J. and Johnson, R.B., 2017. How to construct a mixed methods research design. *Kolner Zeitschrift fur Soziologie und Sozialpsychologie*, 69 (S2), 107–131. doi:10.1007/s11577-017-0454-1

Shafiee, E., *et al.*, 2020. Assessment of the effect of living wall systems on the improvement of the urban heat island phenomenon. *Building and environment*, 181, 106923. doi:10.1016/j.buildenv.2020.106923

Sharifi, E. and Boland, J., 2017. Heat resilience in public space and its applications in healthy and low carbon cities. *Procedia engineering*, 180, 944–954. doi:10.1016/j.proeng.2017.04.254

Speak, A., *et al.*, 2020. The influence of tree traits on urban ground surface shade cooling. *Landscape and urban planning*, 197, 103748. doi:10.1016/j.landurbplan.2020.103748

Steeneveld, G.J., *et al.*, 2014. Refreshing the role of open water surfaces on mitigating the maximum urban heat island effect. *Landscape and urban planning*, 121, 92–96. doi:10.1016/j.landurbplan.2013.09.001

Stevens, N.J., 2018. *Human factors in land use planning and urban design : methods, practical guidance and applications*. Boca Raton, FL: CRC Press.

Sunshine Coast Council, 2020. *Sunshine Coast design*. Sunshine Coast: Not specified.

Tavares, S., 2020. Espaces publics sensibles au climat sous les tropiques: une approche urbaine bioclimatique/climate responsive public spaces in the tropics: a Bioclimatic design approach. *In*: P. Rosier and M. Watin, eds. *Architecture in Millieu Tropical: Construire Le Paysage, Entre Pratique et Recherche*. Montpellier, France: Éditions de l'Espérou, 142–167.

Vasiu, R.A., 2013. Passive design-the rational use of landscape for increasing sustainability and the quality of life. *Agricultura*, 85, 137–139. doi:10.15835/arspa.v85i1-2.10013.

Visontay, E., 2022. Plan to ban dark roofs abandoned as NSW government walks back sustainability measures. *The Guardian*, 9 April.

White, J.T., 2015. Future directions in urban design as public policy: reassessing best practice principles for design review and development management. *Journal of urban design*, 20 (3), 325–348. doi:10.1080/13574809.2015.1031212

Wood, D., Griffiths, K., and Chivers, C., 2018. *Who's in the room? Access and influence in Australian politics*. Grattan Institute. https://grattan.edu.au/report/whos-in-the-room/

Zhang, G., *et al.*, 2019. Impact of morphological characteristics of green roofs on pedestrian cooling in subtropical climates. *International journal of Environmental research and public health*, 16 (2), 179. doi:10.3390/ijerph16020179

Zhang, J., *et al.*, 2019. The impact of sky view factor on thermal environments in urban parks in a subtropical coastal city of Australia. *Urban forestry & urban greening*, 44, 126422. doi:10.1016/j.ufug.2019.126422

Zografos, C., Anguelovski, I., and Grigorova, M., 2016. When exposure to climate change is not enough: exploring heatwave adaptive capacity of a multi-ethnic, low-income urban community in Australia. *Urban climate*, 17, 248–265. doi:10.1016/j.uclim.2016.06.003