Action 09: Mitigate Urban Heat

Book Chapter

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Why

The microclimate surrounding a person has a direct effect on their physiology and psychology. This is true for everything, from a room in a house all the way up to the configuration of a neighbourhood or even a city. This is not surprising as outdoor thermal comfort (OTC) affects all aspects of our lives (Halawa and van Hoof 2012): well-being and health; productivity and economy; liveability and quality of life; and energy consumption and the health of our ecosystems. While global warming will increase the base temperature by an estimated 2°C over the coming decades, the urban heat island (UHI) effect will generate an even more severe temperature increase of an additional 4 to 5°C (Meteorological Service Singapore and Centre for Climate Research Singapore 2015). While no measures on the urban domain can mitigate climate change directly, the UHI effect and, therefore, our OTC can be addressed by climate-responsive urban design.

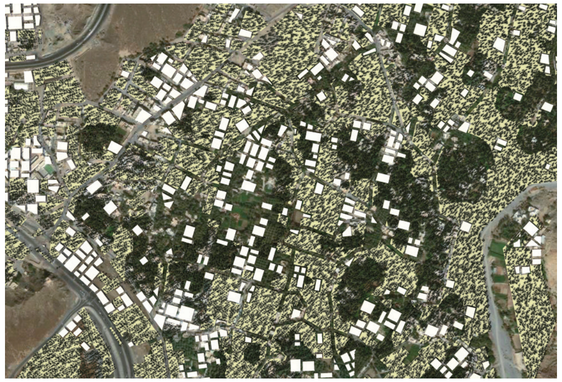
What

The impact of urban heat can be addressed at various levels—from regional, city, district, down to building scales. Urban heat can be absorbed and captured within the urban fabric as well as released into the environment. This has negative impacts on the UHI effect of a city and on the OTC of a district/neighbourhood. The heat island effect is measured through the air temperature difference between rural and urban areas (Mughal et al. 2019). Active and passive strategies can help to better manage the urban climate (Oke et al. 2017) although active measures, such as mechanical ventilation and cooling, require additional energy that will later dissipate as heat back into the urban system. Passive measures can enhance the ventilation and shading of urban areas through the design of street canyons, building geometries and blue-green spaces (Ruefenacht and Acero 2017; Zhong et al. 2019; Acero et al. 2020). These strategies are particularly important for hot-humid cities like Singapore, which are characterised by high temperatures, high humidity and low winds.

How

A combination of urban climate modelling, on-site measurements with sensors, satellite-based remote sensing and surveys of thermal perception can help to understand the extent of the urban heat challenge. Each urban setting is subject to a particular set of local microclimatic conditions. Fast sensing, modelling and evaluation feedback loops allow for targeted measures put together from a catalogue of options. Climate modelling allows us to assess what-if scenarios of single or multiple measures. The results of such modelling inform urban design decisions based on passive strategies (Ruefenacht et al. 2020). These include larger urban geometry such as optimal building orientation and form, the use of wind corridors and enhancing natural features such as topography and vegetation in order to mitigate urban heat with passive strategies for improved OTC.

Evidence



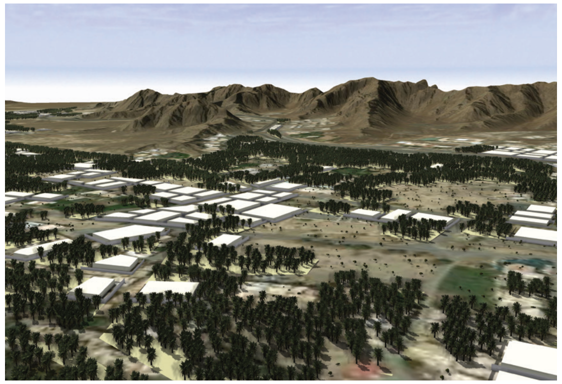


Fig. 08.3 Automatic land-cover classification maps drive three-dimensional figure-ground models of built-up and agricultural spaces in Nizwa, Oman, for further morphological investigation.
Fig. 08.4 Evaluating urban typomorphologies for case studies in Singapore using CityEngine during the 2018 Advanced Studies in Urban Design (AS-UD) course.

The ur-scape platform has been piloted in several cities in South East Asia, including Bandung under the Asian Development Bank's Future Cities initiative (Cairns et al. 2018). Then, the large data sets were linked to parametric and procedural urban modelling techniques to explore large-scale urban form. The 'Urban Elements' method (von Richthofen 2018) served to link conceptual urban design intents, urban science and procedural modelling with typomorphology to further engage in urban planning and analysis in Singapore (see Figures 08.3–4).

Stakeholders

The one-year Advanced Studies in Urban Design (AS-UD) course offered a platform to develop a new urban design curriculum with the Urban Redevelopment Authority of Singapore (URA) from 2017 to 2019. Apart from testing the applicability, transferability and teachability of research conducted at FCL, the course also hybridised and expanded urban morphology and typomorphology in particular. The effectiveness of using CityEngine for urban design workflows was tested in the second and third years of the AS-UD course in 2018 and 2019, which was offered to young professionals at URA and affiliated planning agencies. Knowledge acquired from the course facilitates a better understanding of how CityEngine can bridge the gap between urban design practice and typomorphological analysis.

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Further Reading

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Mitigate Urban Heat

Hygiene and the quest for well-lit and ventilated spaces transformed urban design and planning in the twentieth century (Banham 1984). Recently, the urban microclimate has been conceptualised as an 'artefact' (Roesler 2017), and architects, landscape architects and urban designers increasingly design microclimates (von Richthofen 2018; Philippe Rahm architectes 2018) based on novel digital microclimate sensing and modelling (Ruefenacht et al. 2020; Bauer et al. 2015). As demonstrated in the case of Singapore, the urban microclimate is subject not only to the global warming effects of climate change, but also to local heat absorbed and captured in the urban fabric resulting from urban configuration and use (Kayanan et al. 2019). The trending cooling strategy, for example, green façades, have a cooling effect only at close proximity (Acero et al. 2019).

The measurement of the climatic condition of an urban space could help to validate the effectiveness of potential cooling strategies. For example in Singapore, measurements in the elevation of a building podium provides higher air movement at street level. Remote sensing could provide information about the surface temperature of horizontal surfaces (pavements, roofs, green areas). Indeed, satellite maps from Singapore have shown that dense vegetation and water bodies are the coolest surfaces during daytime (Philipp 2019; Nevat et al. 2020). Furthermore, survey campaigns could reveal insights into people's perceptions, awareness, beliefs and attitudes towards the environment that surrounds them. For instance, a survey conducted in Singapore

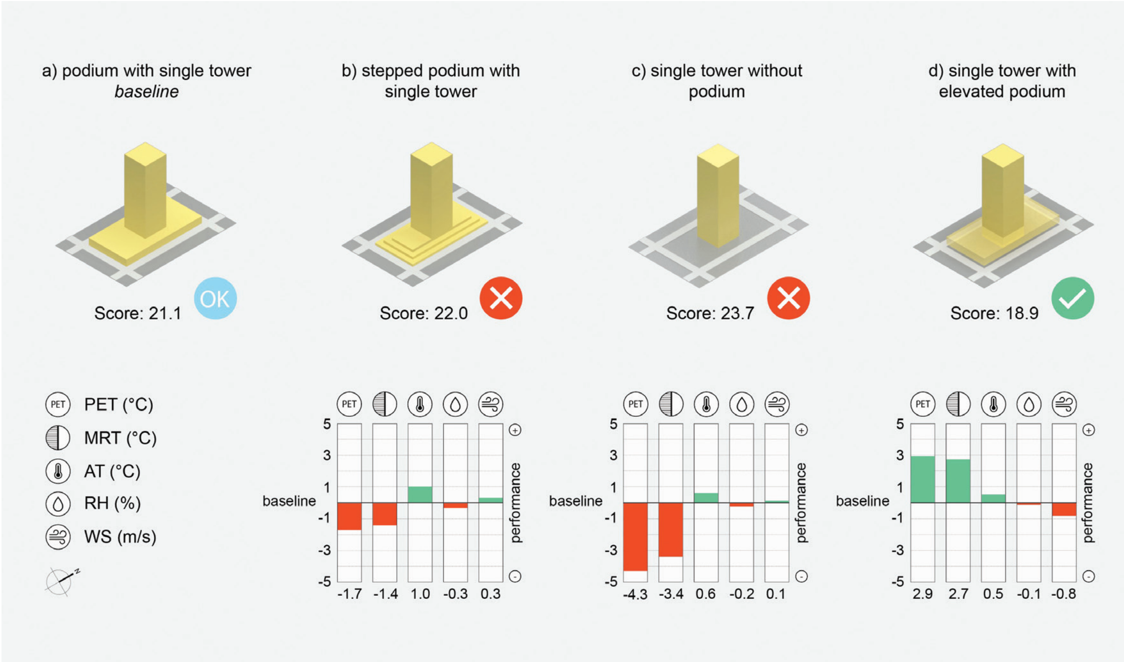

Fig. 09.1 Passive urban design strategies to mitigate UHI and improve OTC

showed that residents ranked green streetscapes as the most effective cooling strategy.

The implementation of passive strategies can be achieved through climate-sensitive design guidelines related to land cover, street geometry, building volume, aspect ratio, shading devices and surface materials, as shown in Figure 09.1 (Ruefenacht et al. 2020; Planning Department 2015).

Stakeholders

Stakeholders, such as citizens, play a big role in the assessment of passive strategies. Through online and on-site survey campaigns, citizens are able to rank the strategies based on their preferences and willingness to pay for the cooling strategies (Borzino 2020; see Figures 09.2–4). Also, older adults are key stakeholders when assessing the impact of heat on the vulnerable population. Through cognitive tests, their attention span and information-processing speed under different climatic exposures, for example, in the sun, in the shade and indoors with fans, can be investigated (Borzino et al. 2020). Urban planners are another important stakeholder group. Climate-design guidelines and an interactive and intuitive decision support system can help planners make appropriate climate-informed decisions at early stages of the planning and design process.

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Fig. 09.2 Citizen workshops in Punggol, Singapore (Source: Cooling Singapore, Lina Meisen Photography 2018)
Fig. 09.3 Preparing the portable weather station to assess the OTC in Punggol, Singapore (Source: Cooling Singapore, Lina Meisen Photography 2018)
Fig. 09.4 Surveys on perceived OTC in Punggol, Singapore (Source: Cooling Singapore, Lina Meisen Photography 2018)

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Plan Diverse Public Space Networks

Our team developed several evidence-informed tools to support the process of designing and planning public space networks. The adopted network perspective provides better understanding of the properties and the qualities of individual public spaces (i.e., nodes in the network); the relationships and connections between these spaces (i.e., links in the network); and the resulting properties of the overall network of public space (i.e., properties of the network).

At the level of individual public spaces (network nodes), we are developing a Multi-Criteria Decision Analysis (MCDA) framework to quantify public space quality for diverse user groups (He et al. 2020;