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Implementation Guides November 2021

How to adapt your city to extreme heat

Adapting to Climate Change | Spotlight On: Nature-based Solutions

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Author(s): **C40 Cities Climate Leadership Group, C40 Knowledge Hub**

Heatwaves are a significant but widely underestimated risk. Extreme heat events in cities can cause mortality spikes of up to 14%,[1] as well as lower workforce productivity and damage to infrastructure such as roads and rail lines. Today, extreme heat impacts around 68 million people globally.[2] This number is expected to increase 15-fold to around a billion if global heating reaches 2°C, while a 4°C rise would mean that nearly half the global population is affected.[3] Unmitigated, urban heat could cost cities up to 11% of their Gross Domestic Product (GDP) by 2100.[4]

Heatwaves are predictable hazards. Their impacts on citizens' health and cities' infrastructures can be reduced, thanks to simple, cost-effective technologies and strategies. This is how cities can adapt to extreme heat to protect their citizens and economies.

Measure urban heat and vulnerability to understand the heat risk

Cities need information on which areas of the city, and which groups of the population, are most at risk. An individual's heat vulnerability depends on their exposure and sensitivity to extreme heat, and their ability to adapt.

How heat kills

Sustained exposure to extreme heat can overwhelm the body's ability to regulate its core temperature. This

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can lead to heat exhaustion, severe dehydration and heat stroke, a form of hyperthermia. Extreme daily maximum temperatures, high overnight temperatures, high humidity and air pollution, and the prolonged duration of a heatwave all lead to higher heat risk. There is a widespread lack of awareness of the symptoms of heat stress, which can include headaches, vomiting, dizziness and low blood pressure, and which are often mistaken for (and misreported as) other health issues. Extreme heat also negatively impacts health conditions such as cardiovascular and respiratory conditions, and diabetes. If the body's core temperature rises too high, the heart is no longer able to maintain adequate circulation, leading to unconsciousness and, ultimately, organ failure.

Work with expert partners to conduct a heat vulnerability assessment – particularly, city- and/ or national-level government health and meteorological departments, and universities. Health and mortality data from local NGOs can be a useful supplement if official data is lacking. This assessment may form part of a wider climate risk assessment.

Identify the most vulnerable population groups, and the local temperature threshold at which heat becomes a threat

The populations that are typically most vulnerable are:

- The elderly, young children, and people with underlying medical conditions, as they are more sensitive to extreme heat. This includes pregnant women and women with babies, as breastfeeding is extremely dehydrating. Buenos Aires' heat risk plan focuses on the elderly.
- Low-income people and those living in poor quality housing, who may have less access to water, green spaces, information, and air-conditioning.
- People who live alone. New York's Cool Neighbourhoods strategy includes the Be A Buddy NYC programme, which encourages New Yorkers to check in on at-risk neighbours.
- Outdoor workers, who have high exposure to heat and may have jobs requiring physical exertion. Ahmedabad identified outdoor workers as well as slum communities as high-risk groups.
- Marginalised groups including homeless people, migrants, refugees, women and girls, as they may have less access to and awareness of cooling options. The city of Melbourne's heatwave response strategy includes a focus on the homeless, based on their analysis of heat risk for homeless people.

Use temperature and health data (such as mortality rates and hospital admissions) alongside qualitative research methods to determine which groups in the city are most vulnerable, why, and the temperature thresholds at which heat becomes a threat.

Consider also assessing economic costs associated with extreme heat to strengthen the case for action. A study commissioned by Tel Aviv-Yafo, for example, estimated that the economic cost of extreme heat in the city to

be between 2 and 4 billion NIS (around $500 million to 1 billion USD) by 2050.

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Higher capacity cities can also develop spatial maps of heat risk

To maximise the effectiveness of emergency management and to target heat mitigation actions toward the most vulnerable people, cities can also map heat risk across the city. A heat risk map – or Heat Vulnerability Index – combines data on heat variability within the city with socio-economic data. Some cities, including New York and Toronto, have Heat Vulnerability Indexes available online, alongside mapped information about the location of cooling centres. Mapping heat risk requires data management and analysis capabilities; cities can work with a local university or other expert organisation to deliver this analysis. The United States Environmental Protection Agency has useful guidance on how to develop heat maps.

The main sources of surface-temperature data that cities can use for this mapping are:

- **State- or national-level meteorological agencies.** Many cities have access to state- or national-level surface-temperature data from on-the-ground sensors. Toronto, for example, uses meteorological data from Environment Canada, while Barcelona uses data from the Meteorological Department of Catalonia. Be aware, however, that national meteorological sensors are often located outside the city centre at locations such as airports, where temperatures are typically lower.
- **Satellites,** which measure the temperature of land surfaces across the globe using a thermal infrared sensor – in particular NASA's LANDSAT thermal data, which is available for cities across the globe. Washington D.C. developed a surface-temperature map layer using LANDSAT data.
- **Local temperature sensor networks.** Cities can install local on-the-ground temperature sensors to map the urban heat island effect in real-time. For example, Madrid has installed a meteorological sensor network, which measures temperature, humidity and other metrics with 27 sensors across the city.

Cities that are implementing an air quality monitoring network can consider using high quality or 'smart' sensors that also monitor temperature, alongside air quality. Read *How to set standards and monitor air quality* for more information about how to establish monitoring networks.

Heat vulnerability mapping in Durban, South Africa

Durban worked with researchers to create an Urban Heat Island Intensity map, using information from temperature projections and detailed information about urban surfaces, such as roads and buildings, from the city spatial development plan in that region. This was overlaid with socio-economic data relating to heat sensitivity, such as low income levels, to develop a social vulnerability index for sensitivity to heat, adjusted

for population density. The maps (see below) show the correlation between heat stress and so[illegible] vulnerability.

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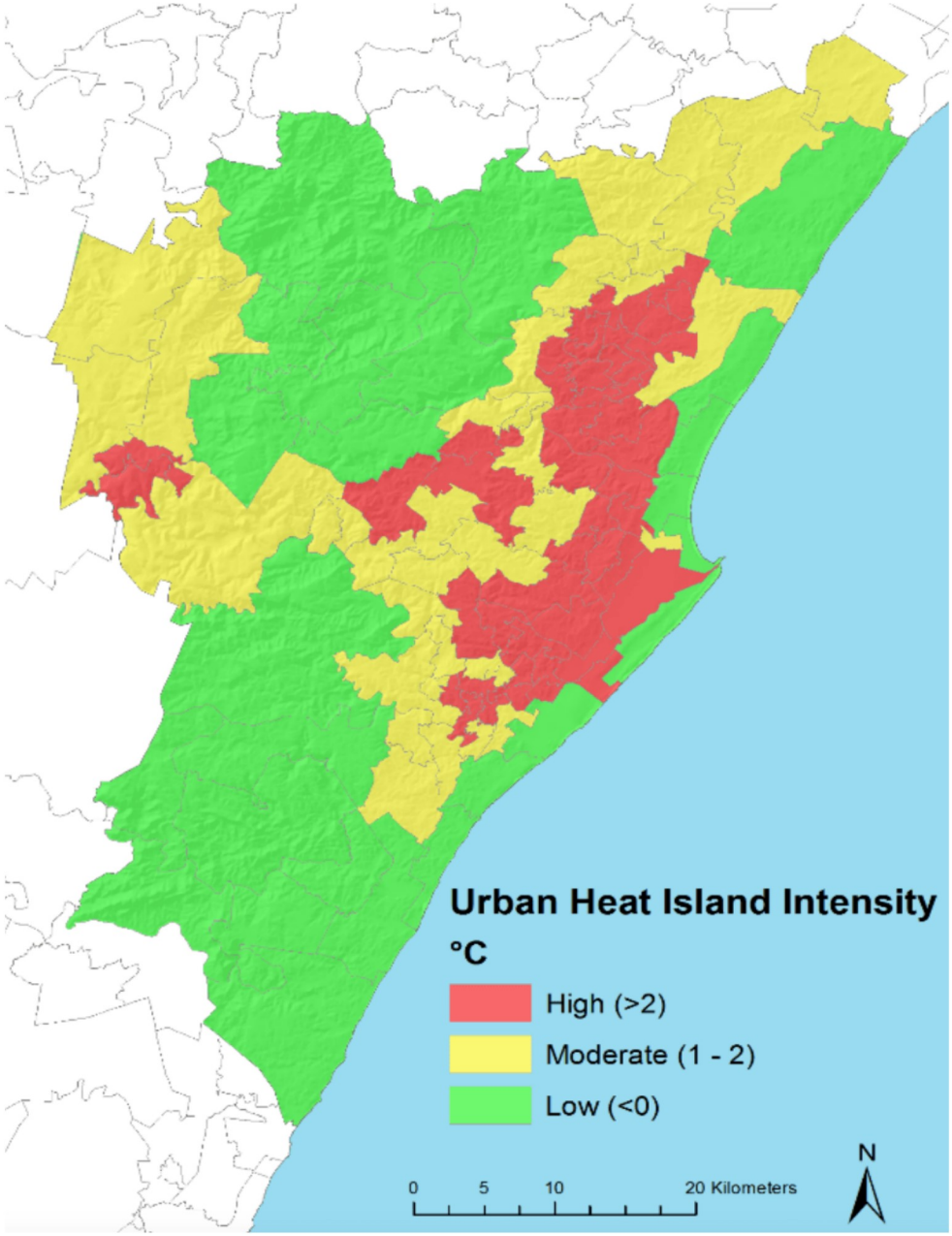

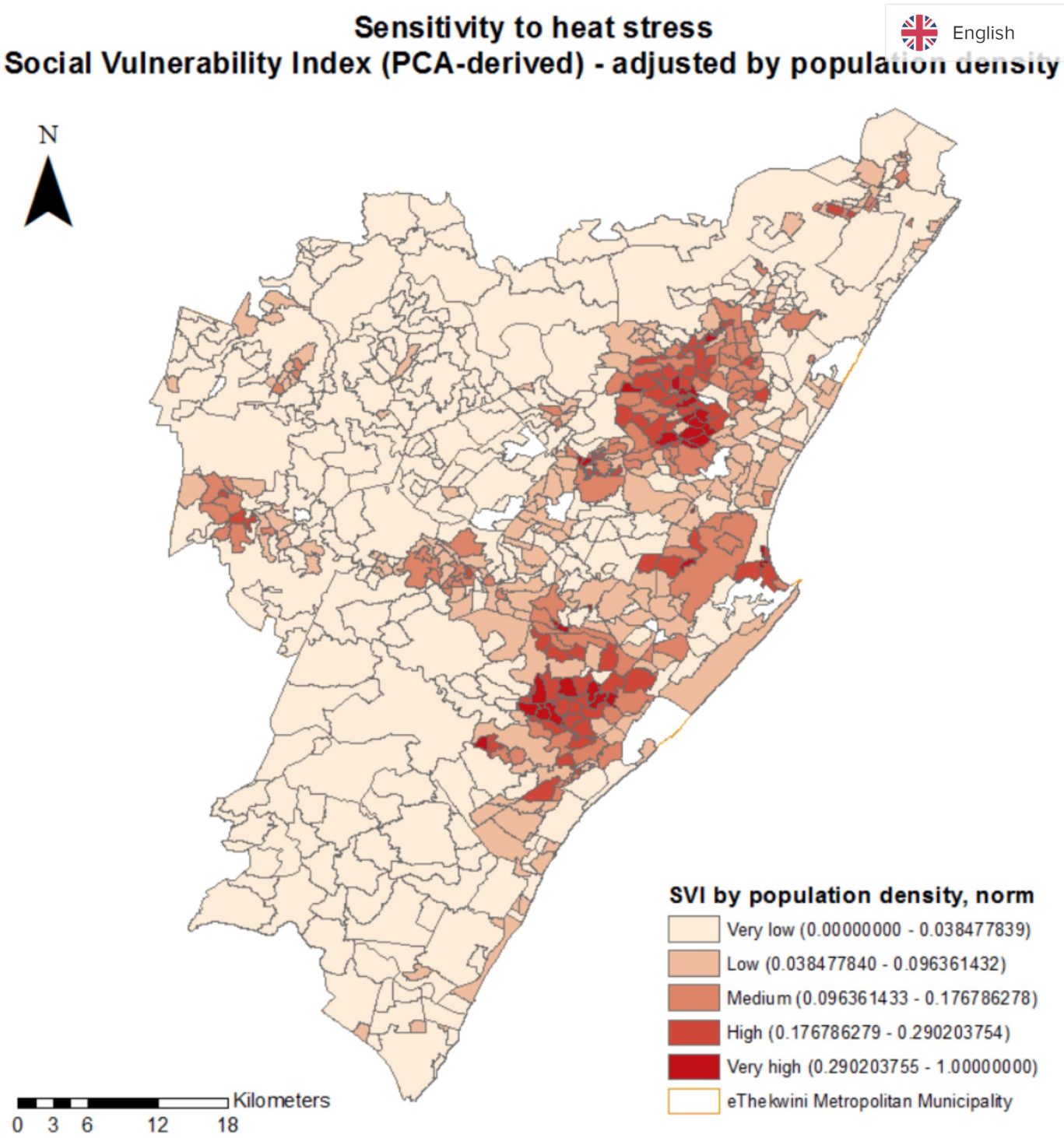

Develop a heatwave response plan

Work with national and/ or state government departments, meteorological institutes and emergency response departments to develop a heatwave action plan.

In advance of the heat season, cities should:

- **Ensure the city receives a temperature forecast.** This is vital to enable heat emergency planning but many cities, especially cities in the Global South, don't have access to a reliable weather forecast.

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Cities can work with the national meteorological department, or seek help from universities or meteorological agencies in other countries, to fill this gap.

- **Build partnerships and coordination** between the city government, meteorological agencies, health and emergency departments, the media and other partners, to develop and implement the response plan. Appoint a steering group or lead officer to coordinate between these stakeholders.
- **Build capacity among health-care professionals** to recognise and respond to heat-related illnesses.
- **Communicate with the public, and work with businesses employing vulnerable workers,** to raise awareness about the heat risk and ways to mitigate it. The *Home Cooling Tips* messaging toolkit can support this.
- **Determine the heatwave response actions that are triggered by a heat alert,** or different levels of a heat alert. Priority actions should include distributing the heat alerts and information, opening and promoting cooling centres with drinking water facilities, and rolling out heat emergency measures in hospitals and elderly homes.

Evaluate and update the heatwave response plan after each heat season.

Read the *How-to-Manual: Steps to Develop a Heat Action Plan*, and the detailed *Heatwave Planning Guide: Development of Heatwave Plans in Local Councils in Victoria*, for detailed guidance on which agencies to work with, effective heatwave response actions, and more, based on experience from Indian cities and from Australia respectively.

Cooling centres are public or private spaces such as libraries, museums or parks, which cities set up temporarily to provide cooling shelter for citizens. **Cool routes** are shaded walkways. Cities must promote awareness of the locations of these centres ahead of, and during, a heatwave, for example by using billboards, phone applications or text messages.

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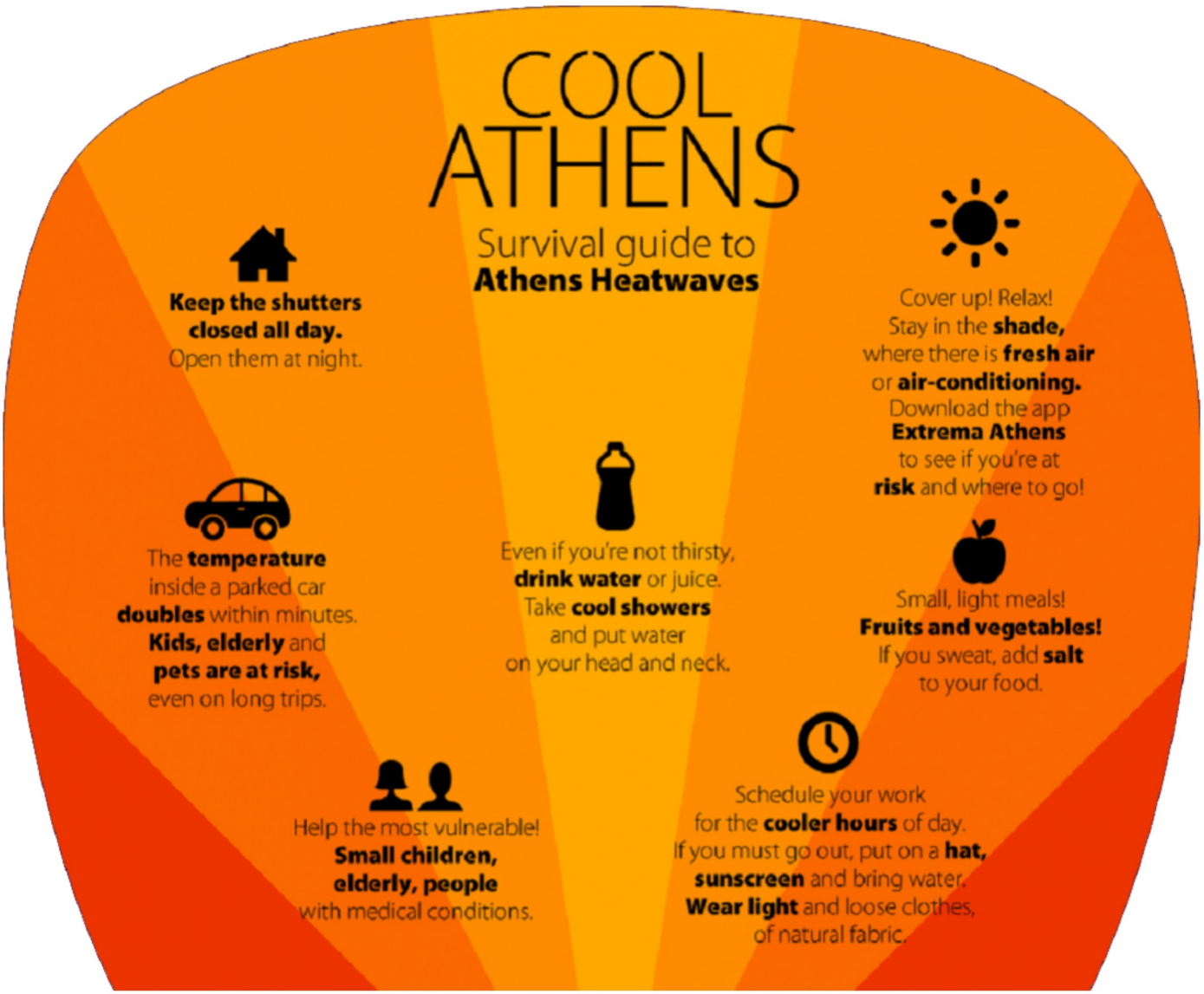
Cities can also map these using online platforms, as Toronto, New York's Cooling Centre Finder (only available during heatwaves), and Washington D.C. have done.

Paris, Athens, and Rotterdam have launched the EXTREMA app in their cities, which assesses users' heat vulnerability and directs them to the nearest cooling centre.

Communicate with citizens during a heatwave using messages in prominent places such as bus stops or pharmacies, and by distributing visual guidance.

For example, Athens distributes information on printed fans:



The Extreme Heat Safety Social Media Toolkit from the United States Department for Homeland Security contains messages and graphics that cities can use.

Heat Action Plans in Ahmedabad, India

Ahmedabad, India, has avoided over 1,100 heat-related deaths annually since the city implemented South Asia's first ever Heat Action Plan, in 2013.[5] It emphasises heatwave preparedness and response, and includes four pillars: building public awareness and community outreach; an early warning system and inter-agency coordination; capacity building among health-care professionals; and adaptive efforts to reduce heat in the city. For example, the Cool Roof Programme uses a white lime wash to provide a simple and cost-effective solution to extreme heat in the city, targeting low-income households and municipal buildings such as hospitals. The city evaluates and releases a new plan every year – read the *2019 Heat Action Plan*, and watch the short video below to find out how they did it.

Develop a comprehensive long-term plan to reduce the heat threat

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Heat mitigation strategies that reduce the urban heat island effect should be part of the city's wider climate action planning and incorporated into relevant sectoral legislation, particularly for new and existing buildings, transport, and urban planning.

The urban heat island effect

The heat threat is exacerbated in cities due to heat-absorbent building materials; heat emitted by the built environment, transport and industries; higher air pollution; and a lack of vegetation (which cools through evapotranspiration), among other factors. This phenomenon is known as the urban heat island effect, and means that cities are typically 3 – 8°C warmer than rural areas.

The main heat mitigation solutions are:

- **Trees and vegetation.** Trees cool cities by shading the ground and structures around them, and through evapotranspiration, offsetting the urban heat island effect. They offer a cost-effective way to reduce urban heat. Read *How to expand your city's tree canopy cover* to learn more.

- **Cool roofs.** Roofs can be painted white or with other highly reflective paint, or covered with sheet covering, highly reflective tiles or shingles, to reflect more sunlight and absorb less heat than a standard roof – cutting building energy use by up to 20%.[6] Even in cooler climates, the gains in summer outweigh the small heat use increases in winter.[7] In New York the NYC Cool Roofs initiative provides local jobseekers with training and work experience installing cooling, energy-saving reflective roofs, and provides low- or no-cost white roofs to building owners, who apply to take part. The initiative is a partnership between the NYC Department of Small Business Services, the Mayor's Office of Sustainability, the Mayor's Office of Recovery and Resiliency, and Sustainable South Bronx, and has since been replicated in cities including Busan and Seoul in South Korea.[8] Also in the United States, the Los Angeles, Philadelphia and Washington D.C. building codes require the use of cool roofing materials for specified building types. *Cool surfaces* looks at cool roof policies in place in Toronto, Cape Town, Tshwane, Madrid and Buenos Aires, as well as cities' cool pavement initiatives.

Examples of heat mitigation plans include:

- New York City's Cool Neighborhoods NYC, which combines heatwave response and adaptation actions.
- Los Angeles' Green New Deal (2019) and Resilient Los Angeles (2018) (Goal 6: Prepare and protect those most vulnerable to increasing extreme heat).

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- Barcelona's Climate Plan 2018 – 2030 (Line of Action 3: Preventing excessive heat).
- Melbourne's Climate Change Adaptation Strategy Refresh 2017, which addresses heat throughout.
- Paris' Climate Action Plan (Goal: Strengthen solidarity and resilience in response to heatwaves).
- Sydney's Adapting for Climate Change long-term strategy (2017) and subsequent five-year Turn Down The Heat Strategy and Action Plan (2018).

- **Cool pavements and road surfaces.** Conventional paving materials, which typically cover around 40% of a city, reach peak summertime temperatures of up to 65°C (150°F) and heat the air above them. Cities can use lighter colour paving options to create more reflective paved surfaces that reduce heat risk. Permeable pavements, including reinforced grass pavements, can also cool a pavement through the evaporation of moisture. In Japan, the Tokyo Metropolitan Government has installed or provided a subsidy for cool pavements as part of road construction and maintenance in priority areas.[9] Other cities using cool pavements include Paris, Los Angeles, Chula Vista and Sydney. Read *A Practical Guide to Cool Roofs and Cool Pavements* for more information.

- **Green roofs and walls.** Covering a building's roof or wall with a layer of vegetation shades building materials, which would otherwise absorb heat, and can reduce temperatures. Toronto's Eco-Roof Incentive Program provides grants for both green and cool roofs to homes and businesses. The City of Barcelona's *Guide to Living Terrace and Green Roofs*, and the *Guide to Green Roofs, Walls and Facades in Melbourne and Victoria, Australia*, are useful resources setting out the benefits, social and technical considerations, and advice on choosing green roof types.

Nature-based solutions can reduce the threat from heat as well as other hazards

Trees, green roofs and other natural assets act as buffers to climate hazards. They also improve physical and mental health, make cities more attractive, and provide excellent value for money. *Nature-based solutions: How cities can use nature to manage climate risks* looks more closely at these options and how to use them.

- **Alternative shading and cooling methods,** which include artificial shading structures, canopies and water features such as 'spray parks'. For example, Tel Aviv's Shade Planning Guidelines sets standards on the quantity and quality of shade, using vegetation, fabric or structures. Cape Town has implemented six water spray parks within heat-vulnerable and underprivileged neighbourhoods. Spray parks are safe water play areas within public parks, primarily for children. They use significantly less water than swimming pools and are much more cost effective to build.

- **Heat-sensitive urban planning.** Urban design can play an important role in cooling cities. For instance, linear parks and green corridors help to enhance ventilation, and a high 'sky view factor'

cools cities by enabling the release of trapped heat into the sky. The *Integrating Climate Adaptation* toolkit for urban planners and adaptation practitioners explains more.

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All of these approaches and more are captured in the *Urban Cooling Toolbox*, which presents a series of cards that cities can use in climate action planning and stakeholder workshops.

Neighbourhood Level Cooling sets out ways to understand urban heat and involve local people in implementing cooling solutions at the neighbourhood scale. Low Carbon Living's *Guide to Urban Cooling Strategies* also provides more guidance on these options, based on Australian cities' experience, while *Adapting to Urban Heat: A tool kit for local governments* explains these solutions alongside policy tools to increase their use. The Cooling Singapore project's *Strategies for Cooling Singapore* details over 80 measures to mitigate the urban heat island effect.

Take a whole-system approach using the *Beating the heat* handbook

By taking a whole system approach to tackle urban heat, cities can address the multiple factors that contribute to it and maximise the benefits of cooling for health, energy demand and more. *Beating the heat* is a comprehensive guide to developing an urban cooling action plan, taking a whole system approach, with a clear framework to support planning and 80 good practice examples from cities across the world.

C40's Adaptation and Mitigation Interaction Assessment Tool (AMIA)

The AMIA tool can help cities to understand the interactions between climate change adaptation and mitigation strategies in climate action planning. The tool maps the synergy potential, trade-off potential, mal-investment risks and piggybacking opportunities of a wide range of actions, including heat mitigation solutions. You can download it and find out more about how it works here.

Heat reduction targets

Cities can establish targets to help drive and communicate action as part of the city's heat strategy. Targets are typically linked to a heat mitigation approach and/ or a temperature reduction goal. For example:

- **Los Angeles:** the Sustainable City pLAn 2019 set out an urban heat island reduction goal to reduce the urban/ rural temperature differential by at least 1.7°F by 2025, and 3°F by 2035 (see Chapter 11). The city also set targets for new cool roofs and pavements linked to these goals.
- **Melbourne:** the Urban Forest Strategy sets out to cool the city by 4°C. To achieve this, the city has a

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target to double the tree canopy cover by 2040 – requiring at least 3,000 trees to be planted every year.

- **New York:** In 2007, the city launched its Million Trees NYC programme, which planted its millionth new tree in 2015, two years ahead of schedule.
- **Paris:** The city's climate action plan sets targets for 30 additional hectares of green space open to the public; 100 hectares of vegetation on walls and roofs, one third of which should be dedicated to urban agriculture; and 20,000 new trees planted.
- **Barcelona:** The Climate Plan 2018–2030 sets a target for 1m^2 of greenery per resident by 2030, equivalent to 160 hectares of new green space by 2030.

Raise awareness of the wider benefits of action to reduce urban heat

As well as reducing the risk to citizens' health and cities' economies, action to reduce urban heat provides many other benefits. Develop simple and understandable informational materials, run educational sessions with schools and community groups, and raise awareness through campaigns to highlight the wider benefits. The main benefits are:

- **Creation of jobs and new careers.** Initiatives to reduce urban heat create business opportunities and jobs, for example in installing cool or green roofs. Cities such as New York and Seoul provide skills training services and aim to connect participants to full-time work.
- **Reduced energy costs** for building owners and tenants, due to lower demand for cooling. If all commercial buildings in the United States switched from dark to light roofs they would together save almost $1 billion a year in avoided electricity use.[10]
- **Improved energy security.** Extreme heat days put considerable strain on electricity grids as demand for air conditioning increases, which can lead to service disruptions and lost productivity.
- **Improved air quality and sequestration of carbon dioxide.** Cooler temperatures reduce the risk of smog, while green heat solutions help to clean cities' air and remove the greenhouse gas carbon dioxide (CO_2) from the air. Arup's Cities Alive: Green Building Envelope looks at the benefits of green roofs and walls for urban heat as well as air pollution and acoustics.
- **Increased wellbeing.** Extreme heat impacts health, and reduces physical activity and time spent outdoors. Urban greening and cooling actions can have direct positive impacts on wellbeing.
- **Increased equity.** If unmitigated, heat takes a disproportional toll on lower income communities in neighbourhoods with lower quality building stock, less tree cover, and less air conditioning. *Urban Heat and Equity* offers experiences from 12 cities which are working to reduce the inequitable distribution of heat risks, and *Cooling Schools* provides recommendations for cities seeking to protect children from heat.
- **Improved efficiency of rooftop solar panels.** When solar panels become very hot, their efficiency can drop by up to 25%.[11] Cool roofs help to mitigate this.

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The *Heat Resilient Cities* Excel-based tool may be helpful to support the quantification of health, economic and environmental benefits of planned urban heat adaptation options.

Read *Why your city should use nature-based solutions to manage climate risks* for more about the benefits of green and blue infrastructure for mitigating risk from other climate hazards, improving biodiversity and more.

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