ARUP

Urban Heat Snapshot

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How can digital tools help reduce the urban heat island effect in our cities?

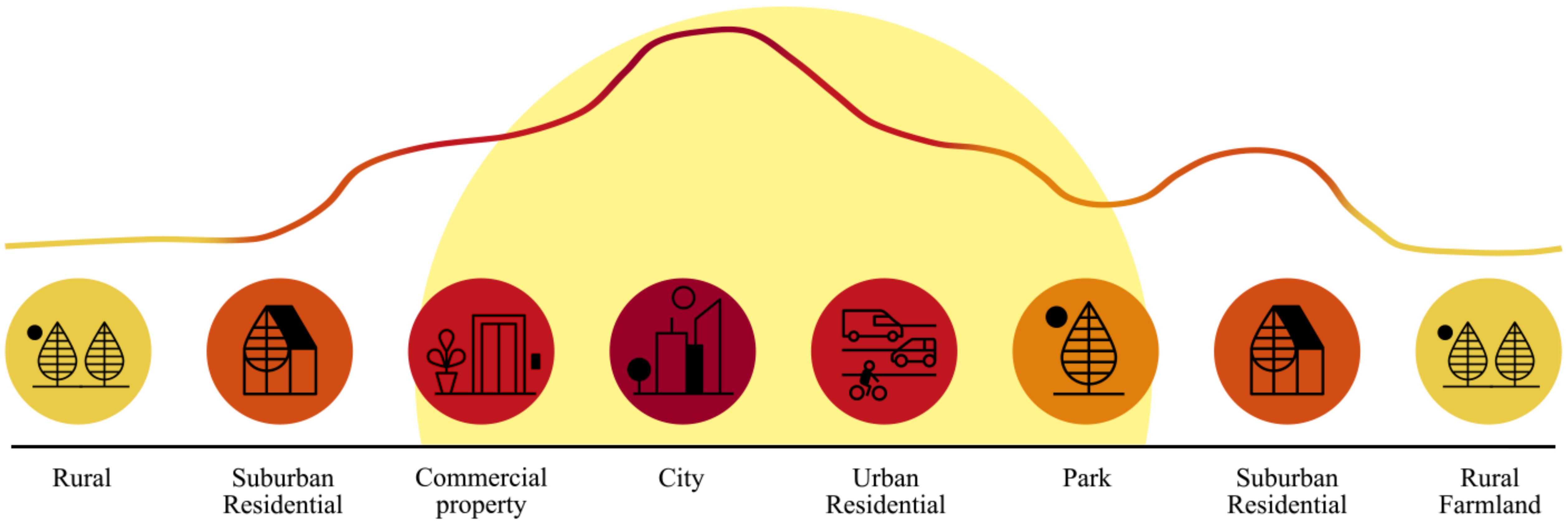
Foreword

The world has watched records be smashed as extreme heatwaves have hit in 2023. China confirmed a record temperature of 52.5°C, the UK had its hottest June on record, people in Italy were warned to stay indoors and the province of Alberta in Canada was under a state of emergency as wildfires burned. Heatwaves kill – they put people's lives and health at risk. And they cause real suffering for millions. It is something that almost all cities around the world are going to rapidly need to get better at managing.

My focus is on studying the impact of weather and climate extremes in cities – and through modelling understanding the risk they face from increasing extreme heat and heavy rainfall events. In academia we have extremely complex models such as the urban climate model SUEWS (Surface Urban Energy and Water Balance Scheme) that allow us to understand what causes cities to heat up, and what can help cool them down. Outside of academia measuring and understanding urban heat is often very crude, with people sent out into the field to measure with thermometers, or land surface temperatures taken which don't really give a sense of how people experience heat on the ground.

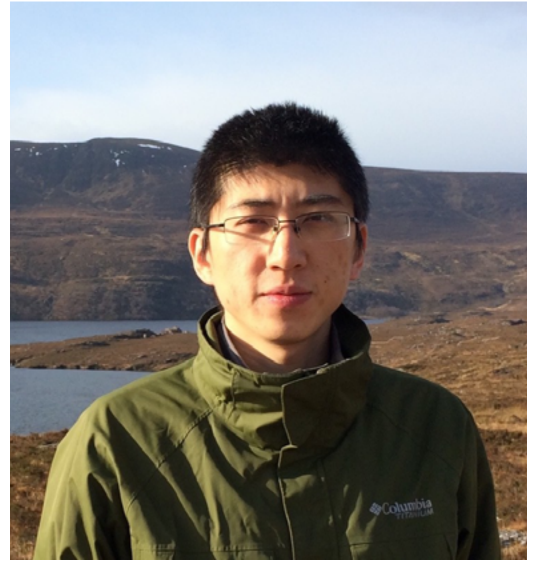
That's why I have been so excited by the development of the UHeat tool by Arup. Arup is involved in thousands of built environment projects globally working with a vast array of clients. I have been pleased to help them take the complex analysis of SUEWS and distil it for a rapid modelling tool. This gives those shaping the built environment a tool that lets them test different scenario and interventions and give evidence to support different solutions.

This Urban Heat Snapshot shows off the power of this tool across major cities. And it brings an important message. Cities need to fully understand – street to street – the risks being faced by their citizens from extreme heat. Because as this snapshot shows – the risk being faced is not the same for everyone. All cities need to understand their urban heat island hot spots where there is a significant uplift in temperatures – sometimes from one neighbourhood to the next. Only then can they work to mitigate them – particularly by using nature-based solutions.



The Urban Heat Island effect

"UHeat provides a tool for urban designers and planners to test different interventions and give evidence to support different solutions"



Dr Ting Sun
University College London, Institute for Risk and Disaster Reduction

Cooling our cities by designing at a street, neighbourhood and city scale

Dima Zogheib, Nature Positive Design Lead, Arup

Climate change is making our cities dangerously hot, with the number of cities exposed to extreme temperatures of 35°C and above expected to triple by 2050.

To a large extent, we have designed our cities to be hotter. We've pushed out nature, concreted our streets and built high in steel and glass. That makes the built environment a huge contributor to the build-up of heat in cities, compared to their rural surroundings. This is known as the urban heat island (UHI) effect.

The effects of heat are broad, but not everyone is impacted equally by heat. Often, it's the most vulnerable who are most impacted by these urban heat island hot spots. Income inequality can play a role in the ability for people to be able to cool themselves, as well as being less likely to have greenery and shade from trees to keep their streets cool.

It's encouraging to see growing efforts to highlight the problem of urban heat, with cities such as Seville and Athens now naming heatwaves to build awareness and appointing Chief Heat Officers to drive forward heat resilience planning.

Arup's Urban Heat Snapshot

We undertook this survey to highlight the importance of cities tackling their hot spots. We want to demonstrate that urban planners and designers can make a real difference to heat resilience on a street, neighbourhood, and city scale. We also want to show that there are digital tools out there to help us understand the impact of design choices on heat, and to adjust them accordingly. When combined with information like cities' socioeconomic makeup and heat vulnerability data, this can help target interventions where they are most needed.

The results of our survey were stark. In two cities it showed a massive 8°C difference in temperature between areas in close proximity to one another. And it highlighted the risks for vulnerable people, for example in the area studied in Madrid we identified approximately 492,000 children and older people living within UHI hot spots of 7°C or more. This is worrying, given these groups' vulnerability to heat-related illness.

Our survey also revealed that in many of the cities the urban heat island effect is heightened in the evening and in the night-time. This is also especially concerning, in light of a recent study[1] which estimated that by 2100, the risk of death from excessively hot nights could grow six-fold compared to 2016.

[1] Study published in the Lancet Planetary Heath Journal, The effects of night-time warming on mortality burden under future climate change scenarios: a modelling study.

Bosco Verticale, Italy
Bosco Verticale is a vertical forest in the sky. The design creates a biological habitat within a total area of 40,000m^2 and includes a total of 900 trees between 3m and 6m in height planted on the terraces up to the 27th floor, along with 5,000 shrubs and 11,000 floral plants. Find out more.

Building urban heat resilience

The good news is that not only can urban heat be mitigated, but this can be achieved with solutions that have been around for centuries. Each city, and area within it, needs its own bespoke plan, but there are some broadly applicable approaches to building heat resilience:

Increase tree canopy cover

Trees have proven to lower temperatures in cities and reduce heat-related mortality. Advanced technologies allow designers to understand exactly the type and number of trees needed to impact urban temperatures and protect people. In Albania, Arup used its land-mapping AI and machine learning tool, Terrain, to quantify the urban heat benefits of Tirana's Orbital Forest – 2 million trees that aim to help the city address its heat and flooding challenges.

Create more permeable surfaces

Permeable surfaces, such as bare or planted soil, tend to absorb less heat compared to impermeable surfaces like concrete or asphalt. Increasing permeable surfaces and allowing water to infiltrate into the ground will cool the surrounding environment. Sustainable Urban Drainage schemes such as Arup's design for the UK's Greener Grangetown in one of Cardiff's residential neighbourhoods, are not only slowing down water runoff during heavy rainfalls, but also increasing areas of green space, and cooling neighbourhoods during hot temperatures.

Use every space possible

More than half of the space in cities (including roofs and streets) is open space, providing a large canvas for building resilience – all that's required is some creativity. Arup has been working with local authorities in London to assess the potential for a mass roof retrofit using reflective and solar PV, to cool the buildings themselves and reduce the need for air conditioning, as well as capturing energy to help decarbonise its energy use. This will have a significant impact on the urban heat island effect – with less heat being released by buildings at night.

Creating cool islands

With cities set for heatwave conditions every summer we need to create a network of cooling spaces in cities for people to take refuge. For example, in London we worked to map cool spaces where locals could find opportunities to shelter during hot days in a bid to reduce risk to health from hot weather. Also, something as simple as bringing back drinking water fountains to cities could improve health for citizens, becoming the main access point to water during a drought.

Spark behaviour change

But design can only do so much. Fundamentally, people will need to change the way they live in cities within the next decade. Hot countries around the world have been adjusting their lives to this for centuries, and it's time to learn from them – incorporate siestas, re-consider office hours, introduce shop and restaurant closures over peak heat.

Adapting to extreme heat requires a vision and incremental implementation. But we cannot afford to shy away from this challenge – now is the time to rethink how we build and live in cities.

Dima Zogheib
Nature Positive Design Lead, Arup

Resilient cities are biodiverse cities: raising our ambition in the age of the Anthropocene

Neil Harwood, Biodiversity and Nature Specialist, Arup

We are on the verge of scientists proving that humans are the driving force in changing the way our planet functions. So much so, that we have now moved into a new geological epoch: the Anthropocene era.

Nowhere else is this impact more apparent than in cities. Every inch of space is controlled by humans, while nature, where it exists, is selected and pruned for its aesthetic properties alone.

As our Global Sponge Cities Snapshot and Urban Heat Snapshot have shown, using AI and satellite data, the huge extent to which grey infrastructure is dominating our cities. Where green and blue spaces cut through, they are often carefully controlled and disconnected - clipped, maintained and shaped to suit the tastes of us humans. Meanwhile, often not enough thought is given to their impact on biodiversity.

But as an ecologist, I have been heartened by the steady growth in interest in the role of green and blue infrastructure in our cities. There is a growing recognition that grass, trees, ponds and other natural elements are vital assets that can play a major role in helping cities become more resilient and able to cope with increasing shocks and stresses caused by climate change, from heavy rain to extreme heat.

However, when discussing nature-based infrastructure we need to get a lot more ambitious a lot more quickly. We need to move beyond seeing green and blue spaces as nice-to-haves, designed with their aesthetic qualities in mind above all else. They are far more existentially important to our cities, forming critical infrastructure which needs the same systems thinking and level of checks and balances as grey infrastructure.

How do we make sure that our green and blue infrastructure is working as hard as possible? How do we make sure it is resilient? Crucially, we need our nature-based solutions to contribute to complex biodiverse systems in our cities.

Wild West End, UK
The Wild West End project is seeking to make this corner of London more biodiverse and resilient to climate change, and in doing so, create a better place to live, work and visit. Read more.

Biodiversity is the key to resilience

Biodiversity is not a 'nice to have'. It is as critical as load testing and structural safety checks on a bridge. There is huge risk in a lack of diversity - deploying one plant species or habitat typology en masse leaves this vital infrastructure vulnerable to pests, disease, and climate shocks. No-one wants to see trees or green spaces wilt and die, but badly designed features requiring lots of maintenance are less likely to be able to survive a heat wave, drought, extreme rainfall, or disease. The green interventions that fail can also erode public trust in nature-based solutions, showing them as unsustainable or unreliable investments in the long run. To put it simply – if we have the space to put in five trees to shade a road, instead of five identical, pretty lollipop trees that require high levels of care and maintenance, let's opt for a more diverse and practical range of three to five different species that will be able to withstand shocks and serve us for generations to come. Our level of ambition needs to match the scale of the challenge.

To give another example, developing a range of water systems is key to cooling down cities and making them more liveable. We've seen this in Seoul, South Korea where the Cheonggyecheon Stream has been brought back to the surface after being paved over in the 1950s to make way for a new road. The new stream became a tourist attraction, and a valued public space that the community flocks to during heatwaves.

However, many cities that could benefit from similar interventions are concerned that new water features will bring mosquitoes. That's understandable – climate change is increasing the risk of the spread of mosquito-borne diseases in Europe. But, as an ecologist, I know that complex, diverse ecosystems built around water will bring with them not just mosquitoes, but also dragonflies, damselflies, birds, bats and fish. These will collectively keep mosquitoes in check, while allowing the water to deliver a whole host of other benefits, from a cooling effect to flood resilience to spaces for urban communities to interact with nature.

Designers also need to adjust to local conditions through the use of locally appropriate species, but we should be wary of native species purism in urban environments. When designing large scale interventions, we need to take into account future climates too - increasing heat, droughts or extreme rainfall events and prioritise resilience to those. This may widen the pool of appropriate plant species beyond those that are considered to be native, though we can always focus on those non-natives known to be used by and of benefit to local fauna species. Fundamentally, biodiversity is about diversity.

Cheonggyecheon Stream, South Korea
In Seoul, South Korea, the Cheonggyecheon Stream has been brought back - a valued public space that the community flocks to during heatwaves.

Think like an invertebrate

For biodiversity to flourish, we also need a mindset shift. We need to change the idea of what we see as beautiful, reimagining every piece of unused hardstanding or manicured lawn as a potential habitat and opportunity to cultivate more complex ecosystems.

One initiative which encourages this different attitude is No Mow May. A global campaign that calls on garden owners and green space managers to hold off mowing grass in the month of May, creating space for nature to flourish, at a crucial time of year for many invertebrate species in many parts of the world.

But creating space for biodiversity doesn't need to mean unkept, long grass, untidiness and neglect. Take spaces alongside our roads. A compromised approach can mean the creation of a transitional ecosystem, starting with a short-mown edge, blending into ankle-high grass, up into longer, tall grass fringes that are then backed by scattered shrubs and small trees. This type of managed ecotone provides a perfect habitat transition that doesn't compromise on road safety or aesthetics.

We need to think similarly about our own back gardens. Recent interventions, such as bans on artificial lawn products and council incentives for UK households that allow nature to flourish around their property, can help accelerate the greening of our cities.

Fundamentally, we need to accept that our city spaces are not just ours. Imagine a neat stack of rocks on a roof of a building. To a human, it's a bit of rubble, but to a spider it's a mountain range that can become a home.

Building complex ecosystems through collaboration

Importantly, while change starts at street, neighbourhood, or development level, if we want to create complex ecosystems in our cities, we need to join up all these aspects. Wildlife doesn't care about property boundaries, and we need scale to be able to build truly biodiverse, functional ecosystems in our urban spaces.

Like in London, where the Wild West End project has brought together some of the capital's largest property owners - the Crown Estate, Grosvenor, The Howard de Walden Estate and more - alongside communities that live and work in the area, to introduce green steppingstones within the built environment between Regent's Park and Hyde Park. These individual interventions combine to build a green corridor, made up of green roofs and walls, planters, flower boxes and trees, which is becoming a more robust ecosystem supporting birds, bees and bats, as well as spaces people want to spend time in.

Surprising symbiotic relationships

I'm often asked what works best for urban roofs to bring down temperatures - solar panels or green roofs? I always say - do both! Rooftops can be stressful environments for plants, having to withstand direct heat, sunlight and wind. Elevated solar panels create more favourable conditions by providing much-needed shade and shelter. Meanwhile, greenery reduces the degree variation in temperatures on the roof's surface, helping the panels' performance. It's a win-win situation. We need to open our eyes to the opportunity for sometimes surprising symbiotic relationships.

We have to rapidly establish a way to bring back nature into our human-centric spaces. It's up to us to make that impact positive and move away from exploiting nature, instead creating a symbiotic relationship reconnecting people and nature that serves us all.

Neil Harwood
Biodiversity and Nature Specialist, Arup

Digital solutions: a pathway to resilient, nature positive cities

Dr Will Cavendish, Global Digital Services Leader, Arup

More than 4.5 billion people already live in cities around the world, and by 2050 we expect 2.5 billion people more. This presents a profound challenge: to provide for these people's needs for housing, energy, transport, water and wider amenities equitably and fairly, while at the same time living within the planetary boundaries. It's an urgent challenge, given we have already used 80% of the carbon budget that would keep us within 1.5-degrees of global warming, and nature is evidently in crisis around the world.

What gives me some hope for the future, is the way in which digital solutions are providing a step change on the journey to net zero and restoring nature, while meeting human needs. Innovators are combining insights from things like machine learning, new satellite data, digital visualisations and advanced algorithms, with traditional disciplines such as engineering, urban design and ecology, to create new solutions and new approaches. It's an exciting time for human ingenuity and creativity – and it's never been more important.

Tackling the urban heat island crisis

This is a great example of how digital is helping solve global challenges. Arup's digital solution UHeat allows rapid complex modelling, combining remote sensing data with a climate model, to calculate urban heat island effects at a very local level, across an entire city. But critically, it also exposes the factors contributing to the urban heat island effect, giving city planners, designers, authorities, and those shaping cities the insights they need to rapidly understand the impacts of their design on urban heat and how to cool their cities down.

Such complex heat modelling has historically been reserved largely for academics, and been a time-consuming exercise, but UHeat bridges this gap, drawing on the technical work and methods developed by researchers and combining them with increasing amounts of city data available through remote sensing. This means that city leaders, designers, and planners can rapidly understand what interventions will be effective in bringing down temperatures in their local climate and context at a street, neighbourhood, and city scale - protecting people from extreme heat in their cities.

For example, we have used UHeat with the UK's Greater London Authority on a city-wide programme of retrofitting existing buildings with 'cool roofs' – featuring reflective paint and solar photovoltaic (PV) panels – to help guard against rising temperatures due to climate change. The project shows how adaptations at scale will lower temperatures inside and outside buildings, resulting in positive impacts on health and wellbeing for Londoners.

The tool has also been used in Tanzania's largest city, Dar es Salaam, to evaluate its future urban heat profile based on major projected increases in population. This has helped show the potential of nature-based solutions to tackle the UHI effect, reducing temperatures across the city.

Dar es Salaam, Tanzania

Harnessing the power of nature-based solutions

Nature-based solutions are up to 50% more cost effective than man-made alternatives and deliver 28% more added value. However, unlocking finance for nature-based solutions can be difficult. Institutions and governments are used to investing in traditional concrete and steel solutions and there is a lack of data and understanding of the wider benefits that nature-based solutions can bring. But advanced digital tools are helping make green infrastructure projects bankable.

Terrain, our AI land-use digital mapping tool, helps cities rapidly understand how land is being used. It is able to analyse 20,000 m^2 per second and is so powerful it can distinguish between a tree nursery and a forest. This precise insight can provide the evidence for moving away from "grey thinking", and instead bringing in green and blue infrastructure solutions.

In a UK town of 100,000 people, Terrain helped a water utility company demonstrate that, whilst a traditional grey concrete design method would cost marginally less, when examining the whole value case a green structure would be more cost effective. For example, green spaces could provide health benefits to the local population and result in significant long-term savings for the NHS from the air quality improvements.

In Shanghai we've designed an urban drainage masterplan for a population of 15 million, that used Terrain to interpret images and categorise the entire area into 12 categories of flooding protection required. Instead of focusing solely on drainage, a visionary "blue, green and grey" approach was designed to support an integrated water cycle within the city.

Another use of of Terrain has been to better understand the "sponginess" of cities around the world and demonstrate the role of nature-based solutions in flooding resilience. Our Global Sponge Cities Snapshot is aimed at getting cities thinking more about nature as an asset, as infrastructure – to be protected and enhanced.

Monitoring and promoting biodiversity

We are also using digital tools to measure and support Biodiversity Net Gain (BNG) plans around the world. Far from traditional, manual approaches, for projects such as the East-West rail in the UK, Arup has devised an innovative digital solution that tracks BNG throughout the design stage and beyond.

Using satellite imagery, our machine learning tools can produce highly specific habitat maps, calculate and quantify biodiversity scores, and monitor their progress. By using satellite data imagery we can use habitat and BNG estimates at the start of the project, increasing the chances for nature positive outcomes.

With multiple datasets stored in a single, centralised database, project designers have a live source of truth, enabling them to rapidly reflect BNG outcomes in their design choices. As well as ensuring projects already underway have a positive impact, these BNG insights can be used to underpin investments, including high-fidelity green finance and offsets.

Hunter's Point South, USA
Sustainable urban ecology schemes such as Arup's design for Hunter's Point South, a waterfront park in New York City, are transforming previously unused industrial and urban areas into a cool oasis for urban dwellers with features like bioswales and streetside stormwater planters. Read more.

Reducing carbon emissions

Digital technologies also have a huge role to play in reducing carbon from buildings and infrastructure. We're using AI-based tools to listen to the vibrations of buildings to understand their structural health, allowing us to safely extend the lifetime of buildings – providing an alternative to demolition.

We also need to think smart when it comes to keeping existing, aging infrastructure in use, and new digital tools are making this possible. For example, in the Netherlands, a team is working to extend the life of two highway bridges that are no longer fit for purpose and would normally be removed.

Automated digital tools and structural health monitoring sensors are allowing the team to remove one bridge and renovate it offsite nearby and then use it to replace the second bridge, which has in turn been renovated and re-used elsewhere.

With our latest digital generative design digital tool, InForm, we can evaluate 1000s of potential designs for building, infrastructure and city masterplanning projects. Using InForm, an embodied life cycle assessment for linear underground infrastructure was developed for CERN and KEK. CERN and KEK are leading the science community to deliver new collider systems, enabling advances in healthcare and aviation, as well as particle physics. The tool enables stakeholders to understand the carbon savings that can be achieved through design optimization and using lower carbon materials for the Compact Linear Collider (CLIC) and International Linear Collider (ILC) projects. Through this life cycle assessment, real embodied carbon reduction opportunities of c.40% were demonstrated, aligning with the UN Breakthrough Outcomes of projects using 40% less embodied carbon by 2030.

The ultimate goal is to change the way we design and manage cities – and we have the tools for transformation at our fingertips. Advanced digital technologies have a crucial purpose in decarbonising infrastructure, helping us adapt to climate change, and reversing biodiversity loss. If we are to solve the massive challenges that climate change and the biodiversity crisis are causing – from urban heatto biodiversity loss – we must harness these powerful technologies to create better solutions for our planet and the people who inhabit it.

Dr Will Cavendish
Global Digital Services Leader, Arup

Methodology Overview

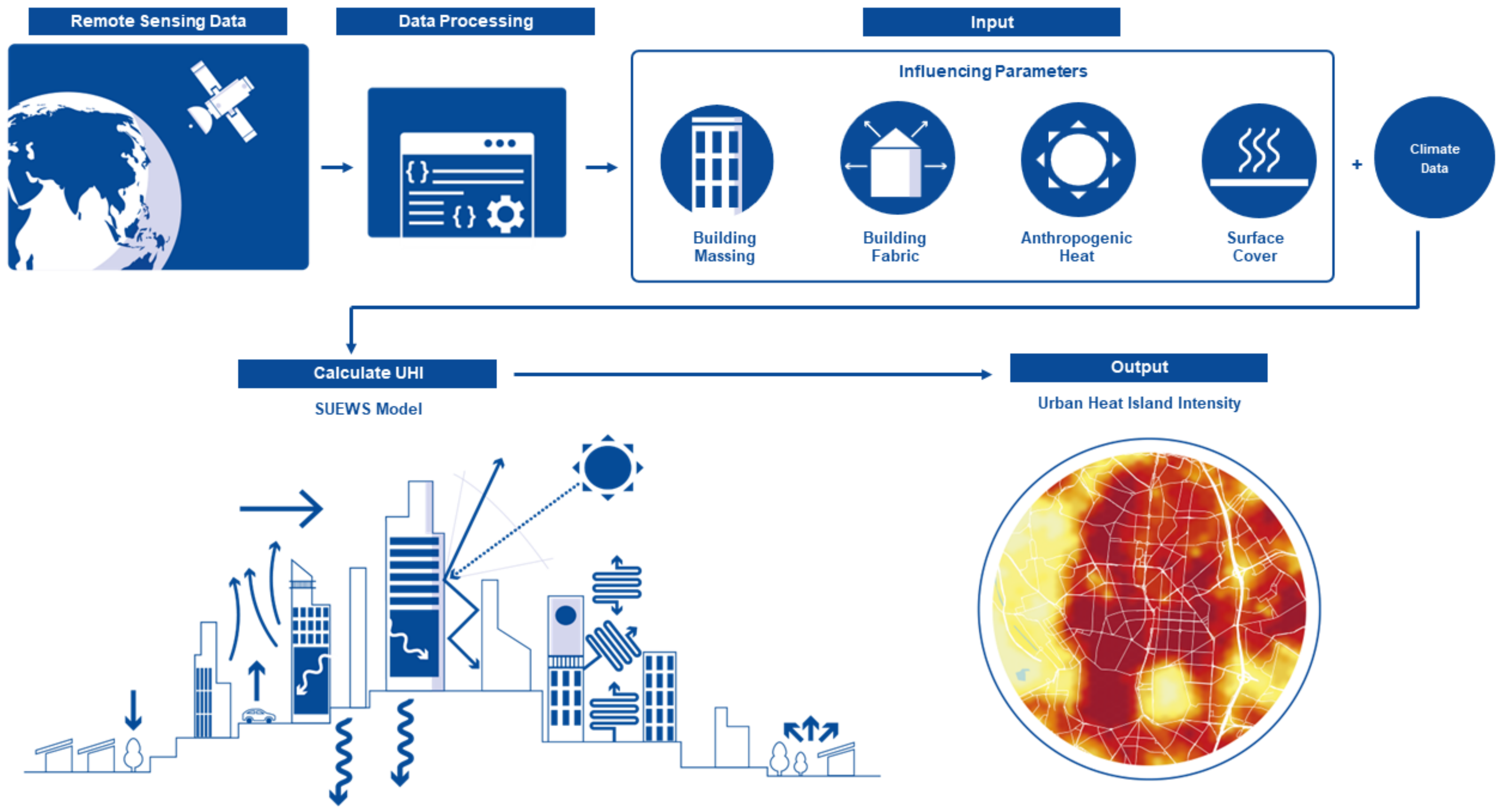
Our digital analytics team investigated the urban heat island effect for a 150km^2 snapshot of the urban centre of each of the cities – focusing on the hottest day the city experienced during a major heatwave of 2022 or 2023.

These areas were broken down into 60,000m^2 hexagonal blocks. This allowed the difference in air temperatures experienced that day and night to be modelled from neighbourhood to neighbourhood to understand how this heatwave was experienced across the urban centre.

Our UHeat tool allows rapid complex modelling, providing the air temperatures of cities, which is much closer to what people actually feel (compared to more commonly recorded surface temperatures). It models factors including building heights, surface albedos (reflectiveness), the amount of green and blue infrastructure, impervious surfaces, population density and the urban climate.

UHeat also uses data from our AI land-mapping tool, Terrain, that accurately quantifies the amount of green and blue infrastructure (e.g. trees, and lakes) versus the amount of grey (e.g. concrete roads, buildings) from satellite data. Terrain is so powerful it can distinguish between a tree nursery and a forest, and identify small amounts of greenery, from a small garden to trees on the side of a road. For the snapshot, our digital analytics team modelled a typical rural surrounding area for each city to use for reference.

UHeat uses the Surface Urban Energy and Water Balance Scheme (SUEWS) model developed by Professor Sue Grimmond at the University of Reading. Working alongside Dr Ting Sun UCL, Insitute for Risk and Disaster Reduction, Arup has integrated this academic model into UHeat to provide rapid analysis that can be used to understand the impact of design on urban heat.



UHeat methodology

Urban Heat Snapshot Results

Our survey is not intended as a score card, but to provide a snapshot of how digital tools can be used to better understand a city's urban heat island hot spots. UHeat allows city leaders, urban designers and planners to test different designs and interventions to reduce urban heat.

City and most severe UHI effect	Most severe UHI hot spot location	Coolest spot location	Temperature difference between hottest and coolest spot in the surveyed area
Brisbane UHI: 5.5°C | 10°F Afternoon, 12/02/23	Brisbane Central / Queen Street (1% vegetation, 0% water)	Royal Queensland Golf Club (70% vegetation, 1% water)	4.5°C | 8°F
Cairo UHI: 5°C | 9°F Evening, 11/06/22	Bulaq Ad Daqrur (0% vegetation, 0% water)	South of Qorsaya Island (Pharaonic Village) (28% vegetation, 30% water)	6 °C | 11°F
London UHI: 4.5°C | 8°F Night, 19/07/22	Kilburn / South Hampstead (38% vegetation, 0% water)	Regent´s Park (89% vegetation, 1% water)	7 °C | 12.5°F
Los Angeles UHI: 5°C | 9°F Afternoon, 04/09/22	West Lake (5% vegetation, 0% water)	E Debs Regional Park (96% vegetation, 0% water)	5 °C | 9°F
Madrid UHI: 8.5°C | 15.5°F Evening, 15/06/22	Plaza Juan Pujol (3% vegetation, 0% water)	The North of Casa de Campo (89% vegetation, 0% water)	8 °C | 14.5°F
Melbourne UHI: 6°C | 11°F Afternoon, 17/02/23	Melbourne Central (8% vegetation, 0% water)	Yarra Bend Park (87% vegetation, 1% water)	5°C | 9°F
Mumbai UHI: 7°C | 12.5°F Afternoon, 16/03/22	Ghatkopar East (39% vegetation, 0% water)	Maharashtra Nature Park (21% vegetation, 74% water)	8 °C | 14.5°F
New York City UHI: 4.5°C | 8°F Afternoon, 09/08/22	Washington Heights (3% vegetation, 0% water)	Ferry Point Park Area (77% vegetation, 1% water)	4.5 °C | 8°F
Singapore UHI: 6°C | 11°F Night, 13/05/22	Telok Ayer / Raffles Place (6% vegetation, 0% water)	Upper Peirce Reservoir Park (12% vegetation, 88% water)	6.5°C | 11.5°F

Urban Heat Snapshot

Brisbane, Australia

Heatwaves are a significant hazard in Australia and a study published in the International Journal of Environmental Research and Public Health found they have been responsible for more human deaths than any other natural hazard, including bushfires, storms, tropical cyclones, and floods. Brisbane itself is likely to experience much hotter temperatures by 2030, with modelling for the Queensland State Government finding that the climate of Brisbane will be more like the current climate of much hotter Bundaberg by the end of the decade.

In our survey we focused on the peak of a heatwave on the 12th of February 2023. The greatest urban heat island (UHI) hot spot was located at Brisbane Central/Queens Street. The area has 99% hard impermeable surface cover, and just 1% vegetation. Along with high building density and heat emissions, this contributed to a UHI effect of 5.5°C.

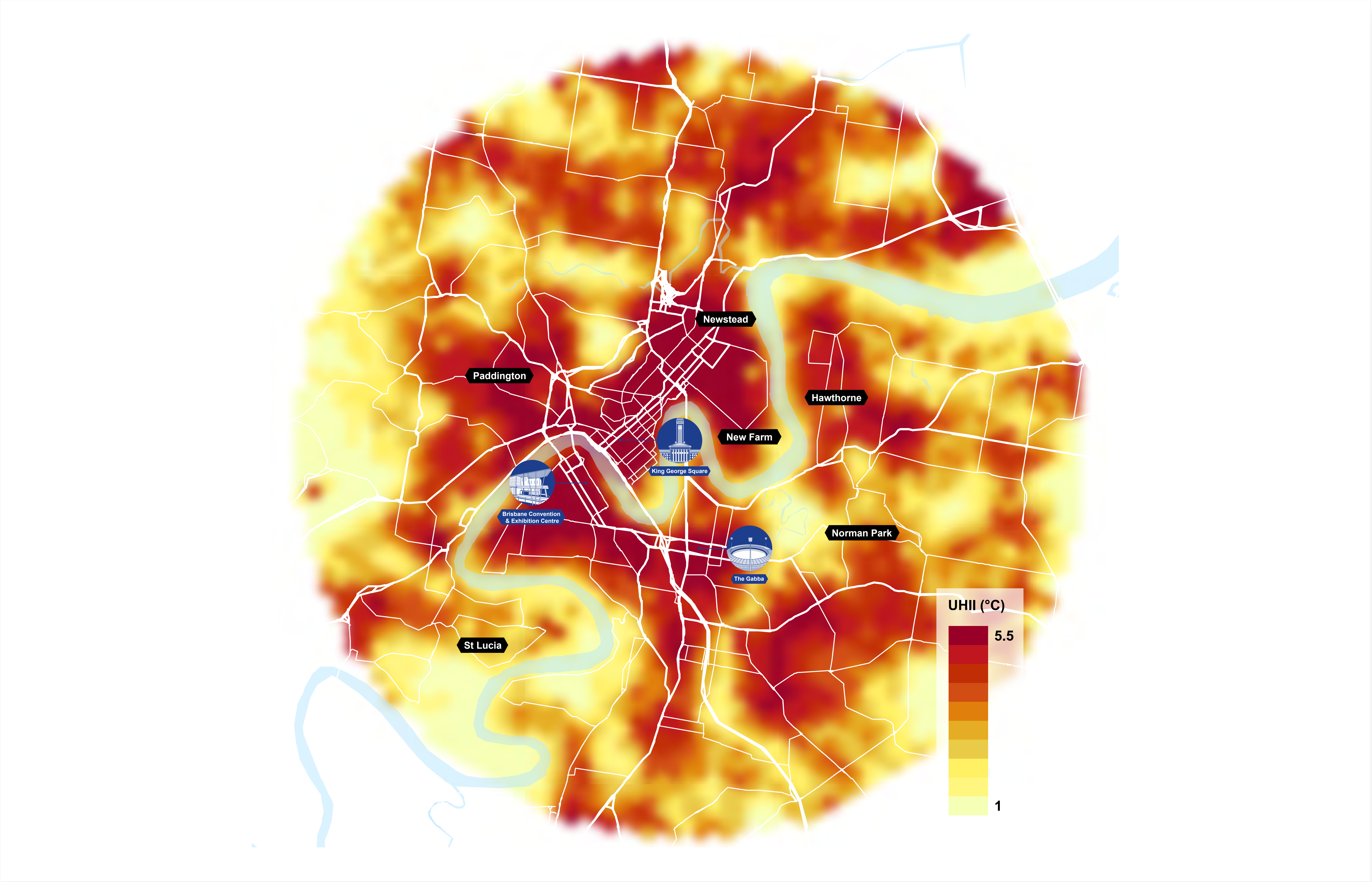
The coolest spot in the study area was at the Royal Queensland Golf Club, an area of considerable greenery with 70% vegetation cover.

Greatest UHI

Afternoon

5.5°C / 10°F
UHI hot spot

4.5°C / 8°F
Temperature difference between hottest and coolest spot

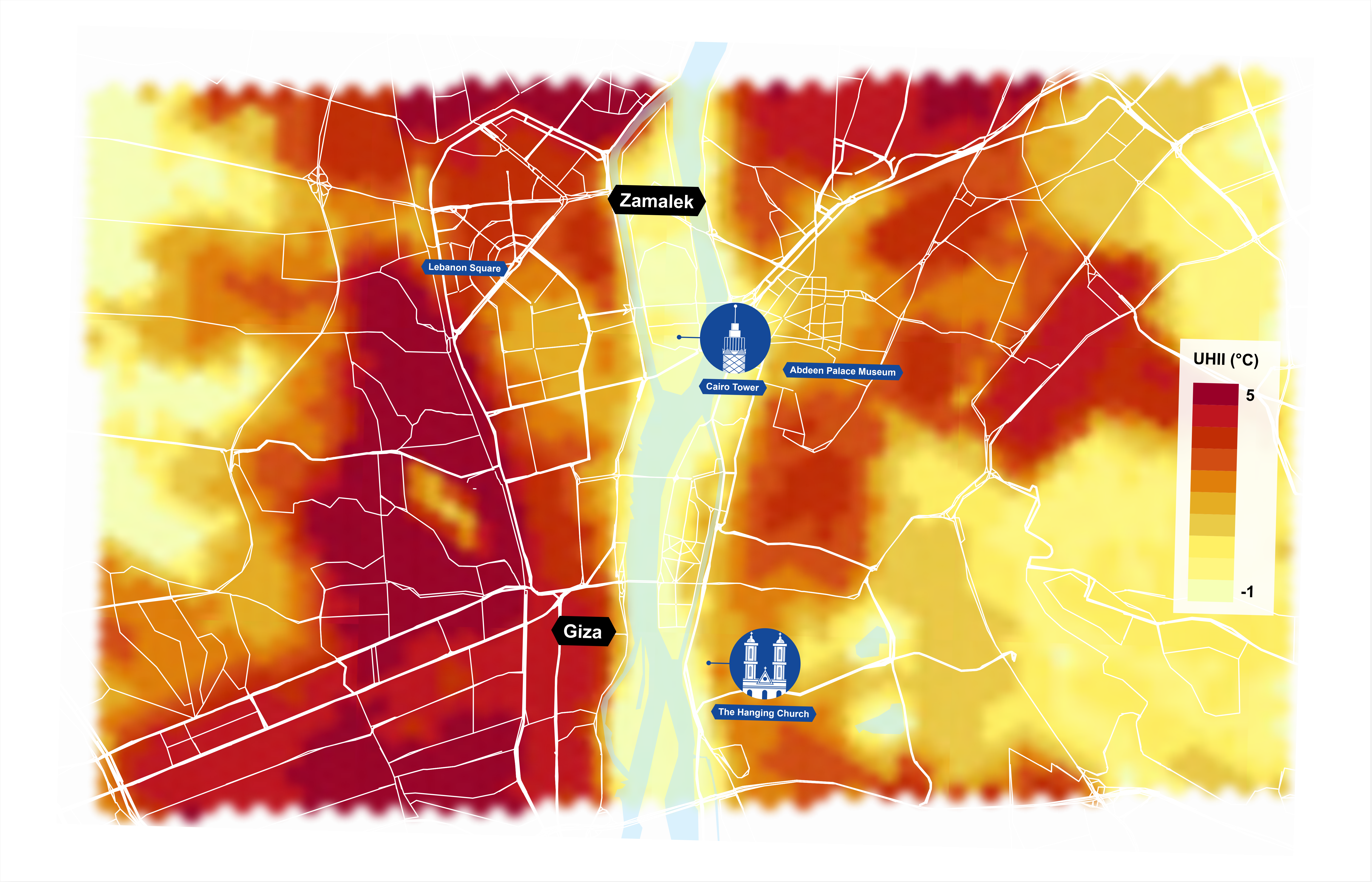


Cairo, Egypt

The World Bank estimates that climate change will increase temperatures in Egypt by between 1.5-3°C by mid-century. This will mean heatwaves become more frequent, severe and long, with an average of 40 additional days of extremely hot days per year projected.

Our survey focused on the peak of a heatwave on the 11th of June 2022. The greatest urban heat island (UHI) hot spot was found in a very built up and dense area at Bulaq Ad Daqrur, where 100% of the zone is built up. There is no vegetation or water in the area, which helped contribute to a UHI effect of 5°C.

There was a large UHI swing of 6°C to the coolest area, found at the south of the Qorsaya Island on the Nile, near Giza. It benefits from nearly 60% of its surface being covered by natural features (28% vegetation and 30% water).



Greatest UHI

Night-time

5°C / 9°F

UHI hot spot

6°C / 11°F

Temperature difference between hottest and coolest spot

London, UK

In 2022, the UK government issued a national emergency in response to unprecedented temperature spikes, hitting a record 40.3°C in England for the first time.

In the survey, we focused on the peak of the 19th of July 2022 heatwave. During this time, the greatest urban heat island (UHI) hot spot was found in the Kilburn and South Hampstead area, where at night-time people experienced a 4.5°C heat uplift compared to the rural surroundings.

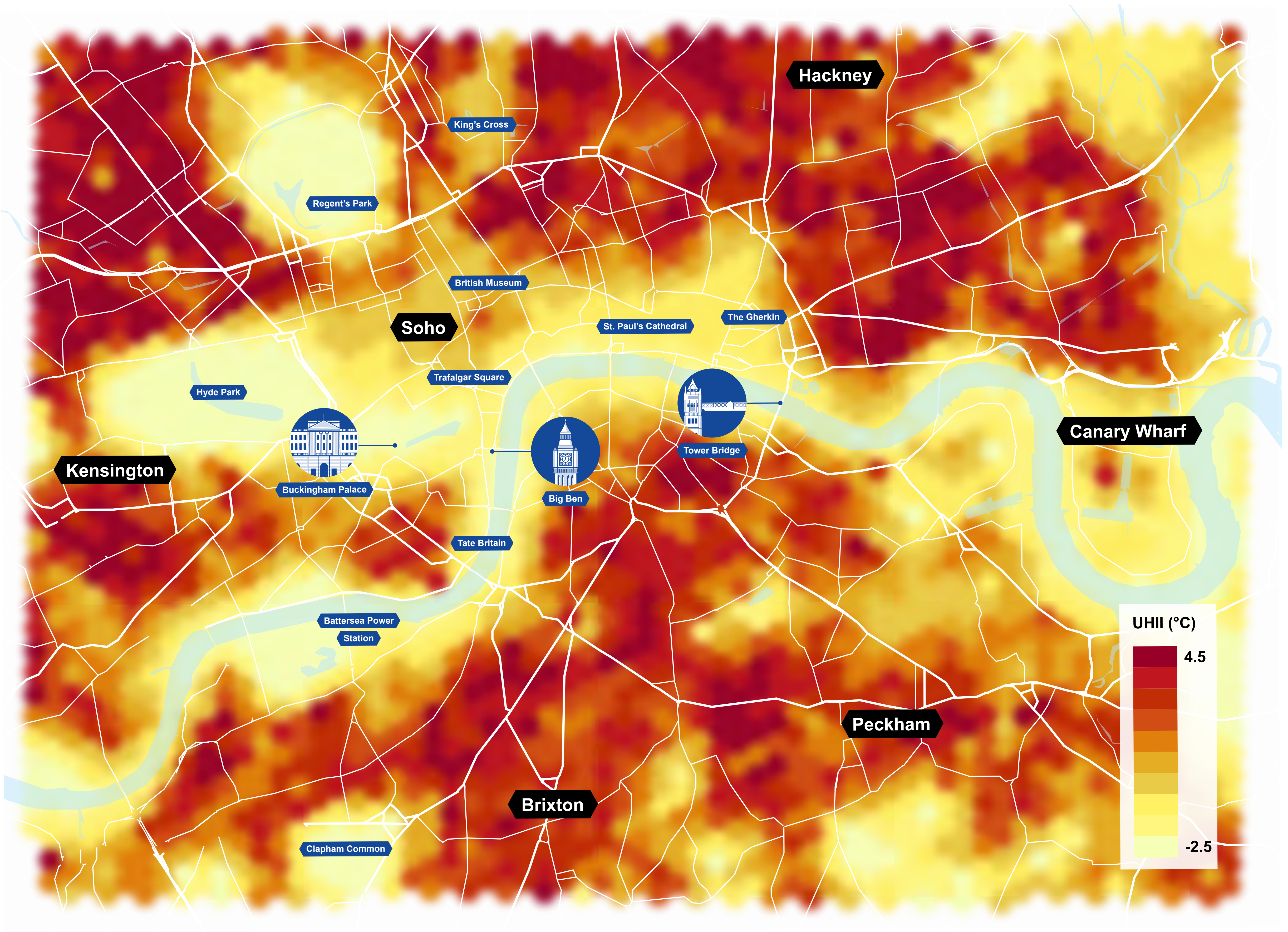
This medium-density, residential area has a high (over 60%) amount of hard, impermeable surface cover (for example hard surfaces such as concrete paving) and 38% vegetation. In comparison, at the same time, the temperature in Regent's Park (with 89% vegetation and 1% water), was a massive 7°C cooler. In the area surveyed, we found that almost 950,000 people experienced a UHI spike of 4°C or more on this day in July, which included 82,000 elderly people (65 years and above) and over 142,000 children (below 15 years old).

Greatest UHI

Night-time

4.5°C / 8°F
UHI hot spot

7°C / 12.5°F
Temperature difference between hottest and coolest spot

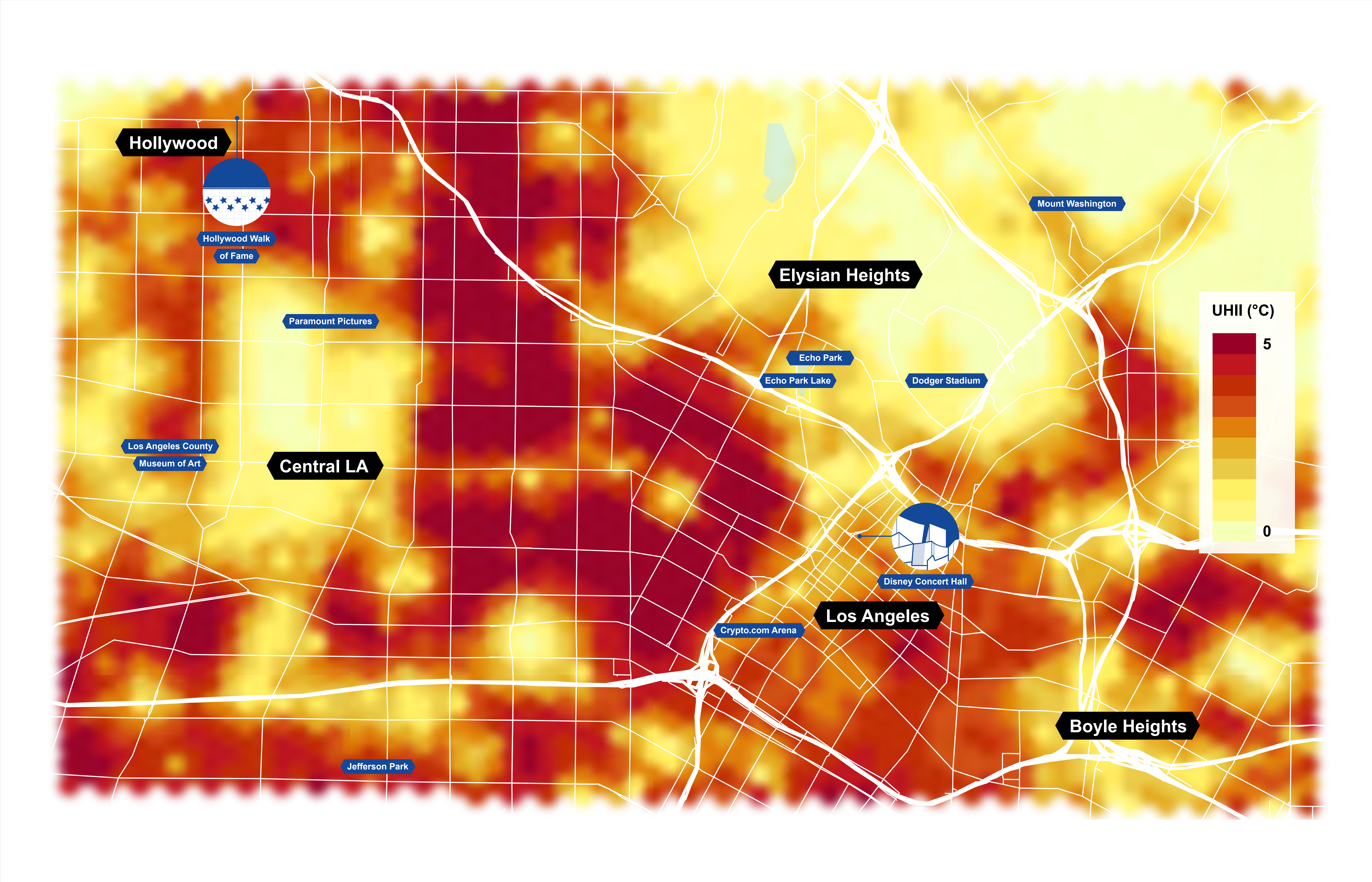


Los Angeles, USA

Los Angeles has been forecast to double the number of days it reaches 35°C or hotter by 2050, according to a study by UCLA.

In our survey, we focused on the peak of the heatwave on the 4th of September 2022. During this time, the greatest urban heat island (UHI) hot spot was located in the West Lake area of the city. This residential and commercial neighbourhood in central Los Angeles has a high proportion of hard impermeable surfaces and very little vegetation (around 5%). In comparison, Ernest E. Debs Regional Park, with 96% vegetation, at the same time, experienced temperatures 5°C cooler.

In the area studied, we found Los Angeles had 80,000 elderly people (65 years and above) and 101,000 children (below 15 years old) living in a hot spot with UHI of 4°C or more.



Greatest UHI

Afternoon

5°C / 9°F

UHI hot spot

5°C / 9°F

Temperature difference between hottest and coolest spot

Madrid, Spain

Spain experienced its hottest year on record in 2022, with over 11,000 heat-attributable deaths in the country in that year, according to scientists at the Barcelona Institute For Global Health and the French National Institute For Health.

In our survey, we focused on the peak of a heatwave in Madrid on the 15th of June 2022. The greatest urban heat island (UHI) hot spot was located in at Malasaña's Plaza Juan Pujol, reaching 8.5°C hotter than the rural surrounding area. This area was found to have over 90% impervious surfaces (these hard surfaces typically absorb and retain heat) and very little green surface cover (3% vegetation).

Madrid had the greatest temperature difference within the snapshot – with the coolest spot found North of Casa de Campo, experiencing temperatures 8°C cooler.

In the area studied, Madrid had over 313,000 elderly people (65 years and above) and over 178,000 children (below 15 years old) living in a hot spot with a UHI of 7°C or more.

Greatest UHI

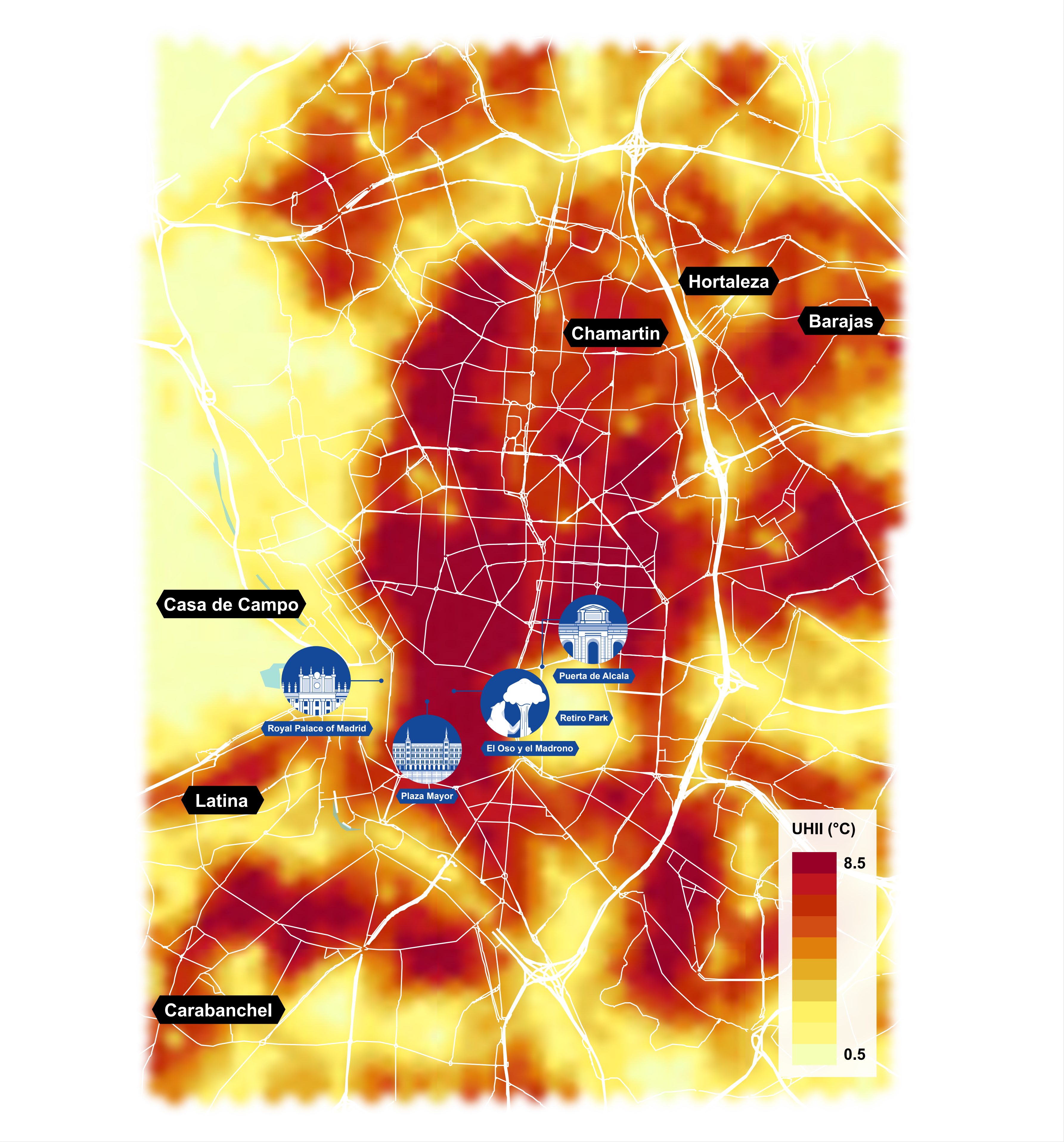
Evening

8.5°C / 15.5°F

UHI hot spot

8°C / 14.5°F

Temperature difference between hottest and coolest spot



Melbourne, Australia

Heatwaves are a significant hazard in Australia and a study published in the International Journal of Environmental Research and Public Health found they have been responsible for more human deaths than any other natural hazard, including bushfires, storms, tropical cyclones, and floods. Research by the Commonwealth Scientific and Industrial Research Organisation has also forecast that Melbourne could experience up to 21 days over 35°C each year by 2050, much higher than the average of 8 days it saw up to 2010.

In our survey we focused on the peak of a heatwave on the 17th of February 2023 when the greatest urban heat island (UHI) hot spot was located at Melbourne Central. The area has 89% hard impermeable surface cover, and just 8% vegetation. These factors, along with its densely packed tall buildings and high heat emissions, contributed to a UHI effect of 6°C.

The coolest spot is at the Yarra Bend Park, which benefits from a substantial amount of greenery, with 87% vegetation cover.

Greatest UHI

Afternoon

6°C / 11°F
UHI hot spot

5°C / 9°F
Temperature difference between hottest and coolest spot

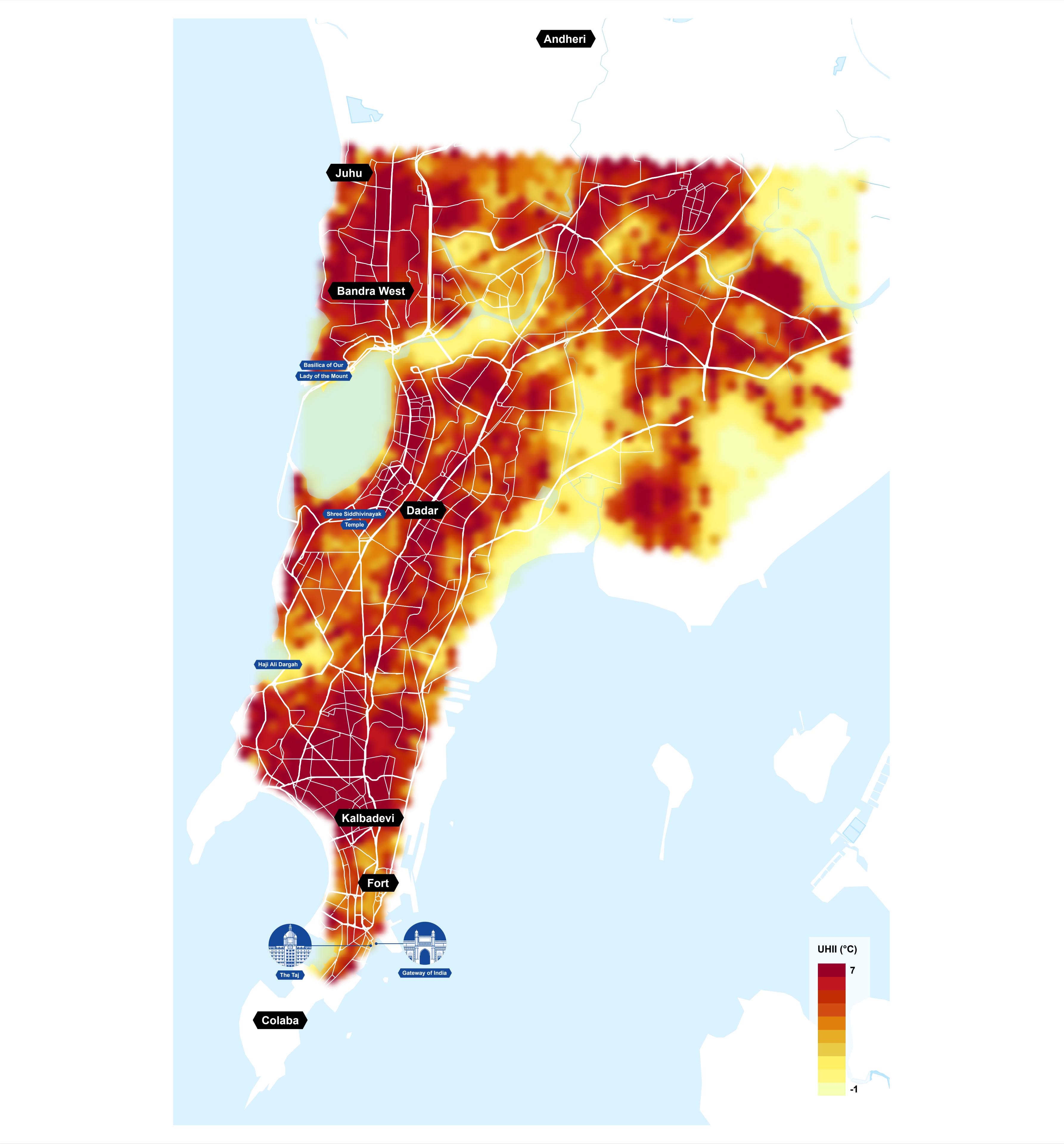
Mumbai, India

Last year, India experienced a devastating heat wave, where parts of the country reached more than 49°C - with the country seeing its hottest March on record.

Our survey focused on the peak of a heatwave on the 16th of March 2022. The greatest urban heat island (UHI) hot spot was located at Ghatkopar East, North Mumbai, reaching 7°C hotter than its rural surroundings.

The area lies far inland with 60% hard impermeable surface cover. The high population density and tightly packed tall buildings contributed to the area's elevated temperature.

The coolest area is at the heart of the Maharashtra Nature Park, featuring wetlands, marshes, and forest with 21% vegetation cover and 74% water. This coolest spot experiences temperatures 8°C cooler than the hottest spot in Mumbai.



Greatest UHI

Afternoon

7°C / 12.5°F

UHI hot spot

8°C / 14.5°F

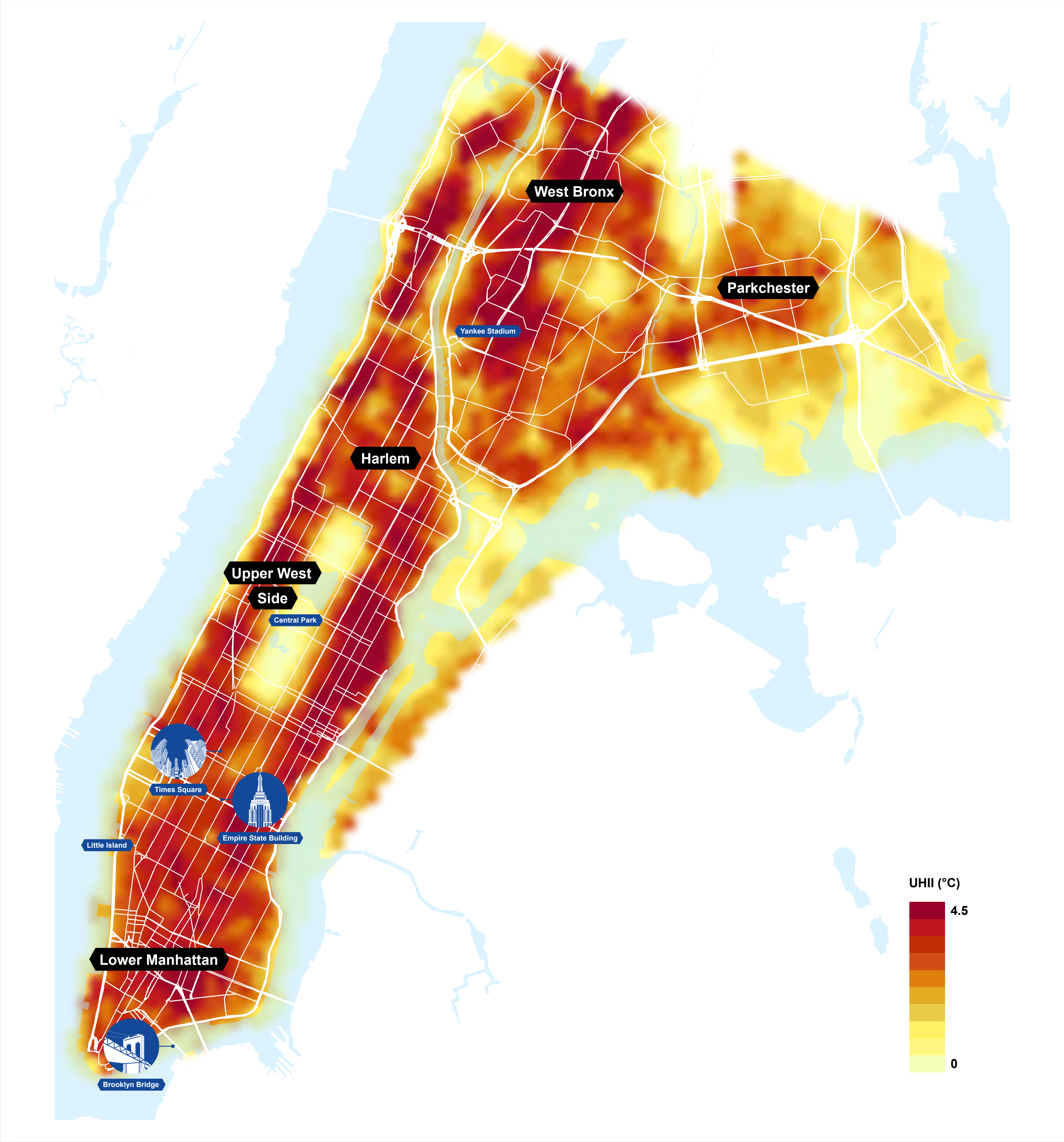
Temperature difference between hottest and coolest spot

New York City, USA

Between 2000 and 2004, New York experienced an average of seven heat waves every ten years. By the 2050s, this rate could increase to up to eight heat waves per year for some regions of the state.

In our survey, we focused on the peak of a heatwave on the 9th of August 2022. The greatest urban heat island (UHI) hot spot was found in Washington Heights. This area has dense development with a high proportion of hard surface (over 90%, with only 3% vegetation) and a high volume of built-up areas, blocking heat from rising into the sky. In comparison, Ferry Point Park, with 77% vegetation and nearby water features, experienced temperatures 4.5°C cooler.

In the area studied New York had 15,000 elderly (65 years and above) and 9,000 children (below 15 years old) living in a hot spot with a UHI of 4°C or more.



Greatest UHI

Afternoon

4.5°C / 8°F

UHI hot spot

4.5°C / 8°F

Temperature difference between hottest and coolest spot

Singapore

Singapore is heating up at twice the global average at 0.25°C over the past decade according to the Meteorological Service Singapore (MSS). This could lead to the island's average daily maximum temperatures climbing as high as 37°C by the end of the century.

In our survey we focused on the peak of a heatwave on the 13th of May 2022. The greatest urban heat island (UHI) hot spot was located within the Central Business District in Singapore. The area has 90% hard impermeable surface cover, and just 9% vegetation. These factors, along with its densely packed tall buildings and a high population density, contributed to a UHI effect of 6°C.

In comparison Upper Peirce Reservoir Park, where 88% of the land is covered with water and the remaining 12% with vegetation, was 6.5°C cooler.

Click here to discover the UHI of the whole of Singapore.

Greatest UHI

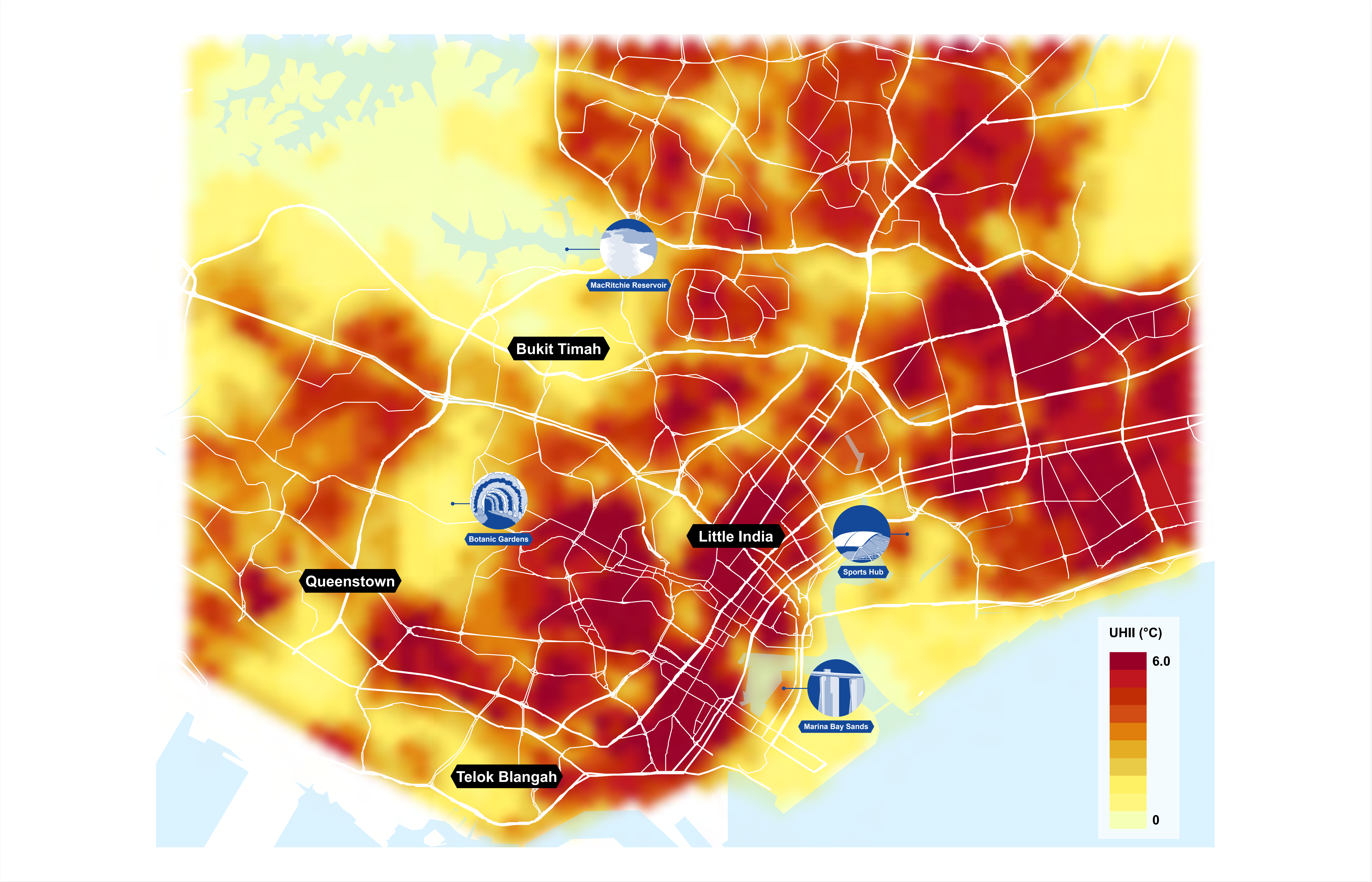
Night-time

6°C / 11°F

UHI hot spot

6.5°C / 11.5°F

Temperature difference between hottest and coolest spot



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The following datasets were used for climate and population analysis to inform the results of the Urban Heat Snapshot.

Data set	Citation
ERA5	Muñoz Sabater, J. (2019): ERA5-Land hourly data from 1950 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.e2161bac
Building Heights	Pesaresi, Martino; Politis, Panagiotis (2022): GHS-BUILT-H R2022A - GHS building height, derived from AW3D30, SRTM30, and Sentinel2 composite (2018) - OBSOLETE RELEASE. European Commission, Joint Research Centre (JRC) [Dataset] doi: 10.2905/CE7C0310-9D5E-4AEB-B99E-4755F6062557 PID: http://data.europa.eu/89h/ce7c0310-9d5e-4aeb-b99e-4755f6062557
GHSL Global Human Settlement Layer	Schiavina M., Freire S., Carioli A., MacManus K. (2023): GHS-POP R2023A - GHS population grid multitemporal (1975-2030).European Commission, Joint Research Centre (JRC) PID: http://data.europa.eu/89h/2ff68a52-5b5b-4a22-8f40-c41da8332cfe, doi:10.2905/2FF68A52-5B5B-4A22-8F40-C41DA8332CFE
Land cover satellite imagery	Imagery © 2023 Maxar Technologies
Population data	UK Census 2021 data - Contains National Statistics data © Crown copyright and database right 2023

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