SIMP@CT

SMART IRRIGATION MANAGEMENT FOR PARKS AND COOL TOWNS

NSW Government Planning & Environment

Western Sydney University

The ARCS Group

SAPHI

Sydney Olympic Park

UTS University of Technology Sydney

eratos

CTS CentraTechSystems

Sydney Water

Monash University

HARC hydrology and risk consulting

total water plumbing + irrigation

This project took place on the land of the Wann-gal. We treat this land with respect and acknowledge that it always was and always will be Wann-gal land.

This project received financial support from the NSW Digital Restart Fund, Sydney Olympic Park Authority and Sydney Water. The Smart Cities Acceleration Program and the Smart Places team provided important strategic and administrative support throughout the development, delivery and in-practice phases of SIMPaCT.

The entire project was designed to improve community resilience against climate change impacts, especially those driven by increasing summer heat.

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THE SIMPaCT ECOSYSTEM

Carbon-neutral, or better still, climate-smart cooling has become an urgent need for cities around the world. SIMPaCT provides a new tool for urban planners, designers and managers to take action against overheating of towns, cities and metropolitan regions. SIMPaCT uses smart sensing technology and digital infrastructure to maximise the Park Cool Island Effect. While this brochure provides a comprehensive insight into the functionality of the system, it is important to recognise the wider efforts to cool cities. These efforts scale from local government initiatives all the way to multilateral organisations like the United Nations. All have one goal – make humans safer in a warming world. SIMPaCT delivers this goal.

Selected exemplary documents (in chronological order) that form the ecosystem in which SIMPaCT exists.

2017 – Strategies for Cooling for Singapore by the Cooling Singapore Initiative

2017 – Guide to Urban Cooling Strategies by the Corporate Research Centre for Low Carbon Living

2018 – Heat Watch: Extreme Heat in Western Sydney by the Australia Institute

2018 – Turn Down the Heat Strategy and Action Plan by the Western Sydney Regional Organisation of Councils

2019 – Evaluation of the Heatwave Plan for England by the Department of Health Services Research and Policy

2020 – The Pulse of Greater Sydney by the Greater Cities Commission

2020 – Primer for Cool Cities: Reducing Excessive Urban Heat by the Global Platform for Sustainable Cities

2021 – Beating the Heat: A Sustainable Cooling Handbook for Cities by the United Nations Environmental Program

2021 – A Catalogue of Nature-Based Solutions for Urban Resilience by the GFDRR and World Bank Group

2022 – BiodiverCities by 2030: Transforming Cities' Relationship with Nature by the World Economic Forum

2023 – Nature Positive Sydney – Valuing Sydney's Living Infrastructure by the Committee for Sydney

And check out these resources for urban cooling in the C40 Knowledge Database.

MULTI-AWARD-WINNING

SIMPaCT has won six important national awards in the IoT, Sustainability and Technology sectors. The project was a 13-times finalist in national and international competitions and was awarded a commendation from Parks and Leisure Australia (NSW/ACT). The judges of these competitions rewarded the team with praise for its elegant and safe digital solution for a pressing real-world problem.

The accolades the project has received are the results of hard work. They emphasise our strong team spirit, shared belief in developing an amazing product and working seamlessly across many disciplines and professions.

We thank all organisations and experts that shone a spotlight on us and rewarded us with words of praise. We stand proud, showing off our awards at the start of this project overview, because we believe they are the visible manifestation of a unique, novel and trailblazing use of technology that effectively combats the impacts of climate change on cities.

We hope you enjoy learning more about SIMPaCT and how it can transform urban green infrastructure into effective cooling systems.

IoT Alliance Australia, Impact Award Finalist: **Smart Places and Infrastructure**

IoT Alliance Australia, Impact Award: **Research**

IoT Alliance Australia, Impact Award: **IoT for Good**

InnovationAus, 2023 Award for Excellence: **Industry 4.0**

InnovationAus, 2023 Award for Excellence: **GovTech Project, Product or Service,** and **People's Choice**

World Smart City Award 2023: **Energy and Environment**

Banksia Foundation, NSW Banksia Sustainability Award: **Placemaking**

Banksia Foundation, NSW Sustainability Award: **Climate Technology Impact**

Banksia Foundation, National Banksia Sustainability Award: **Healthy Planet, Healthy People**

Banksia Foundation, National Sustainability Award: **Climate Technology Impact**

Australian Institute of Landscape Architects, AILA NSW/ACT 2024 Landscape Architecture Award of Excellence: **Research, Policy & Communication**

Parks and Leisure Australia, PLA NSW 2024 Awards of Excellence Commendation: **Best Use of Technology**

INTRODUCTION

SIMPaCT is an innovative approach to urban cooling using smart technology. By leveraging IoT technology, sensors, and data analytics, smart irrigation systems can be enhanced to optimise water usage and enhance the maintenance of parks and public spaces, addressing both social and environmental challenges.

SIMPaCT's primary focus is to create urban coolth by maximising the Park Cool Island Effect and mitigating the Urban Heat Island Effect. In Australia extreme heat kills more people every year than all other natural disasters combined. By optimising the health of large-canopy trees in Bicentennial Park we encouraged maximum shade and evaporative cooling by up to 4°C. This cooling effect was also felt in the surrounding grey urban centre of Sydney Olympic Park, improving the comfort and livability of nearby residential areas and reducing heat-induced health issues.

BACKGROUND

SIMPaCT tackled three challenges facing Australian cities: urban heat; water scarcity; and providing high quality green spaces. As the climate crisis deepens, and cities are densifying, these challenges are becoming more pronounced. The increasing frequency and intensity of extreme heat events have direct impacts on the wellbeing of metropolitan communities and are a threat to local economies and the environment. Water scarcity is an emerging issue when land managers want to use urban green infrastructure to provide respite from heat. Watering green spaces prior to heat events maximises evapo-transpirative cooling during the event, and thus keeps air temperatures down (the Park Cool Island effect - see p. 14 for more information). SIMPaCT focusses on effective water management to maintain thriving green infrastructure and maximise air cooling.

As proof-of-concept, SIMPaCT was developed for Sydney Olympic Park Authority (SOPA), NSW Department of Planning and Environment (DPE) and Sydney Water to maximise cooling inside and around Bicentennial Park. At its technical core, the system is a digital platform that enables irrigation management based on Machine Learning (ML), digital twinning and scenario modelling. The service this technology provides is improved human thermal comfort, reducing the Urban Heat Island Effect and providing thriving urban green infrastructure that is protected from drought impacts.

It was based in Sydney Olympic Park, the premier event precinct of NSW. Every year, more than 10 million people come and visit Sydney Olympic Park and many also spend time at Bicentennial Park, a 42-ha lush parkland. Importantly, the residential population of the precinct is expected to increase from 8,000 to around 30,000 in

SUSTAINABLE DEVELOPMENT GOALS

SIMPaCT delivers on several SDGs, but importantly also aligns with Environmental, Social, and Governance (ESG)s (bases of WEF framework). The CBA commissioned by the NSW Government attested improved well-being via increased park visitation, increased thermal comfort and improvements in physical and mental health, supporting SDG 3 (Good Health and Wellbeing) and several Principles of Governance, including ethical behaviour and governing purpose. SIMPaCT is scalable and easy to integrate in any public or private green space which means it aligns well with SDG 9 (Industry, Innovation and Infrastructure) as well as SDG 11 (Sustainable Cities and Communities). Subcategories of the ESG Pillars of Planet and People (e.g., Climate Change, Health and Wellbeing, Skills for the Future) are addressed through our work. Improved green infrasctructure health for the benefit of humans, animal and plant species, covers aspects related to SDG 13 (Climate Action) and 15 (Life on Land).

3 GOOD HEALTH AND WELL-BEING

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

15 LIFE ON LAND

2036. Most of these new residents will live in high-rise apartment buildings with no garden. It is reasonable to expect that visitation of the park will further increase, elevating the need to provide a well-presented, accessible green space. The park was built on contaminated industrial wasteland for the 200-year anniversary of Captain Cook's landing. It consists of undulating landscapes, mangroves, a large lake, waterways and hilltops. The vegetation is a mix of lawn, mature trees, undergrowth and native and exotic flora. It is irrigated with recycled water from a nearby greywater treatment plant and water can be provided quite accurately across a mosaic of 193 individually controlled sites. To avoid any potential risks from bacteria or other contaminants remaining in the greywater, and becoming airborne during irrigation, the park is only watered late at night, when the park is closed. Irrigation does not occur at all when public events are scheduled to finish later in the evening.

SIMPaCT was a multidisciplinary partnership assembled to develop smart technology to operate the irrigation system at Bicentennial Park, integrating real-time environmental sensing with forecasting, scenario modelling and ML. The digital twin was based on the CRCWSC-Scenario Tool developed at Monash University. A critical component to the success of SIMPaCT was the collaborative spirit and parallel operation of specialised teams. Integrating methodologies and approaches, researchers effectively communicated and understand discipline-specific language to reach all project goals. Translating the science developed during the proof-of-concept phase and bridging the gap between research and industry has been incredibly exciting.

The 12 entities collaborating on the project included Western Sydney University, University of Technology Sydney and Monash University, NSW government partners including the NSW DPE, SOPA Sydney Water and six industry partners (Eratos, Hydraulic and Risk Consulting, The ARCS Group, SAPHI, Total Water and Centratech Systems). A range of private sector companies were also involved to provide commercial services like the installation and operation of the LoRaWAN gateways.

This collaborative process where scientists and industry specialists worked together to develop a robust and practical solution was key to the success of the project.

MACHINE LEARNING

Ostensibly, machine learning appears to be an impossibly complex subject only accessible to those with a computer engineering degree; however, here we will attempt to break down this complex topic into simpler terms.

What is machine learning?

At a high level, machine learning is nothing more than the science behind making computers learn with minimal human input. The core idea is to develop software that enables these computers to learn from experience and self-improve over time.

From an outsider's perspective, this can seem like magic; or from a more nihilistic perspective, something to fear. However, if we unpack this topic further and peer behind the curtain, what we find is something far more benign and rather easy to manipulate in specific ways to solve some pretty complex problems.

How does it work?

At its heart, machine learning is just a basic algorithm running through a logic loop, consistently returning to a fork of 'yes' or 'no'. Yes to reinforce an action and no to discourage it. Just like how we learn.

To make the algorithm work, we need to fuel it with challenges we call 'inputs', that it can learn to recognise and associate with the right actions as 'outputs'. Crudely defined, an input is a thing or scenario that the algorithm encounters, and an output is the decision or action the algorithm initiates in response. The fundamental goal is to train the algorithm to recognise differences between inputs and initiate the associated outputs according to predefined logic.

In the case of SIMPaCT, we fed the algorithm a set of scenarios (inputs) and taught it what it should do in response to each one (outputs). For example, teaching it in what scenarios it should increase the amount of water flowing through the irrigation and when it should decrease. For example, when the BoM weather forecast predicts rain and cool temperatures, and current soil moisture at an optimal level for a specific site, we wanted the ML to not irrigate that particular area. When maximum air temperatures are predicted to be greater than 30°C without any rainfall for some time, then the ML should irrigate an area with more water to bring soil moisture levels up and thus allow maximum transpirative cooling.

Overtime, we get the algorithm to a position where it does this specific function automatically to manage soil moisture under any given environmental scenario and can run without human interaction.

HOW DOES IT WORK?

IoT sensors were deployed throughout the park to collect real-time data on environmental conditions such as soil moisture, localised temperature, and humidity. This information was used to inform the Machine Learning and GIS models. Using advanced algorithms SIMPaCT identified patterns, predicted water requirements, and determined the optimal irrigation schedule for the various landscapes within the park. Based on the analysis, the smart irrigation system precisely delivered water where and when it was needed. The irrigation system was remotely controlled and monitored via a dashboard. Park managers could adjust settings, monitor water usage, and received alerts and notifications about system performance or potential issues. SIMPaCT considered other factors like water drainage across slopes and vegetation impact. Machine Learning modules tied to micro-locations learnt what optimal soil moisture was for each, and how weather and irrigation events altered soil moisture against additional background contexts. This optimisation worked across a diverse landscape including open turf, garden beds, bushland and tree groves.

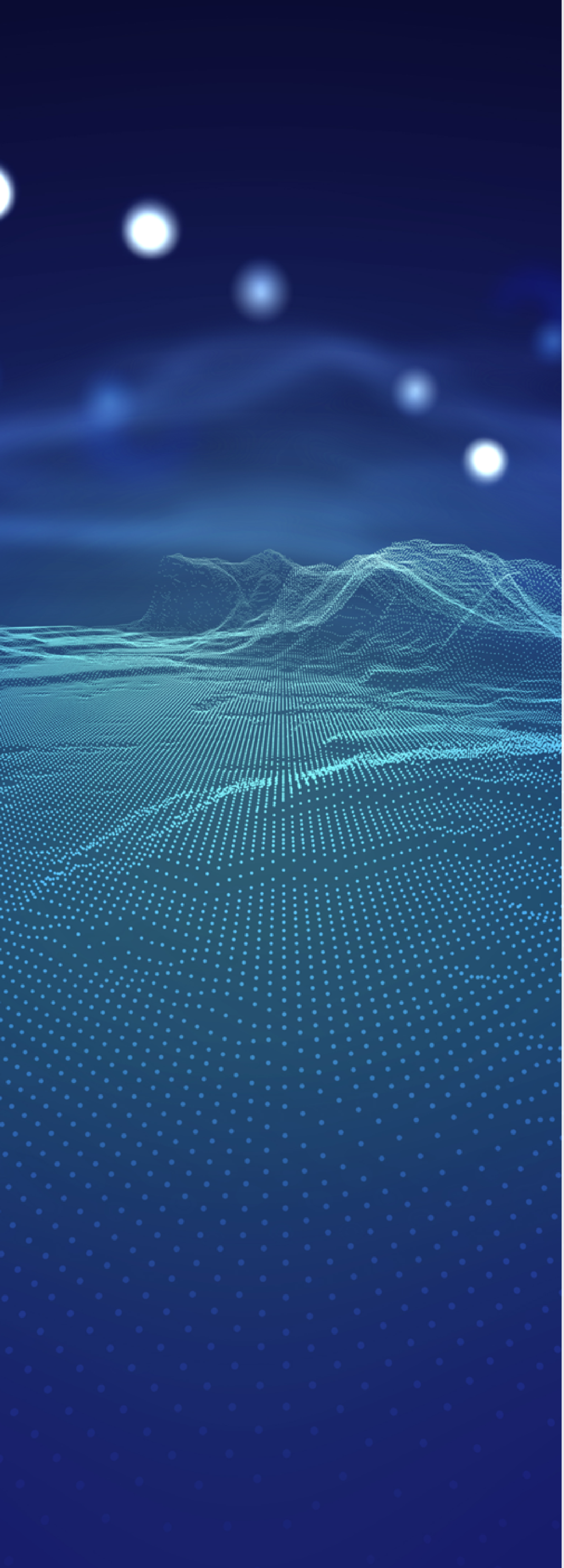
The use of digital twin technology to process data streams and establish a digital representation of the real-world park allowed SIMPaCT to inform and build irrigation schedules - using IoT to capture and visualise data and then automate processes based on those values to achieve outcomes with machine learning and GIS modelling. We used hundreds of 'Ground-to-Cloud' devices to monitor the park environment and, in response to this data, controlled the existing irrigation infrastructure to reduce the ambient temperature of Sydney Olympic Park. The control of the irrigation system was designed to be fully automated with the implementation of machine learning algorithms that trigger actions when pre-defined values are met. Both above ground (ambient temperature sensors) and below ground (soil sensors) end-node devices were deployed in the park, and data was collected via LoRaWAN communication protocol. The network gateways then directed the information to MeshNet Vision and from there to the Senaps platform, a cloud-based data platform for development of applications with real-time sensors and spatial data. The platform included custom mechanisms and bespoke APIs for third-party data ingestion and analysis workflows. Additional data collected from weather stations deployed in Bicentennial Park and the nearby urban centre, as well as BOM forecasts, were used to support and supplement the information collected from the soil and ambient temperature sensors.

SECURITY

SIMPaCT itself is implemented on the CSIRO-developed enterprise IoT workflow and model orchestration engine Senaps, a cloud-based data platform for development of applications with real-time sensor and spatial data. It has a robust security infrastructure that includes authentication, authorisation, and data protection measures. It uses a role-based authorisation model to control access to data, and all APIs are available only via Transport Layer Security (TLS). All interactions with the platform require authentication, and users can create and revoke API keys for additional security. The platform enabled secure connection to SIMPaCT's private IoT network, the extraction of real-time data and the transformation of that data in-flow for analysis and model ingestion.

The platform also includes custom mechanisms for third-party data ingestion and analysis workflows, which can be executed in short-lived, isolated containers to protect data and code. Project data was stored in a secure, replicated database, and all data transfers and backups were encrypted. The machine learning model for the project was designed with a reliable backup model to mitigate the risk of data anomaly or data corruption.

Data from the sensors was routed to MeshNet Vision via LoRaWAN (a Low Power, Wide Area (LPWA) networking protocol), which used an encrypted key for messaging, before being cleaned and directed to Senaps. Meshnet Vision incorporates authenticated log-in with custom system-permission settings, backed up by Amazon Web Server (AWS) -encrypted SSL. All data was backed up to AWS servers as well as stored locally.



WHAT IS IOT?

IoT refers to all of the physical devices out there that are connected to the internet. Your mobile phone, your car, streetlights and even your fridge! There isn't much out there that doesn't fall under the umbrella of IoT. But, with its widespread influence, the question for many of us arises "what is IoT?".

How does it work?
If you were to consult the internet, you would receive an overly complex definition that leaves you with more questions than when you started.

In essence, IoT encompasses pretty much anything that holds electronic components - the phone in your pocket, the laptop on your desk, the TV in your living room, and the car in your driveway are all things that can be connected to the internet. Hence the name Internet of Things. Our team prefer to refer to these things as "Ground-to-Cloud devices".

Why Ground-to-cloud?
We can conceptualise IoT devices as things on the ground that collect data from the environment and transfer it to users around the globe via some medium (the cloud).

It is more than just visualisation
IoT is more than just capturing and visualising data; the real value arises when you can automate processes based on the data captured to achieve outcomes - just like we did at SIMPaCT.

With the SIMPaCT project, in crude terms, we were using hundreds of Ground-to-Cloud devices that monitor the surrounding environment and, in response to this data, controlled the existing irrigation infrastructure to reduce the ambient temperature of Sydney Olympic Park.

The control of the irrigation system was designed to be fully automated with the implementation of ML algorithms that trigger actions when pre-defined values are reached .

DIGITAL TWIN TECH, GIS

HOW IS A DIGITAL TWIN USED IN SIMPaCT?

The SIMPaCT digital twin operated in Bicentennial Park, Sydney. The park consists of over 40 ha of irrigated green space, which is organised into 193 individually controlled irrigation zones. The soil types and depth vary considerably across the park, ranging from heavy clays to loose silts being 30-100 cm deep. Similarly, there is a diverse selection of vegetation types, including turf, ornamental gardens and trees.

The digital twin deployed leveraged the IoT Network in Bicentennial Park with information on over 200 soil moisture probes (at least one for each irrigation zone), 50 air temperature sensors and irrigation pump flowmeters. This information provided an efficient means for park managers to monitor the health of the park and identify irrigation faults in real-time. The data was visualised on the Park Now dashboard (www.simpact-australia.com/now) via interactive GIS-based maps that provided both a high-level overview of the park and detailed histories of each irrigation zone.

In addition to providing a platform to explore live and historic park data, the digital twin integrated several hydrological and machine-learning models. These combined the park data with weather forecasts to predict the soil moisture in all 193 irrigation zones for up to 7 days in the future. The predictions were then used by an irrigation optimisation algorithm to find the most efficient watering schedule according to the given objective. The digital twin had two preset objectives or modes of operation. The first objective was for maximal water efficiency while maintaining plant health,

WHAT IS A DIGITAL TWIN?

A digital twin is a virtual representation of a physical object, system or process, capturing both its physical attributes and behavioural characteristics. It is not just a static model, but a dynamic entity that evolves with the changes occurring in its physical counterpart. By leveraging real-time data, the digital twin can learn from, simulate and predict the behaviour of the physical object or system, allowing users to perform various analyses, conduct what-if scenarios, and make informed decisions.

The quality of a digital twin is driven by the availability and accuracy of the underlying data being provided. IoT networks provide a great foundation on which digital twins can be built, as they enable the seamless integration of real-time data from sensors and connected devices, ensuring that the digital twin remains up-to-date and capable of accurately representing the current state of the physical object or system.

While ideas concerning a digital twin remain quite abstract, their implementation is rapidly advancing, offering real-time data, predictive analytics, and simulation capabilities. As technology evolves, organisations are harnessing the benefits for better decision-making, process optimisation, and overall efficiency, revolutionising industries and shaping the future.

and the second mode was to achieve maximal cooling by providing enough water to maximise plant evapotranspiration.

These optimisations automatically considered aspects such as forecast rain to reduce irrigation schedules to achieve the maximal watering benefit from rain events. There are also provisions for full control and oversight by the park managers, to choose specific hours of operationand other defined constraints.

The final component of the digital twin is its integration with a pre-existing irrigation system. Through a two-way communication channel, the digital twin can receive information about current irrigation constraints imposed by operators and can automatically return an optimised irrigation schedule that a system will execute. This link creates a truly automated but fully transparent process to control any smart irrigation system. All information relating to the decisions made by the digital twin can be shown in real-time on an online dashboard.

The power of the digital twin is being able to provide quantitative metrics to not only describe the health of green infrastructure in real-time, but to use this data to support operational decision-making around irrigation scheduling. Improving a park's water efficiency creates real benefits for both park managers and the environment alike through the effective use of water. SIMPaCT's advanced capabilities showcase how the fusion of digital innovation and the environment can create a greener, more resilient future for urban green spaces.

THE PARK COOL ISLAND (PCI) EFFECT

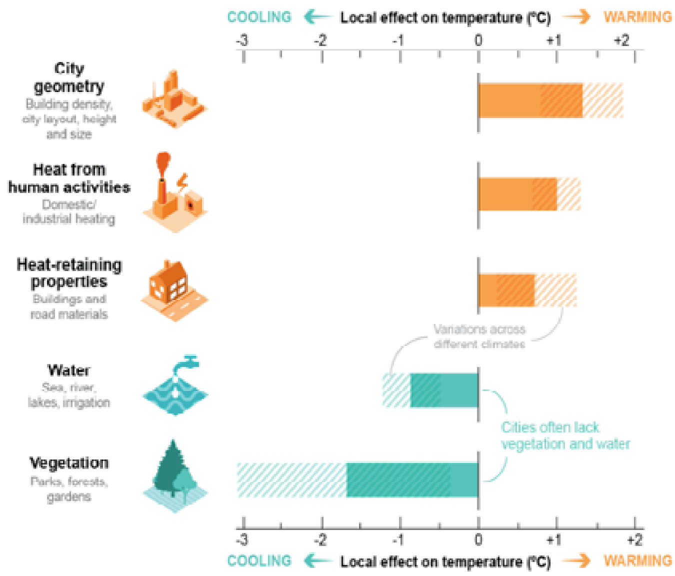
MAXIMISING THE PCI EFFECT

The way temperature is felt in a city is the result of many different effects. These effects scale down many levels, from the geographic location – anything between polar and equatorial, from sea level to mountainous and costal to continental – down to the type and colour of clothing. From the macro to the micro scale.

There is the temperature and relative humidity of the air surrounding you and the speed by which this air is moving around you. The level of direct and indirect solar radiation you are exposed to. The type of activity you are doing and how much you sweat. And then there are all the external sources of additional heat, like heat that is radiated from roads, car parks, buildings and other hard infrastructure and heat generated from human activity, like cars, air conditioning systems or factories.

In 2021, Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC) published The Physical Science Basis Report. For the first time, the 234 scientists from 64 countries created a Fact Sheet about climate change and cities. Why? Because our world is rapidly urbanising, and cities are major sources of heat which impacts billions of people. Moreover, the scientists reported with 'very high confidence' that "urbanisation has exacerbated the effects of global warming in cities". Cities are sources, and their communities are victims of increasing air temperatures.

The absorption, storage, and radiation of heat by grey infrastructure leads to urban warming. Plants and water bodies help cooling our cities. Increasing the area in cities covered by parks, forests and gardens is the most effective way to tackle the issue of the Urban Heat Island (UHI) effect and urban overheating.



Above: Large, free-standing, evergreen park trees. Their crowns provide many square meters of shade which reduces surface temperature. Water loss through transpiration from the leaves cools the ambient air. As shade trees provide cooler air and surface temperatures, while at the same time block harmful UV radiation, it is understandable that most park visitors enjoy spending time in the shade of trees where human thermal comfort is greatly improved.

Left: The warming and cooling effects of grey (top three), blue (Water) and green (Vegetation) infrastructure in cities. The figure was published in the Regional Fact Sheet – Urban Areas by the Intergovernmental Panel on Climate Change (IPCC) in 2021. Image © United Nations Environmental Program (UNEP) and World Meteorological Organisation (WMO)

Collectively termed urban green infrastructure, plants can reduce the air temperature across entire metropolitan regions by several degrees Celsius. Research at Western Sydney University has shown that during a heatwave, air temperatures in a well-shaded residential street was nearly 8 °C lower compared to a nearby street that had barely any trees to shade it.

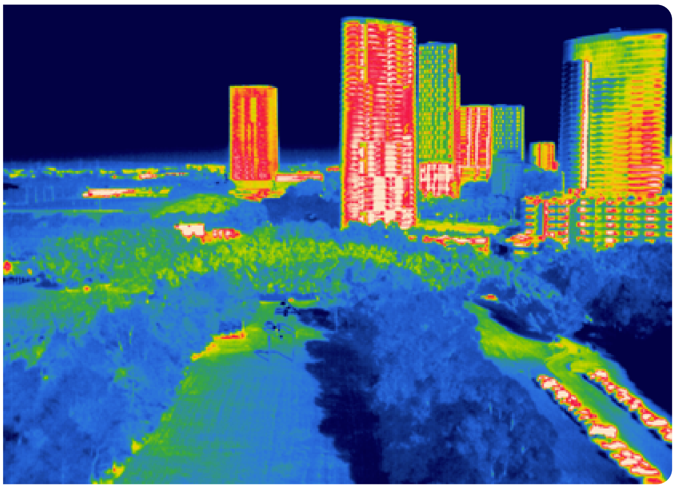
Of all urban green infrastructure elements, which also include green walls and vertical and rooftop gardens, trees are the most effective elements for cooling. Urban trees are the natural air conditioning systems of our cities where they provide cooling in two ways: 1. by shading grey infrastructure, especially ground surfaces and 2. by transpiring water from their leaves.

The best shade is provided by densely foliated, wide tree crowns that are low to the ground. These crowns belong to older trees that had time, water, nutrients, and space to grow tall and expand their branches freely. Dense tree shade can reduce the surface temperature of a road by more than 40°C. By blocking direct solar radiation, shade from a tree brings the temperature of any surface down to ambient air temperature. This has very important implications when we try to reduce the UHI effect. More tree shade in cities will lower surface temperatures, and cities with more trees are consequently cooler.

While the principle of shade-cooling is an easy concept to understand, transpiration cooling is a little more complicated. Soil usually contains some moisture. The atmosphere usually contains much less moisture (except when it rains), and the resulting difference between soil and atmospheric moisture creates a gradient of energy. Evolution has shaped trees into organisms that can utilise this energy gradient to grow into the tall (more than 100 meters), long-lived (more than 4,000 years) organisms we see around the world today.

Trees use the moisture gradient between the soil and atmosphere to allow water to be passively sucked through them. Losing water at the leaf level into the dry atmosphere initiates tension in the capillaries of water that stretch through the leaf-petiole-twig-branch-stem-root continuum. The capillaries run through a water transporting structure called xylem. By simply allowing water to escape from the leaf, the xylem will transport soil moisture from the root to the leaf to replace what was lost.

During the process of transpiration, water inside the leaf undergoes a phase change from being a liquid to becoming a gas. This process, where the water molecules are pulled apart, requires energy, which is provided by solar radiation. Using this energy leads to cooling of the leaf itself and as the leaf is in contact with the surrounding air, it lowers the temperature of this air. Tree crowns can have many thousands of leaves and wind will mix the cool air from



Example of the surface cooling effect from parks and other urban green infrastructure. The left side shows the normal view of Bicentennial Park and its adjacent residential neighbourhood in Sydney. The right shows the infrared view of the same place where surface temperatures are represented by different colours. The coolest surface temperatures can be observed for shaded and for unshaded vegetation. Lawn in the park has a surface temperature around 30°C, like the ambient air temperature when the image was taken at 15:00 on 26 December 2020. Water transpired from shrubs and trees will cool ambient air. In contrast, all hard infrastructure, including cars and buildings have much higher surface temperatures. Solar energy stored in these surfaces is radiated back into the environment as sensible heat, whereby it warms ambient air. Image © Sebastian Pfautsch inside and around the tree crown with the warmer air from the city. Billions of leaves will provide enough cooling to reduce the air temperature inside an entire city.

Not only trees, but also grass, shrubs, and any other vegetation usually transpire water. Some plant types in parks are more effective in cooling surfaces, others are cooling the air or both. Take lawn: it is effective in cooling the surface temperature, but not very effective in cooling the air as it is not tall enough to be much affected by wind. Take a tall tree with a large crown: it can transpire 300-600 litres of water in a single summer day, providing ample air cooling and surface cooling through its shade. The PCI effect describes how the combination of all sources of cooling in a park lower the air temperature in and around the park.

Studies have found that the type, age and density of vegetation, the way the vegetation is arranged, and the overall size of a park influences the PCI effect. In addition, the time of day, season, park geometry and morphology as well as wind channels can have important effects on cooling.

Two parameters are usually used to describe the PCI effect: the Cooling Effect Intensity and the Cooling Effect Distance. The Cooling Effect Intensity varies due to the above-mentioned influence of vegetation, park size and management. Irrigated parks are usually cooler than those that are not irrigated. The relationship with size was found to be curvilinear, whereby the Cooling Effect Intensity increased rapidly from a pocket park to about 10-15 hectare by up to 3°C, after which the park size had only a very small effect. Increasing the Cooling Effect Intensity to 4°C would require a park size of 100 hectare.

Park size was found to have a positive and near linear relationship with the maximum Cooling Effect Distance, lowering ambient air temperatures in adjacent residential and office precincts, which in turn lowers energy requirements for indoor cooling.

SIMPaCT used machine learning to fine-tune the delivery of the irrigation system to optimally hydrate all plant types across the park, especially in summer. This supported maximum transpiration rates throughout the day, keeping air and surface temperatures low, generate the largest possible Cooling Effect Intensity and Cooling Effect Distance.

The pumps delivered recycled water across the diverse landscape of the park.

Irrigation controls and the SIMPaCT dashboard is accessed remotely via apps and websites.

Environmental data was collected using weather stations installed throughout the park, to inform the SIMPaCT models that generate irrigation commands.

REFLECTIONS

It's a really interesting project and it's a really challenging subject for government cooling and greening. That's one of the priorities that I think it will be more important as we move towards this climate change and heat waves and all these challenges in the future.

I was really impressed that the project was delivered on time. For a large project with so many different pieces, I think you would rarely see this actually hit its deadlines the way we hit the deadlines.

The greatest reward was the way we were able to employ one of our graduates and I think just to see him grow in this role is remarkably motivating.

We were working on an important problem with a positive effect on both the environment and the lives of people. We're really trying to optimize these things like how to handle heat due to global warming and saving water. These are all really important problems. I found that was really rewarding to be a part of a project that was addressing those problems.

I really liked the collaboration because it was not competitive at all… we didn't try to outcompete each other but worked together.

Getting the two IOT awards: it's great when you get the external validation, that stamp of approval from someone else looking in and seeing we've done a great job and we've achieved something really, really special.

The integration between the sensor network, building the models, and then having it running on cloud computing platforms to really utilize and scale. It has been just so seamless. We're running all those different forecasts, a few thousand simulations for each of the stations, which takes a desktop computer more than a day to run. We can finish this in Senaps in about 10 minutes.

A really great outcome is ending up with a vision for SIMPaCT that's bigger and broader than what we originally perceived it could be capable of. I think its potential is so exciting beyond just the cut and paste possibilities, that it is solid, with good future potential.

The one thing that really stood out was when I first went to our SIMPaCT project webpage and could see live data coming from the park.

The best thing was when we ended up pushing data and actually seeing results - that was pretty exciting. And then to see how reliable our gear was as well.

The greatest achievement is how our team has been working and collaborating. At the start, obviously, we speak different languages. We found a common language, and have solved quite a lot of problems.

From Sydney Water's perspective, this echoes some of the previous comments of how this is really hitting some very important big issues for the water supply in Sydney. There's more water required in the modelling that City Water has, more water required to keep Sydney cool than what we currently can supply to the city. We have to work out how to make do with what we've got. And what we've got is getting rapidly more expensive. The only way to get urban cooling is by the most efficient way possible. So critically important research, and we've gone a long way down the road. It's been a fantastic project. It's world-leading.

DIGITAL TRUST FOR PLACES AND ROUTINES

A first in the southern hemisphere, Sydney Olympic Park Authority piloted **Digital Trust for Places and Routines (DTPR)**, a communication standard to inform and engage people about technologies in public spaces. Signs using the DTPR standard were posted around Bicentennial Park for SIMPaCT, to communicate how it worked and support management of the park. The signs used a set of icons to show the type of technology being used, its purpose, and includeed QR codes for people to seek more information via a dedicated webpage. By using DTPR to explain technology and support public engagement, SOPA was able to learn that most visitors to the park were supportive of the SIMPaCT technology once they were made aware of the project and understood how it worked.

Visit our website for more about SIMPaCT

WESTERN SYDNEY UNIVERSITY

SydneyOlympicPark