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SIMPACT - STRATEGIC IRRIGATION MANAGEMENT TO TACKLE URBAN OVERHEATING

SNAPSHOT

- SIMPaCT is Australia's largest smart green infrastructure project.
- Based in Bicentennial Park, Sydney, it aims to reduce the urban heat island effect (UHIE) by maximising the transpiration cooling provided by plants.
- The project uses smart technology to optimise irrigation so plants can transpire freely during times when air temperatures are high.
- SIMPaCT uses artificial intelligence to 'learn' from the past and present to predict soil moisture conditions in the coming seven days and make irrigation decisions accordingly.
- SIMPaCT is expected to reduce air temperatures across the park by more than 3°C during hot days and the cooling effect is expected to extend at least half a kilometre into the surrounding urban land.
- The technology will apply to existing or new irrigation projects anywhere. The IP will be public domain and the technical solution follows open technology design principles, making it accessible for utility providers and local governments.

According to the United Nations, two out of three people will live in cities by 2050. This will create massive challenges across every aspect of city life. On top of this, urban populations will need to deal with the accelerating impacts of global warming: sea level rise and associated loss of land, flooding from increasingly intense rainstorms, rising summer temperatures and more intense heat waves.

Warmer cities

The latest report from the Intergovernmental Panel on Climate Change (IPCC) highlighted that cities are hot spots for climate change. Cities currently only cover 0.03 per cent of the surface area of Earth, but cities and their support systems are huge emitters of greenhouse gases. At the same time, owing to the steady growth of urban populations, cities are highly vulnerable to the impacts of climate change.

Even without global warming, surface and air temperatures will always be warmer in cities compared with nearby green areas owing to the *Urban Heat Island Effect* (UHIE) – the fundamental difference in thermal properties between the two types of land surface cover (i.e., green and grey). Vegetated areas absorb rainwater, which can evaporate from the ground and be transpired by plants. Both processes lower air and surface temperatures.

The typical transformation of an area from green to grey involves the replacement of plants with unshaded impervious surfaces with low reflectivity. Because of the low reflectivity and lack of shade, grey areas like cities absorb large quantities of solar energy, which is emitted as sensible heat, warming the ambient air. Moreover, any human activity produces waste heat that leads to further warming of air. The lack of pervious surface reduces the amount of water held by the land and the low number of plants limit air cooling from evapotranspiration. And voila! You have an UHIE.

Urban green infrastructure

Urban green infrastructure, especially mature trees with large crowns, is the most effective tool to cool our cities, reducing air temperature locally by more than 3°C. Our research has demonstrated that tree shade reduces surface temperature of unshaded asphalt from 70°C to 30°C. Green infrastructure improves human thermal comfort – how your body perceives a certain temperature environment. It also reduces cooling energy needs, which in turn lowers emissions generated by cities.

Australia's largest smart green infrastructure research project

The goal of the SIMPaCT (Smart Irrigation Management for Cool Parks and Towns) project is to reduce the UHIE by maximising the transpiration cooling provided by plants. We use smart technology to optimise irrigation of an entire parkland so plants can transpire freely during times when air temperatures are high.

Public parks are the ideal location to implement our work. They are usually located where people live and work, can be enjoyed by everyone, have predominately pervious surfaces and large tree populations, are managed for safety and amenity, and are often irrigated. We have known for decades that during warm days, air temperature inside and around parks is lower than the adjacent built environment, a phenomenon known as *Park Cool Island Effect* (PCIE), which mitigates the UHIE at a local scale. We have designed SIMPaCT to bolster the PCIE.

Located in Bicentennial Park, a 40 ha, fully irrigated parkland in Sydney Olympic Park, SIMPaCT is Australia's largest smart green infrastructure research project. It is funded by the Digital Restart Fund of the NSW Government and Sydney Water and brings together universities, government agencies and industry. The project started in November 2021 and will finish at the end of July 2023. All project partners and companies involved in its realisation are listed at the end of this article.

Bicentennial Park irrigation system

The park is built on landfill, capped by a clay layer. A relatively shallow layer of topsoil sits on the clay and is all that the plants in the park have available as a moisture reservoir. The reservoir holds little water and survival of the plants throughout the park heavily depends on irrigation. The water to keep the park green and lush comes from a nearby treatment plant. The park has an undulating surface, and plant cover is diverse, including pure lawn zones, garden beds, tree groves, native plantings, and mixtures of these elements (Figure 1).

Figure 1. Impressions of Bicentennial Park (Sydney Olympic Park). The vegetation across the parkland is highly variable, from ornamental gardens to native forests, intersected by lawns, wetlands and a large lake. Image © S. Pfautsch.

As a result, a complex sub-surface irrigation system replenishes soil moisture across 200 individual zones. Each zone is controlled by a solenoid valve that can have a single or multiple lateral heads. We use Hunter and Rainbird Rotors, Toro 570s, impact sprinklers and other hardware to distribute the irrigation water across the zones (Figure 2). Field Mouse software from Centratech Systems is used to operate the solenoids, watering the vegetation using a sequence of pumps. Irrigation management, operations and servicing in the park is provided by Total Water.

Figure 2. Irrigation operations at Bicentennial Park (Sydney Olympic Park). Sprinklers were only operated during the day for demonstration purposes. Any scheduled irrigation at the park takes place between 22:00 and 06:00. Image © S. Pfautsch

We installed wireless moisture sensors 10 cm below ground in each zone. In addition to the 200 soil moisture sensors, we also operate 54 ultra-compact wireless sensors that measure air temperature and relative humidity and seven weather stations that record a full suite of environmental information, including rainfall (Figure 3). All sensors take measurements every 15 minutes. SIMPaCT receives these measurements via 4G and three LoRaWAN gateways that we installed in the park and on top of a nearby 126 m tall building. SIMPaCT also ingests seven-day forecasts for the Sydney Olympic Park area from the Bureau of Meteorology (the Bureau). A digital twin of the park and artificial intelligence inside SIMPaCT use the data from forecasting (data from the Bureau) and nowcasting (current data from the park) to predict soil moisture in each zone. If soil moisture in any zone drops below set thresholds where plants do not transpire freely, irrigation commands are sent to Field Mouse and irrigation is provided.

Figure 3. Installation of wireless sensors, LoRaWAN gateways, power-autonomous weather stations and drone technology used to document environmental conditions across Bicentennial Park. Image © S. Pfautsch, B. Puncheon, A. Tovey.

Artificial intelligence learns from data to predict the future

Over time, SIMPaCT records a lot of data, and the AI will learn how soil moisture changed under different environmental conditions and what affect that had on air temperature. This machine learning process is called hindcasting. SIMPaCT combines forecasting, nowcasting and hindcasting to 'learn' from the past and present in order to predict soil moisture conditions in the future. We defined 'future' as the coming seven days. Combining the digital twin for geospatial modelling and scenario analyses with artificial intelligence that can predict future scenarios makes SIMPaCT truly smart and a unique way to manage irrigation of an entire parkland.

SIMPaCT also generates dashboards for Sydney Olympic Park Authority and the public (Figure 4). These dashboards display information to support the operation of the irrigation system in the park, for example the water volumes used

in the past and those required for the coming seven days. Park visitors can use the dashboards to check where the coolest location for their picnic is or where they should not go for a run because it is very warm. We also operate six weather stations across the centre of Sydney Olympic Park and use their measurements to inform the public how much cooler it is in Bicentennial Park to encourage a visit. This information will become important during summer when people can come to the park to cool down and relax in the afternoon and evening, instead of being confined to indoors airconditioned environments.

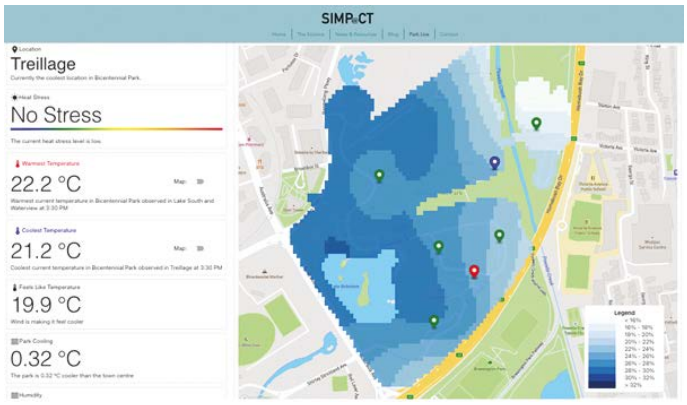

Figure 4. Example of the draft public dashboard (30 October 2022, 15:45), depicting live environmental conditions across the park. The projected map in scales of blue shows soil moisture, the pins indicate the locations for the seven weather stations with blue and red pins identifying the coolest and warmest air temperature, respectively. The dashboard is accessible at www.simpact-australia.com/live.

Cooling within the park and beyond

Based on scientific models, we expect that SIMPaCT will reduce air temperatures across the park by more than 3°C during hot days. The reduction of air temperature is called Park Cooling Intensity. The same models predict that the PCIE of Bicentennial Park will extend at least half a kilometre into the surrounding urban land, reducing the cooling needs in residential and office buildings. The spatial extent of the PCIE is called Park Cooling Distance and will depend on wind speed and direction. SIMPaCT aims to maximise both the Park Cooling Intensity and Park Cooling Distance.

A greener future

Given the expected increase in extremely hot summer conditions, including high air temperatures at night, and the race to net zero carbon, it is necessary to develop new solutions that help keep our cities cool without the need for electricity. Plants, especially trees with large, dense crowns do a wonderful job providing coolth. All they need are optimal soil moisture levels, and SIMPaCT is designed to maintain these levels in a complex parkland. We are developing SIMPaCT in a way that allows it to be applied to existing or new irrigation projects anywhere – it operates in digital space that has no physical boundaries. Importantly, the IP of SIMPaCT will be public domain and the technical solution follows open technology design principles, which makes this 'smart' irrigation solution accessible for utility providers and local governments.

In an increasingly urbanised and warming world, SIMPaCT demonstrates how science and industry can work together to deliver effective urban cooling solutions.

Organisations and companies involved in SIMPaCT:

- Western Sydney University (lead)
- Sydney Olympic Park Authority
- Sydney Water
- University of Technology Sydney
- Monash University
- NSW Department of Primary Industries (Water)
- SAPHI
- The ARCS Group
- Hydrology and Risk Consulting
- Eratos
- Centratech Systems
- Total Water
- Amazon Web Services
- Meshed
- ARA Building Services
- Pacific Urban
- TOBCO

Information. To find out more, visit the SIMPaCT webpage.

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