



Designing tropical cities on a hotter earth



A/Prof Lisa Law
Tropical Urbanism and Design Lab, James Cook University



<https://www.sbs.com.au/nitv/article/do-you-know-what-aboriginal-land-youre-on-today/yfff85vi1>

Acknowledgement of Country



Urban heat



Urban water



State of the Arts in Cairns SoARTS



Regional generation





Urban heat



Oasia Hotel Downtown, WOHA Architects, Singapore (2016)








AGROB BUCHTAL GmbH / Infiniteur



- 27 stories integrated hotel-office development
- Exploration of tropical design
- Trees, gardens, sky terraces; 22 different types of creepers; space for animals and insects
- Like a tree in the city
- A good 'neighbour'

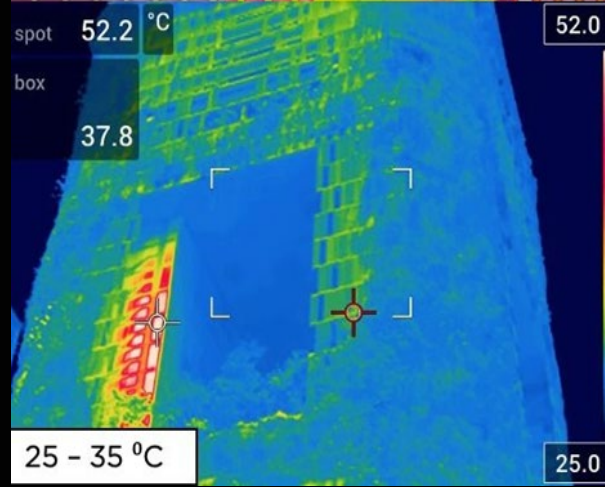
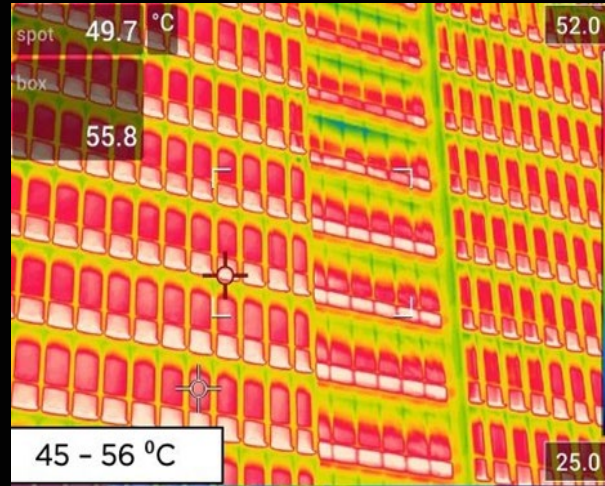


https://upload.wikimedia.org/wikipedia/commons/f/fa/Oasia_Hotel_Downtown%2C_Singapore_-_Facade_A_%282019%29.jpg

 Green Plot Ratio 1110%	 Community Plot Ratio 300%	Self Sufficiency Index  Energy 0%  Food 0%  Water 60%
 Civic Generosity Index 100%	 Ecosystem Contribution Index 60%	

<https://woha.net/project/oasia-hotel-downtown/#>

Jonathan Anderson/LinkedIn

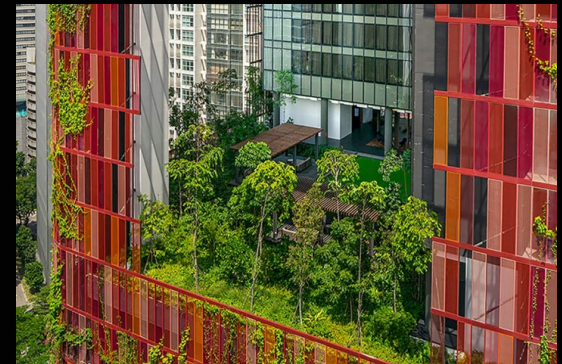


Glass and steel skyscrapers reflect and amplify solar heat

Oasia's façade is 20°C cooler than a typical skyscraper

Reduced solar heat gain = less air conditioning needed + intake is cooler

Instead of contributing to the urban heat island, it cools the air surrounding it



Understanding and measuring the urban heat island in Cairns



David Rissik and
Fahim Tonmoy



Sophie Barrett

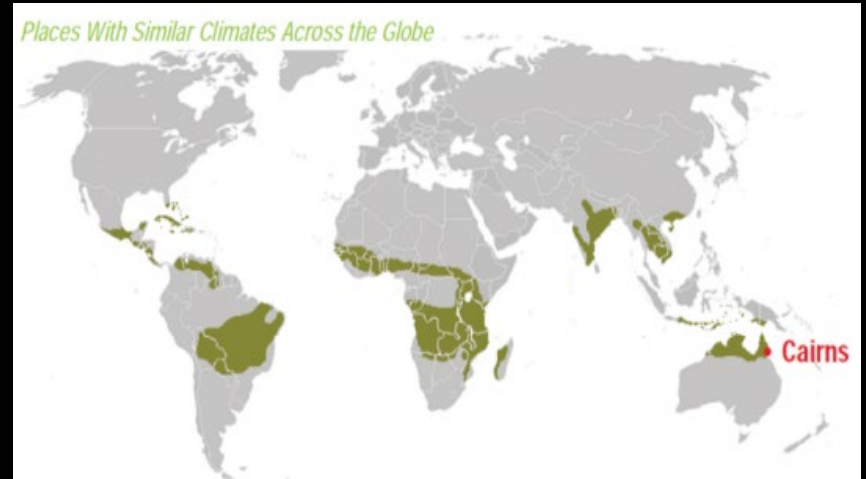
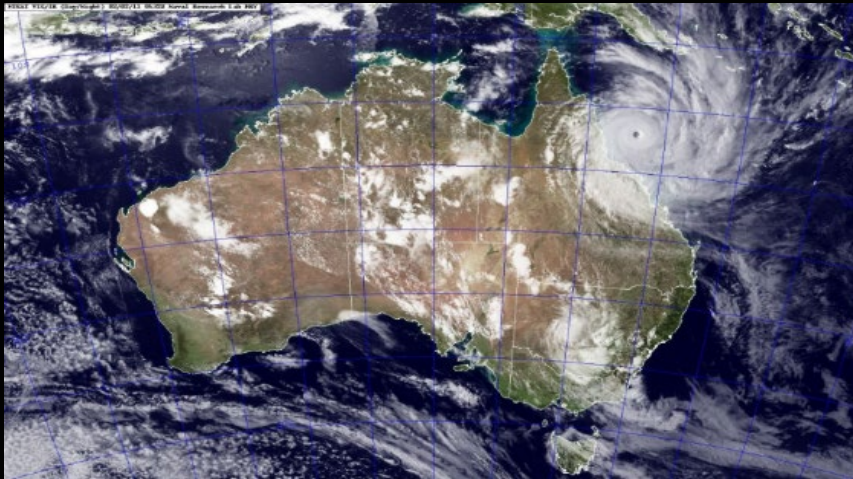
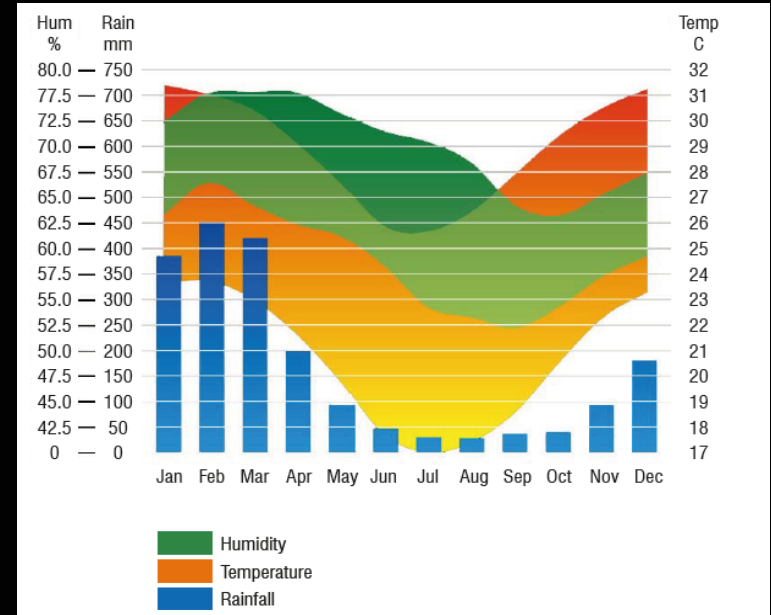
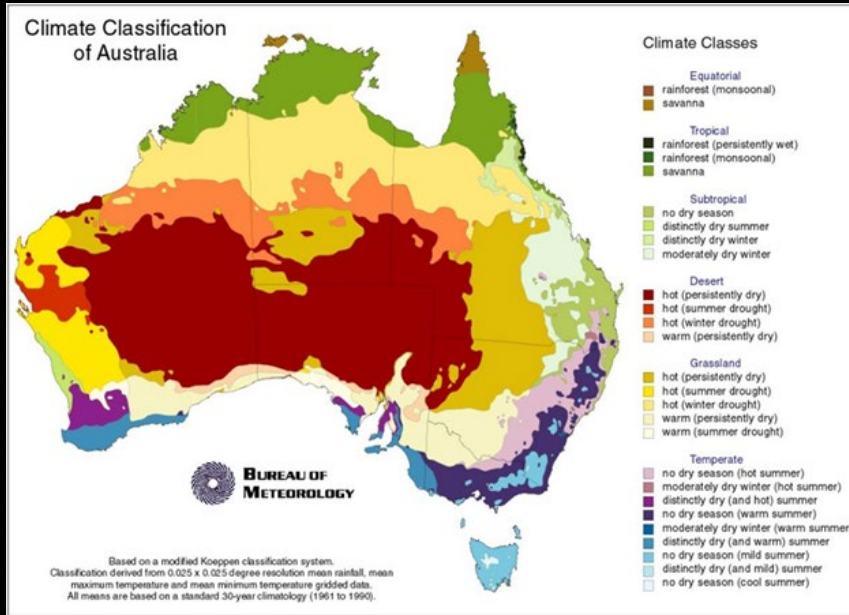
GDA2020LatLng
lat: -16.88919
long: 145.75471

1:36112

2D 3D 360

< Previous Next >

Tropical climate in Cairns



1984



andsat / Copernicus

Google Earth

1994



andsat / Copernicus

Google Earth

2004



Landsat / Copernicus

Google Earth

2014



Landsat / Copernicus

Google Earth



2020



Key factors driving UHIs

Characteristic contributing to heat island	Effect on the energy balance
Lack of vegetation	Reduce evaporation
Widespread use of impermeable surfaces	Reduce evaporation
Low solar reflectance of urban materials	Increase net radiation
Urban geometries that trap heat	Increase net radiation
Urban geometries that slow wind speeds	Reduce convection
Increase energy use	Increase anthropogenic heat

Construction materials

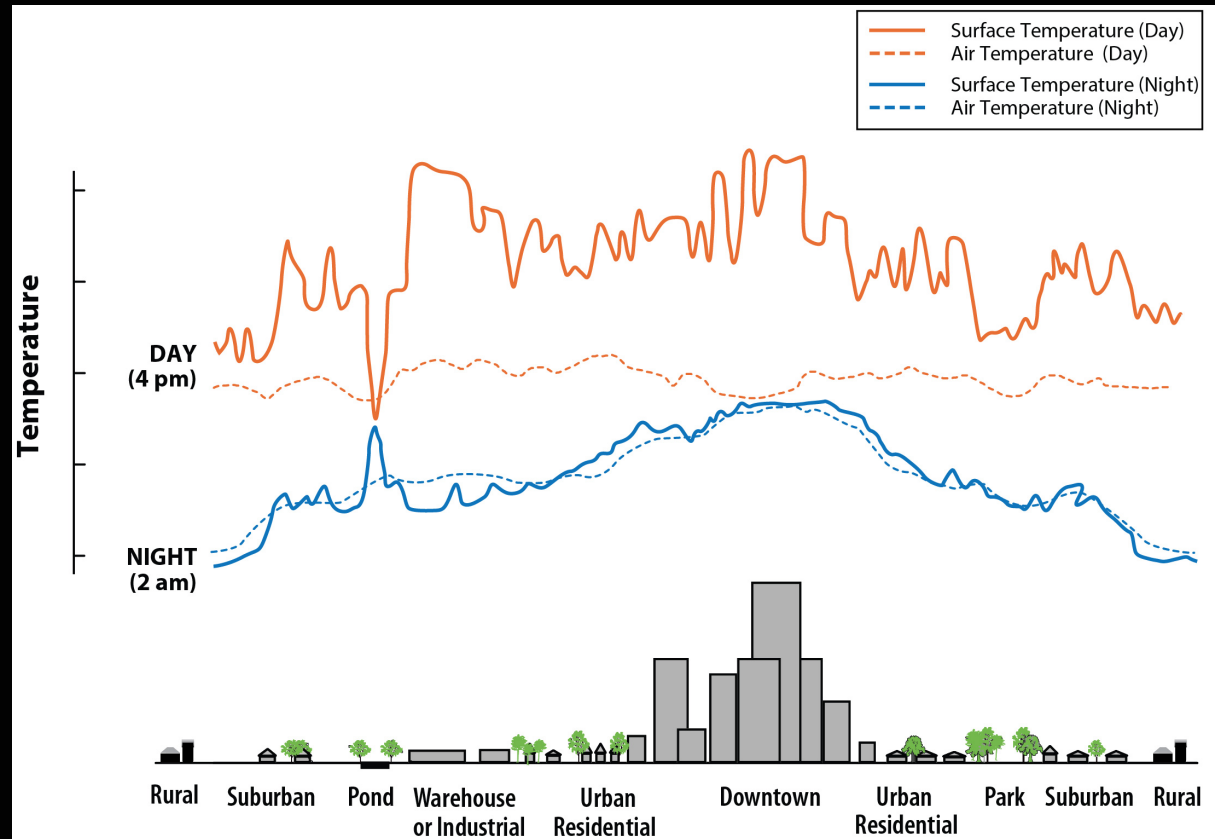
Low reflectivity
High thermal mass

Evaporation and evapotranspiration

Fewer waterbodies, trees
Impervious built surface

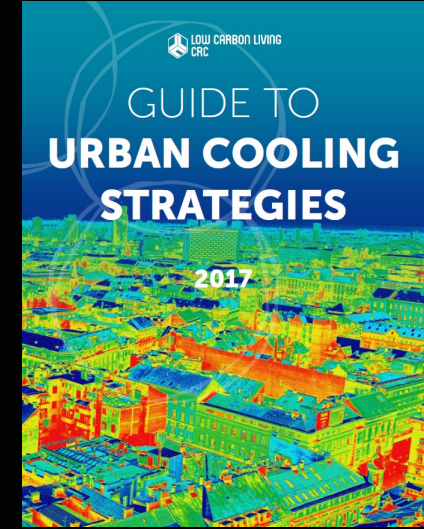
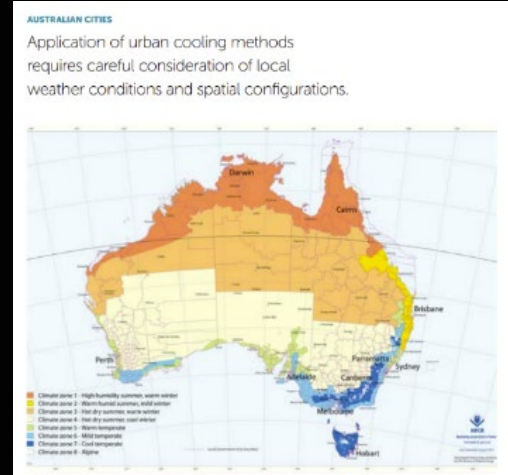
Urban geometry

Reduced wind flow
Increased energy absorption
Reduced long-wave radiation to space



Source: <https://www.usgs.gov/media/images/urban-heat-islands>

Understanding urban heat in (different parts of) tropical Australia requires nuanced understanding

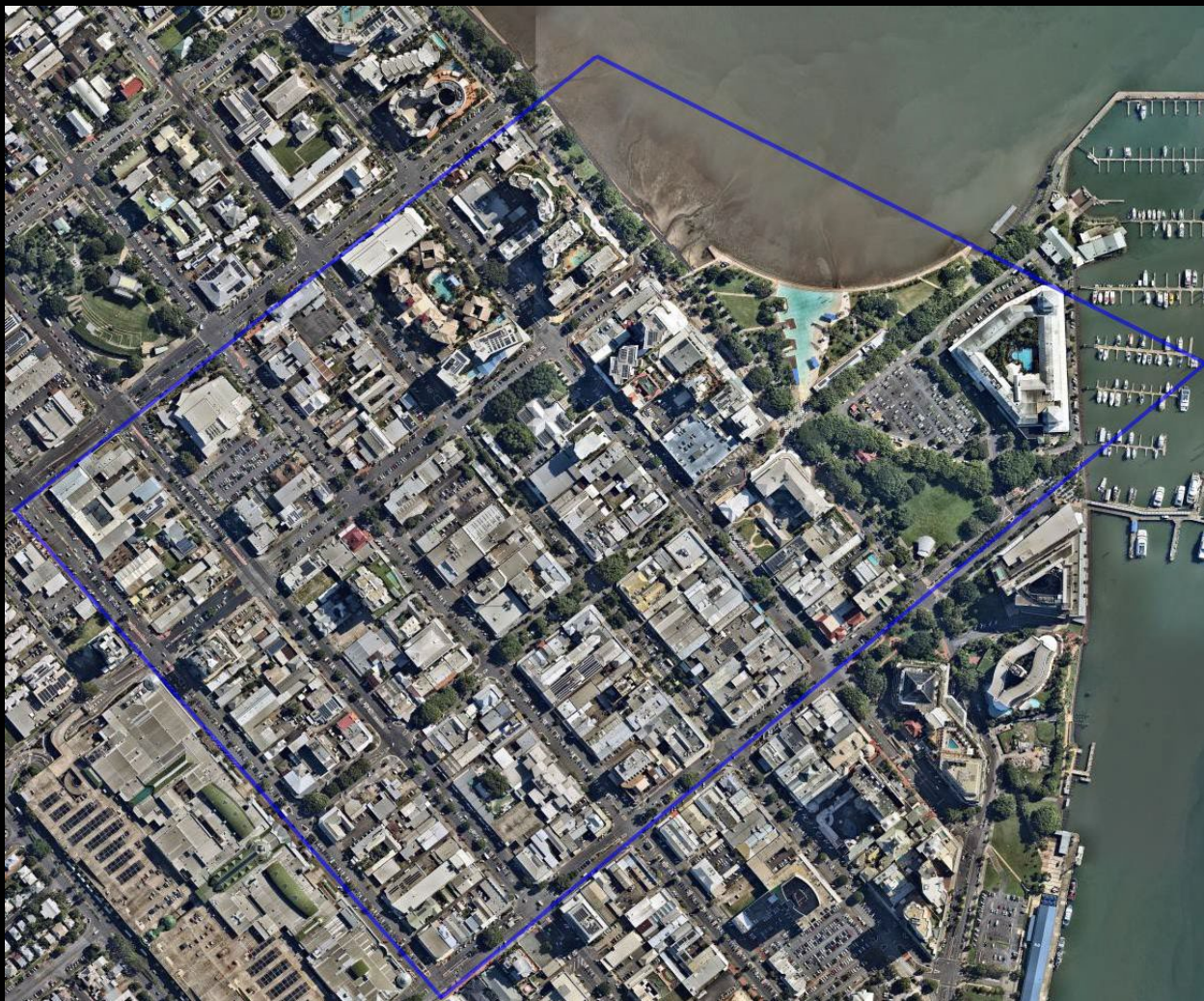


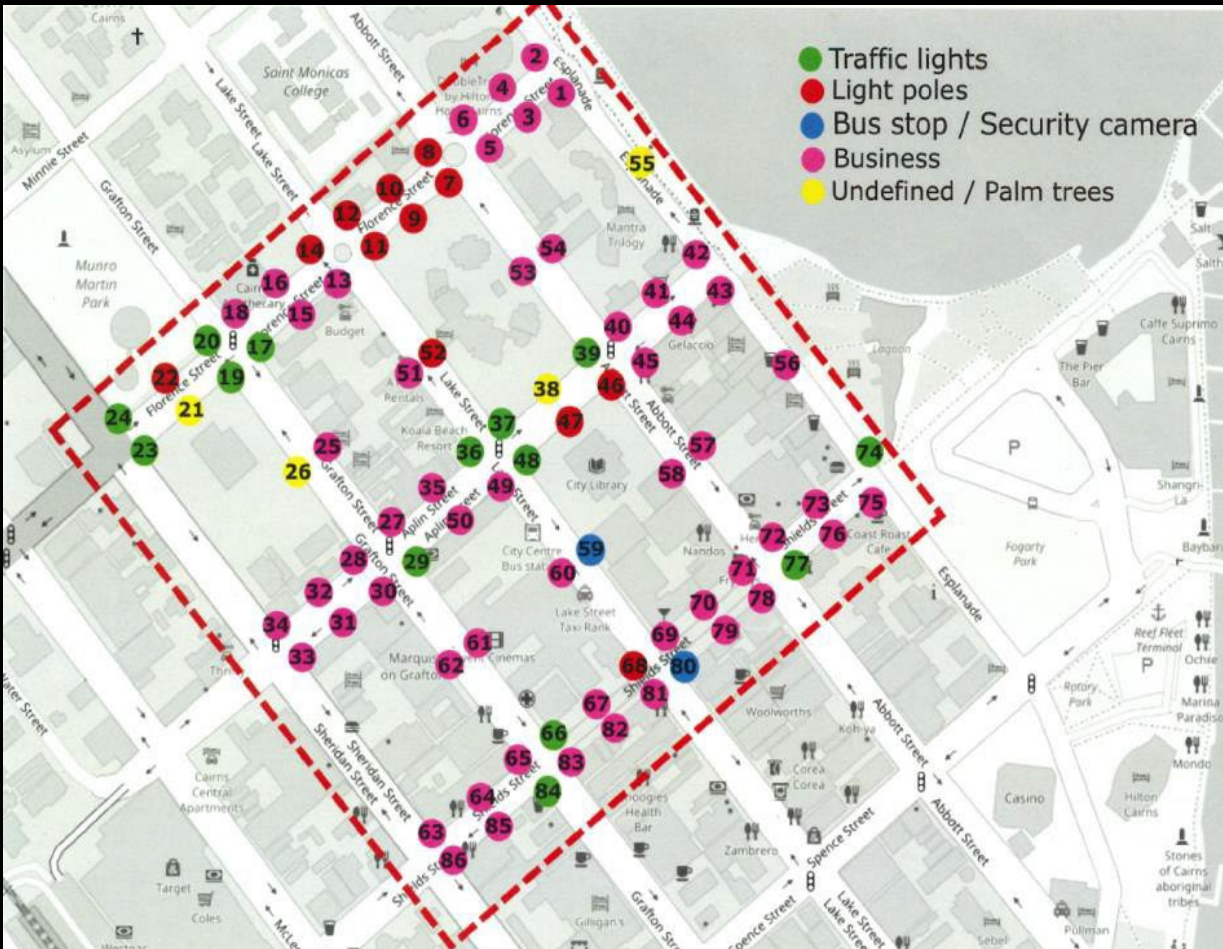
LOCAL CLIMATE		RECORD TEMPERATURE	AVERAGE RAINFALL (MM/Y)	COOL PAVING			COOL ENVELOPE		GREEN ENVELOPE		TREE CANOPY	EVAPORATIVE COOLING		SHADING STRUCTURES
SUMMER: TROPICAL	WINTER: MILD			HIGH ALBEDO PAVING	HIGH EMISSANCE PAVING	PERMEABLE PAVING	HIGH ALBEDO ENVELOPE TREATMENTS	HIGH EMISSANCE ENVELOPE TREATMENTS	GREEN ROOF	GREEN WALL		SURFACE WATER AND EVAPORATIVE COOLING	MISTING FAN	
		Min 6.2°C Max 40.5°C	1999	1	3	3	R-3 W-1	RW-3	2	2	3	N	2	3

Effectiveness
 High = 3 Low = 1
 Medium = 2 Negative = N

W = Wall
 R = Roof

Measuring the UHI in Cairns



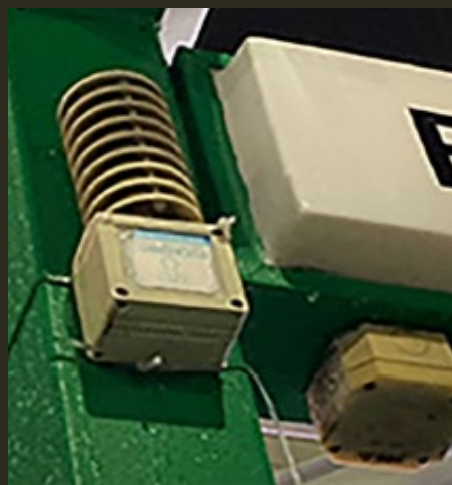
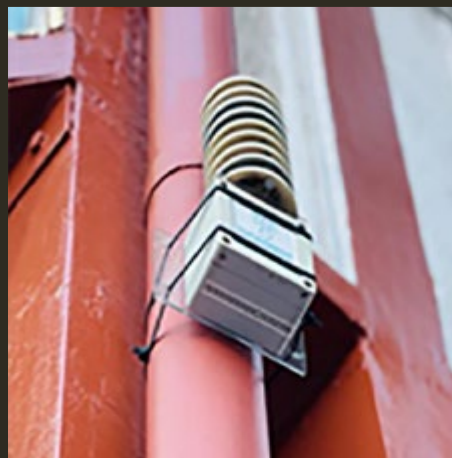


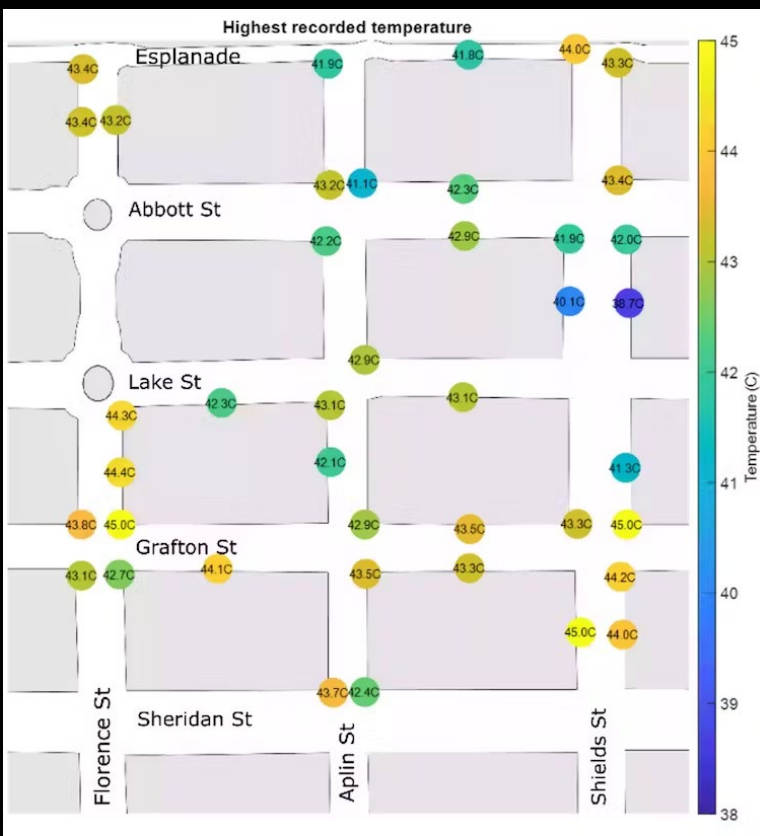
2017: placed 86 sensors 2-3.5 m off the ground

Collected temperature and humidity data every 15 minutes

[Only 26 providing reliable data]







Highest temperatures recorded by JCU sensors during the Nov/Dec 2018 heatwave in Cairns
Image: Bronson Philippa/IoT JCU

2018 heatwave impacts: spectacled flying foxes, ecosystem impacts, human impacts, technology, assets

Case study: Hotter than ever – the Cairns extreme heatwave

For four consecutive days in late November 2018 – 25 to 29 November – temperatures soared to above 42°C in the centre of Cairns, the highest temperatures recorded in the region,³⁸ as shown in Figure I. Hot, sticky conditions continued into ensuing days, all just as the BoM had predicted and warned at a Local Disaster Management Group meeting a fortnight earlier.

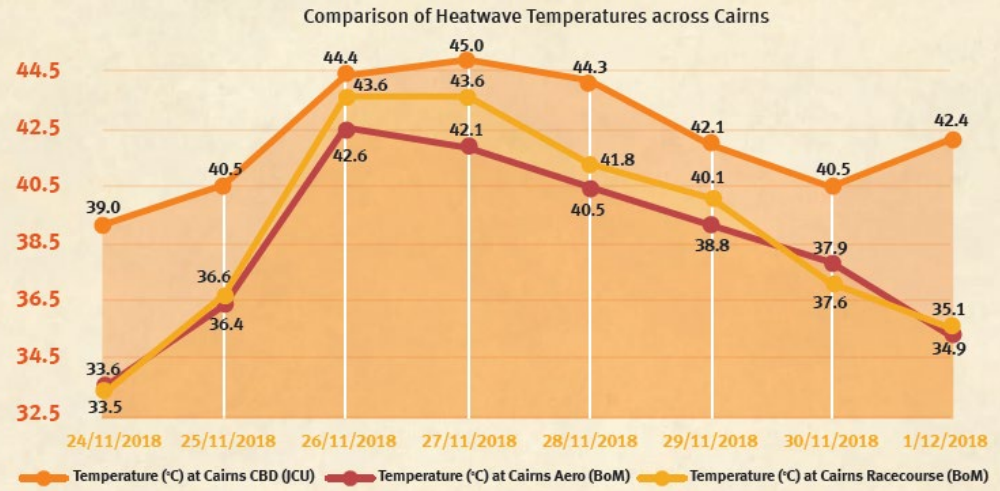
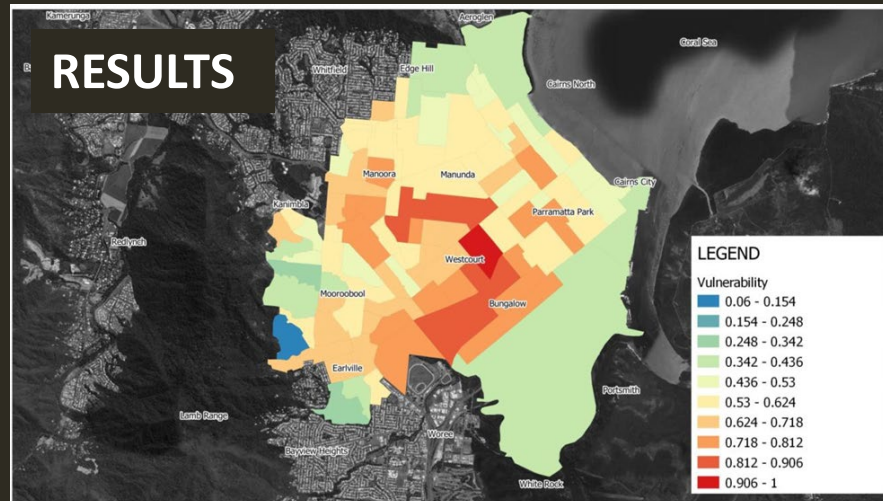
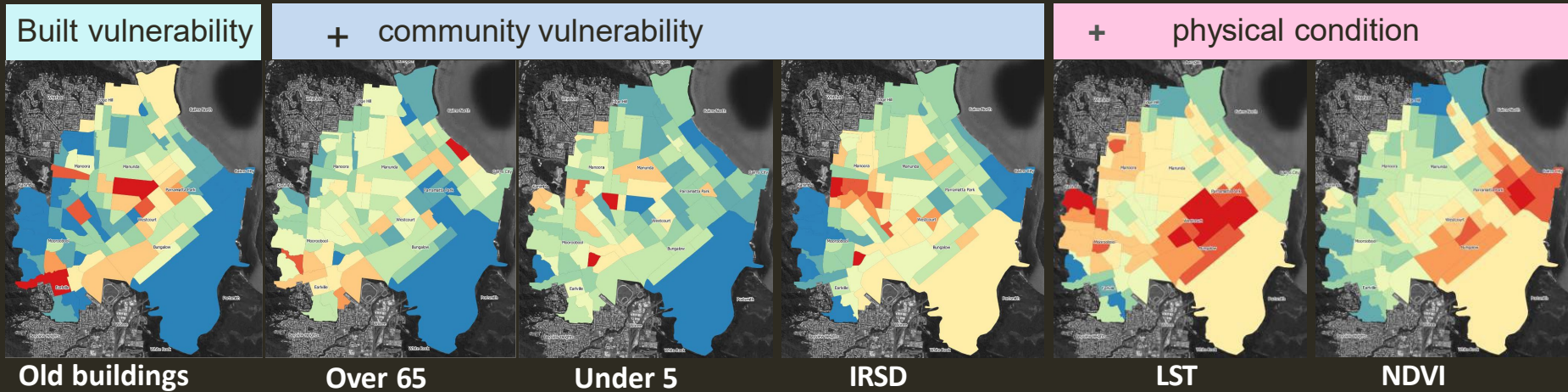


Figure I: Comparison of the highest recorded temperatures within the CBD by James Cook University with those recorded at Cairns Airport by the Bureau of Meteorology. Data provided by Cairns Regional Council



BMT Opportunity analysis



Pedestrian data and opportunities

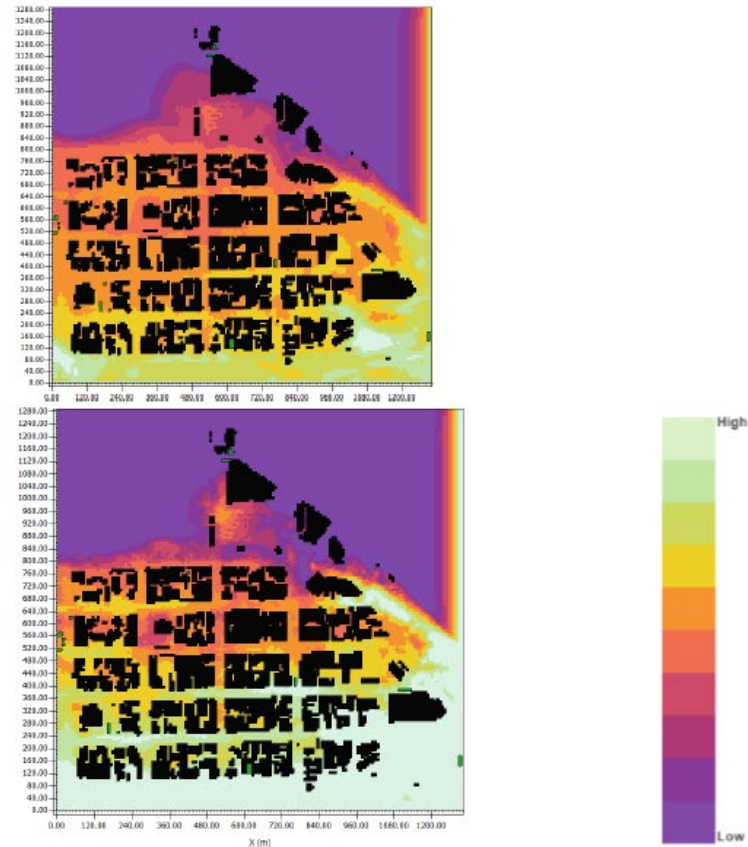
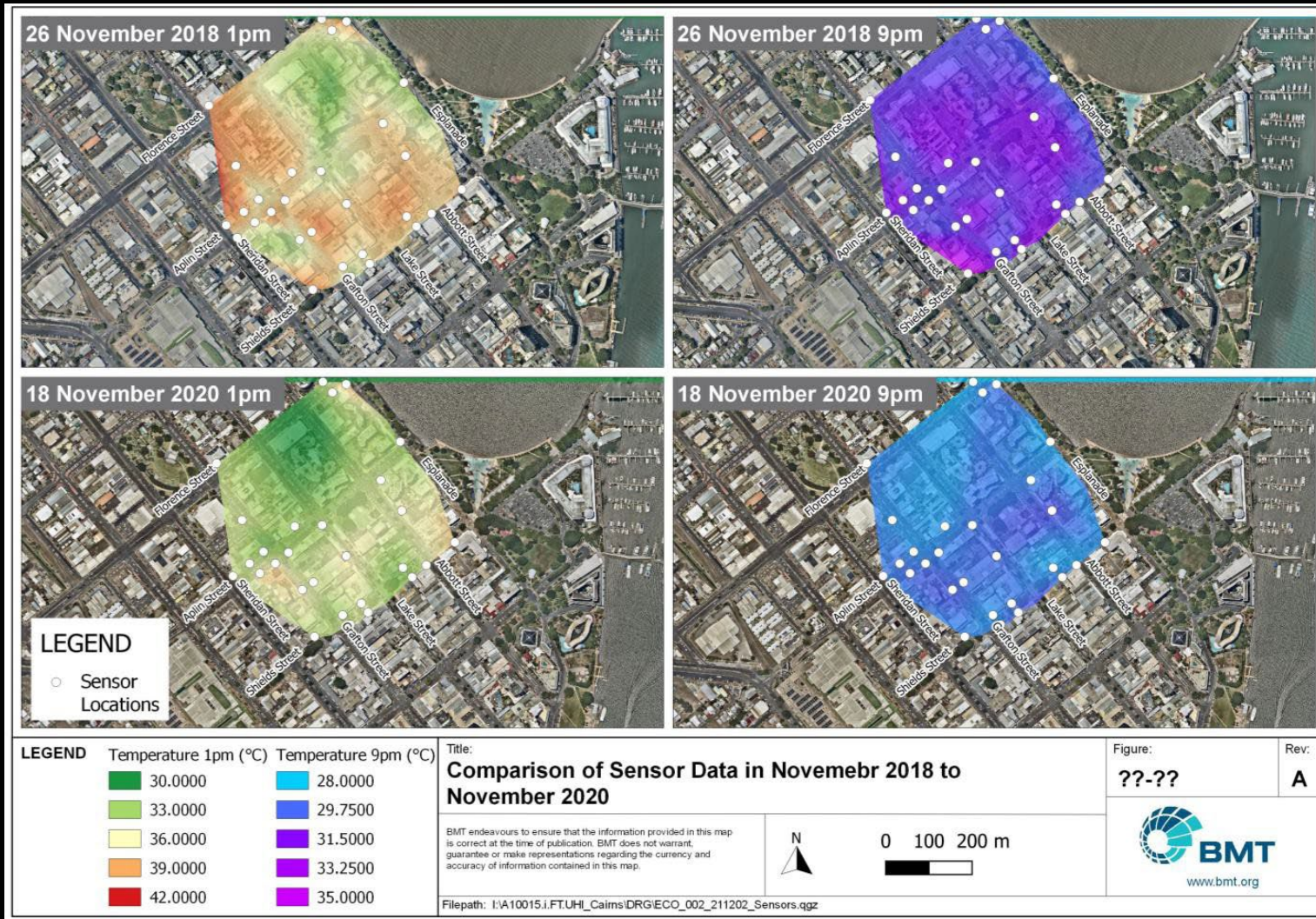
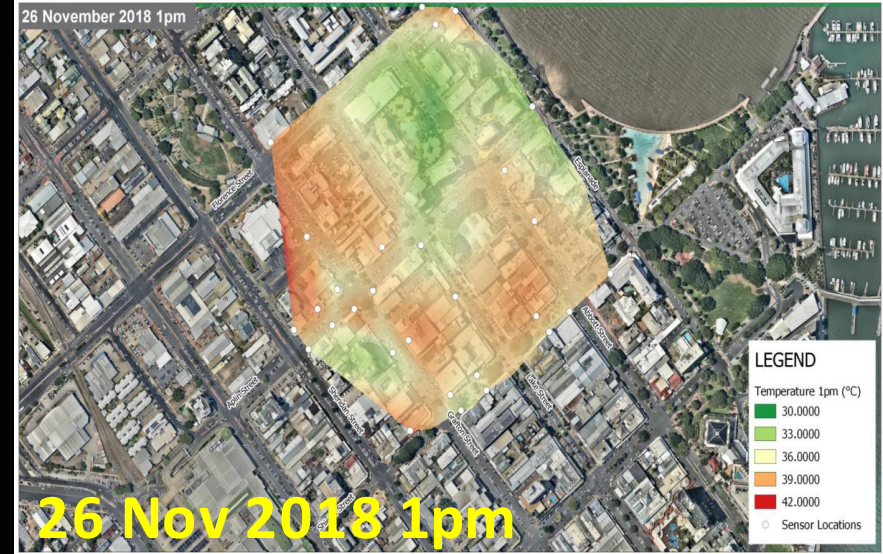
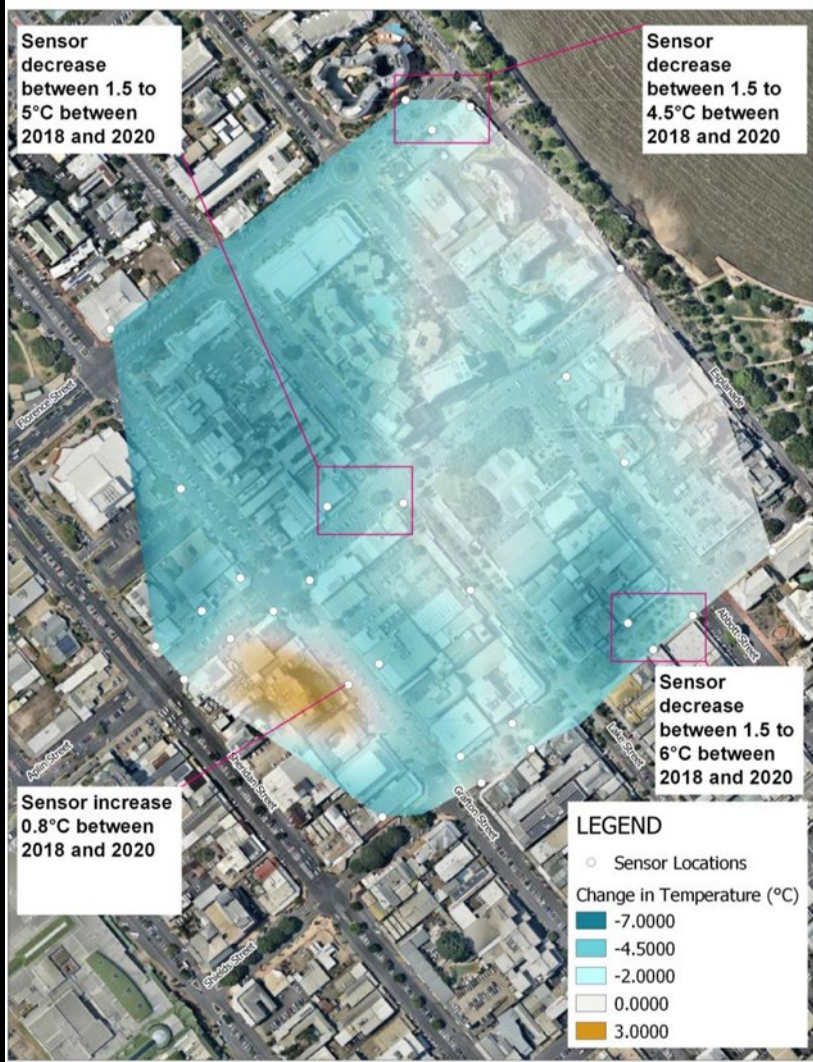


Figure 8.1 Pedestrian movement heatmap: morning (top left), afternoon (bottom left) and air temperature at 1.5 m for 9am (top right) and 1pm (bottom right). Lighter colour refers to higher pedestrian movement and higher temperature, darker colour refers to low pedestrian and lower temperature.

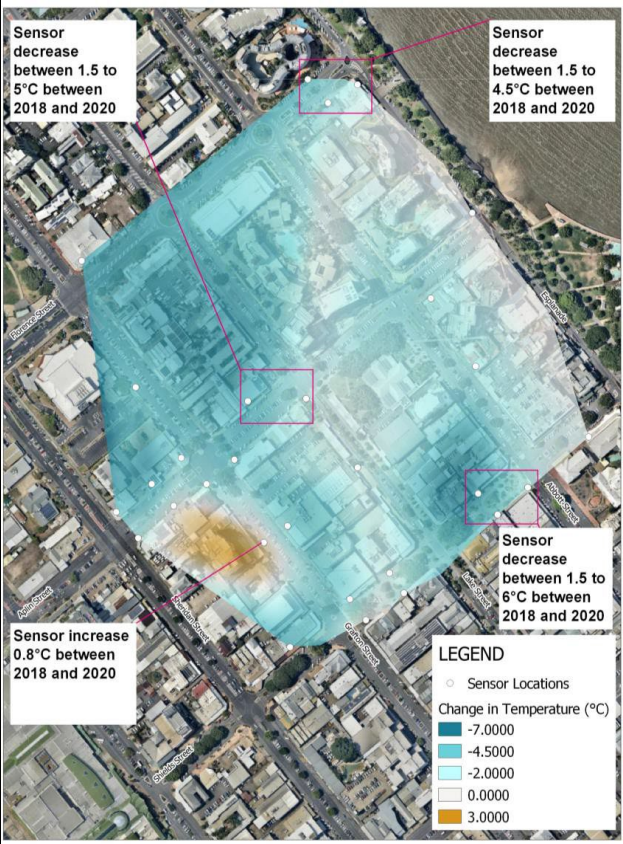
Sensor data: Nov 2018 vs 2020



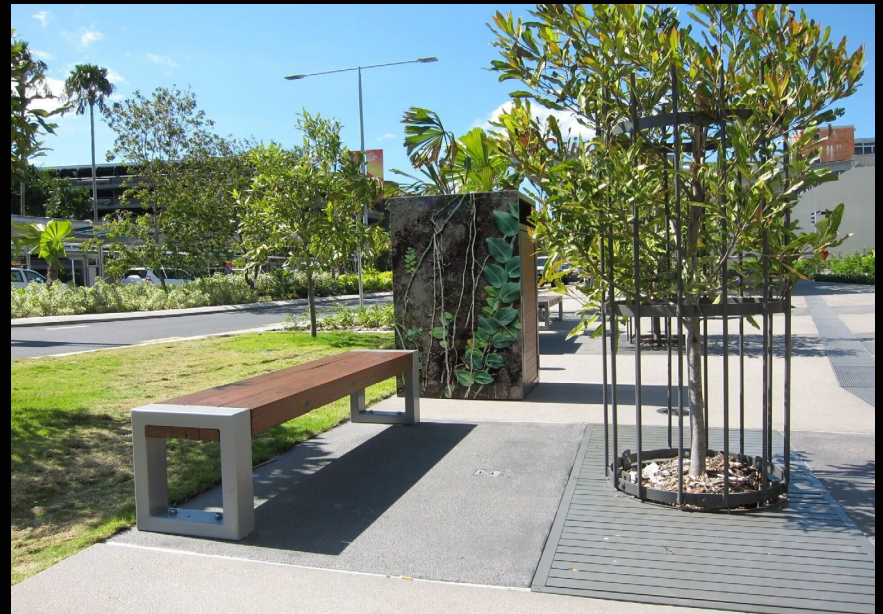
Temperature change



Vegetation change: Comparing NDVI between 2018 and 2020



Since 2014 CRC implementing urban greening





In Cairns, the relationship between built form, city planning, and landscape is expressed as tropical urbanism and is a defining factor of the identity of Cairns

Tropical urbanism is the integration of landscaping and tropical design elements into the built environment



CAIRNSPLAN2016

SC6.16 Planning scheme policy – Tropical Urbanism

SC6.16.1 Purpose of the planning scheme policy

- (1) The purpose of this planning scheme policy is to:
- (a) provide context and guidance for the tropical urbanism, 'city in a rainforest' and qualities of good urban places provisions in the planning scheme
 - (b) provide guidance for satisfying assessment criteria in the planning scheme, in particular the provisions of the City Centre local plan code, and the Building height overlay code; and
 - (c) identify information that Council may request or that may be required for a development application.

SC6.16.2 Context to Tropical Urbanism

- SC6.16.2.1 Biophilia**
- (1) Biophilia is a term that describes the extent to which humans are hard-wired to need connection with nature and other forms of life. It means that cities and their environment, and in particular their natural context, are inextricably linked.

This link is not only made at an emotional level, but it is the very built form of a community and how that built form connects with a community to sight, experience and identity that determines the experience for a resident or visitor, leading to positive memories, pride, control and an emotional association with the experience.

The over-preservation of the natural environment and its abundant landscape makes Cairns 'a city in a rainforest'. It is this close proximity of nature to the city that attracts tourism, energises the experience of locals, and positions Cairns as a unique tropical urban environment.

In Cairns, the relationship between built form, city planning and landscape is expressed as tropical urbanism and is a defining factor of the identity of Cairns.

SC6.16.2.2 Tropical Urbanism

- (1) Tropical urbanism is the integration of landscaping and tropical design elements into the built environment. Development that expresses Tropical urbanism incorporates:
- (a) Shelter from sun and rain;
 - (b) A contrast of light and shade;
 - (c) Sufficient spaces around and between buildings;
 - (d) Minimisation of radiant heat and heat island effects;
 - (e) Air circulation, breeze permeation and passive cooling;
 - (f) Generous outdoor living spaces with large window and balcony openings;
 - (g) Generous floor to ceiling heights;
 - (h) High quality landscaping;
 - (i) Quality public and private spaces that proliferate and enliven the urban form; and
 - (j) Passive design that responds to the tropical climate.

Figures SC6.16.2.2.a and SC6.16.2.2.b below depict the concept of Tropical Urbanism.

Landscaping

25% area within the site to be landscaped:

- buffer & screen planting
- deep planting
- podium planting
- specimen planting

Design principles:

- green and lush with emphasis on foliage
- use of tropical species suitable for climate of Cairns and microclimates
- use of vertical and horizontal landscaping for quality & effect
- use of street in addition to site for landscaping



Vertical landscaping

CAIRNS REGION PLANNING SCHEME



Figure SC6.16.3.7.a – Vertical landscaping



Figure SC6.16.3.7.d – Example of vertical landscaping in North Cairns



Street canopies

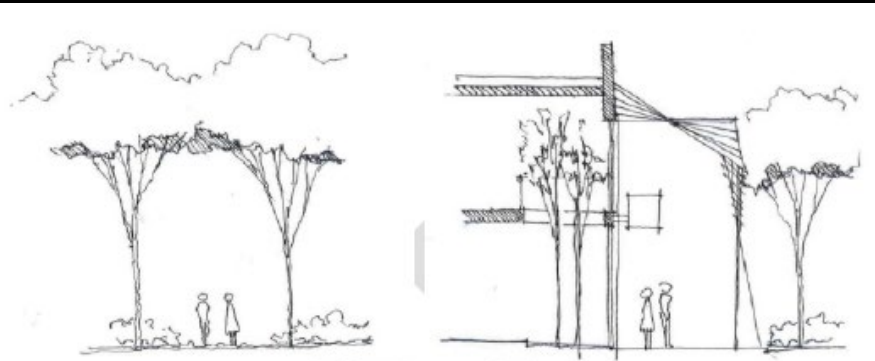


Figure SC6.16.3.8.a – The rainforest canopy in its natural setting

Figure SC6.16.3.8.b – The architectural expression of the rainforest canopy



Figure SC6.16.3.8.c – Street canopy



Figure SC6.16.3.8.g – Street canopy (view from inside)

Figure SC6.16.3.8.h – Street canopy (advertising is located on shop fronts)



Figure SC6.16.3.8.d – Street canopy (typical cross section)

Separation and view retention



Figure SC6.16.3.2.a – Separation between buildings

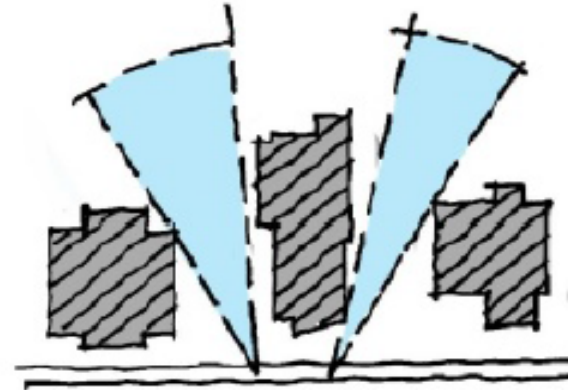


Figure SC6.16.3.5.a – View lines between buildings

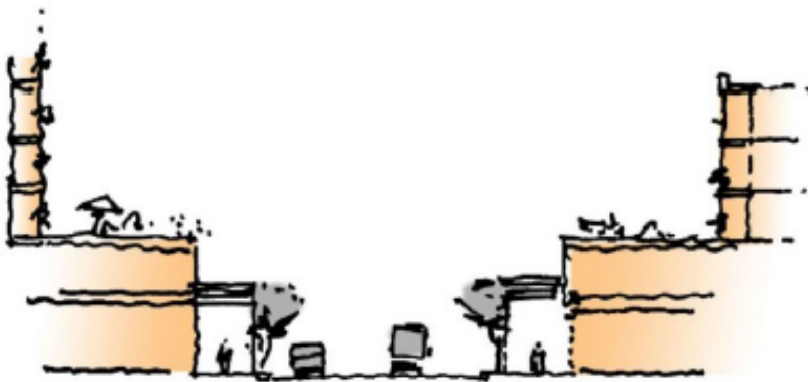


Figure SC6.16.3.10.a – Human scale at streetscape level



BMT microclimate simulations



1.2 THE TUDLAB TEAM



Lisa Law, Associate Professor, James Cook University

Lisa lectures in urban planning and design at James Cook University. She is founder of the Tropical Urbanism and Design Lab (TUDLAB), an interdisciplinary design team addressing urban issues in the tropical world. Her research focuses on the uses and meanings of public space and the role of placemaking and urban design in urban and regional regeneration.



Gisela Jung, CA Architect, Registered Architect and Urban Designer

Gisela is a Senior Architect and Urban Designer at CA Architects. She is passionate about urban planning and design, and is focused on how residential, commercial, and retail spaces can combine to create the very best urban environments. Her portfolio includes a very diverse mix of projects, constantly striving to deliver sensitive integrated design solutions which focus on the relationship between people, land, space and climate in our tropical environment.



Roger Mainwood, FRAS, Director, RW Architects, Registered Architect

With a professional background including architectural experience in Papua New Guinea and Greece, Roger has been practising in North Queensland since 1987. His close involvement with community groups always ensures his concepts are sensitive to the needs of users. His design experience has been recognised with industry awards including 25 awards from the Australian Institute of Architects. Roger is well known for his tropical architecture and ability to seamlessly integrate a project with its environment in a fundamentally sustainable way.



Andrew Prosser, Registered Landscape Architect

Andrew is a registered Landscape Architect and Horticulturist. Since 1990 he has worked in north Queensland, understanding Main Street Programs, tourism advice and project management. Her background is in innovation, architecture, sustainability, urban design, planning and safe design. She has a passion for design as a means to respond to our urban environment through tropical urbanism, climate responsive built form and smart cities techniques.



Sophie Barrett, Strategy and Sustainability Advisor, Cairns Regional Council

Sophie is currently a Strategy and Sustainability Advisor at Cairns Regional Council, providing high level strategic advice and project management. Her background is in innovation, architecture, sustainability, urban design, planning and safe design. She has a passion for design as a means to respond to our urban environment through tropical urbanism, climate responsive built form and smart cities techniques.



Rosalie Fagant Kayes, Masters Student, James Cook University

Rosalie is currently undertaking a Master of Planning and Urban Design at James Cook University. Her background in Environmental Science has given rise to her interest in studying the interface between people and the environment, in particular, the ways in which thoughtful planning and design can improve quality of life.

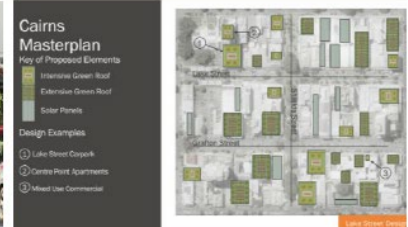


The Design Studio

Lachlan Pether, Joanna Pendergast & Kevin Woodard
 Jake Fisher, Noah Davidson & Cameron Duggan
 Parker Banks, Ashaya Rajuvaran & Millie Knight
 Vania Leo, Dana Prasad, Rosalie Fagant Kayes & Rebecca Jennings
 Mateo Mack, Danni Mack & Chari Beaman-Giles



'Hop-over' landscape design provides passing over opportunities for animals using a continuum of treetops to aid animals in crossing roadways. They can create increase both human and wildlife livability, enhance natural shade and help in reducing urban heat island.



Grafton Greenbelt
 Grafton Green has been identified as a 'cooling hub', particularly for local visitors to the CBD including extensive cafes and the iconic Rusty's fresh food market. There is a notable lack of greenery and shading, with grey, impermeable surfaces dominating. The plan proposes to construct shade structures over the existing on-street parking. Precedence can be taken from Darwin's Greening Street and Murray Martin parklands.

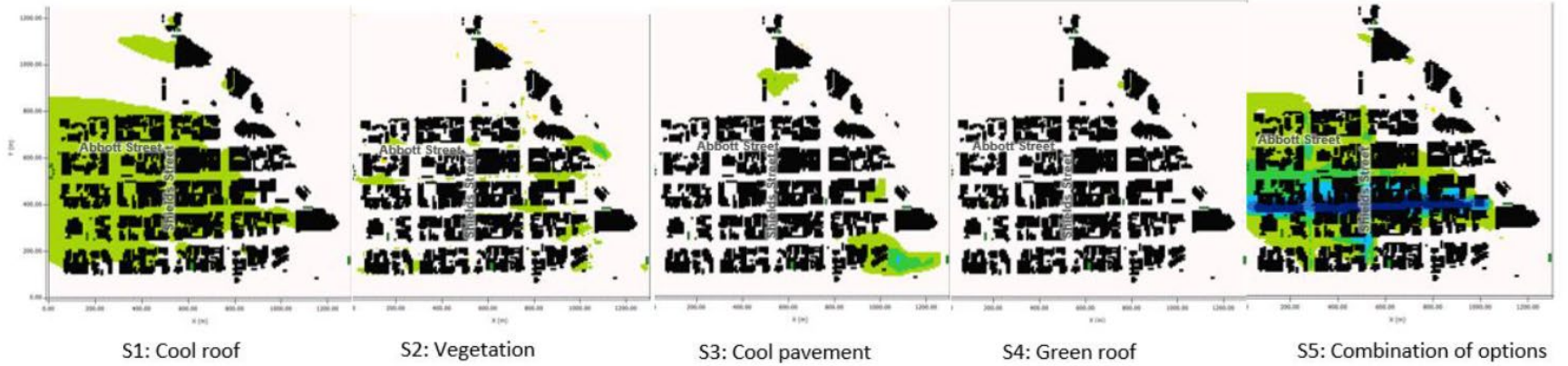


Figure 7.12 Difference of air temperature between present-day condition and different heat mitigation simulations. Green and blue shaded areas have shown improvement in air temperature.



Take homes

- Tropical design for heat mitigation needs place-based understanding
- It is difficult to accurately measure the UHI and microclimates
- Evidence-based urban planning helps mitigate urban heat and justifies infrastructure spends