Governing Climate-Smart Cities in India

Never Stand Still | Built Environment

GRIHA Summit

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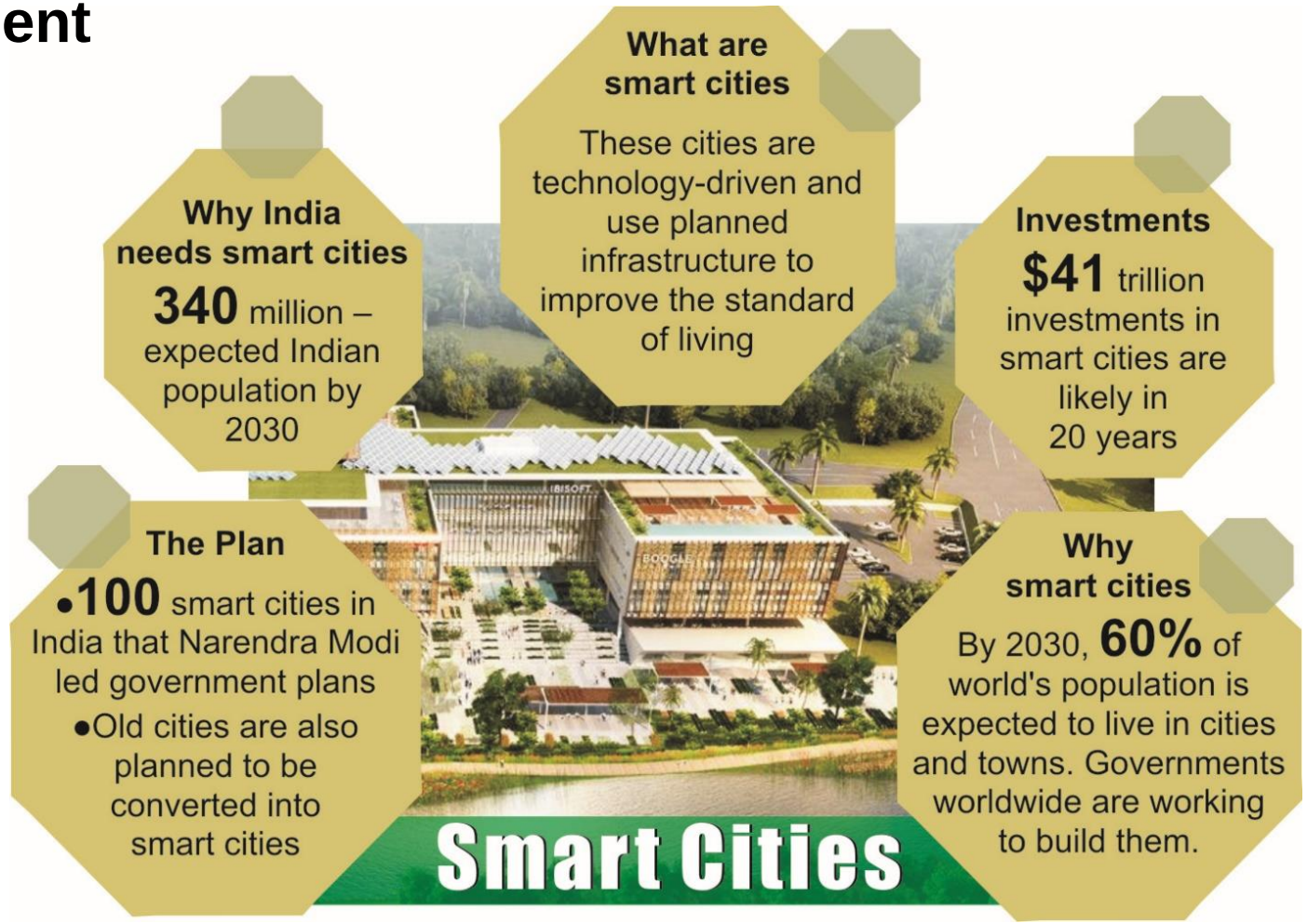
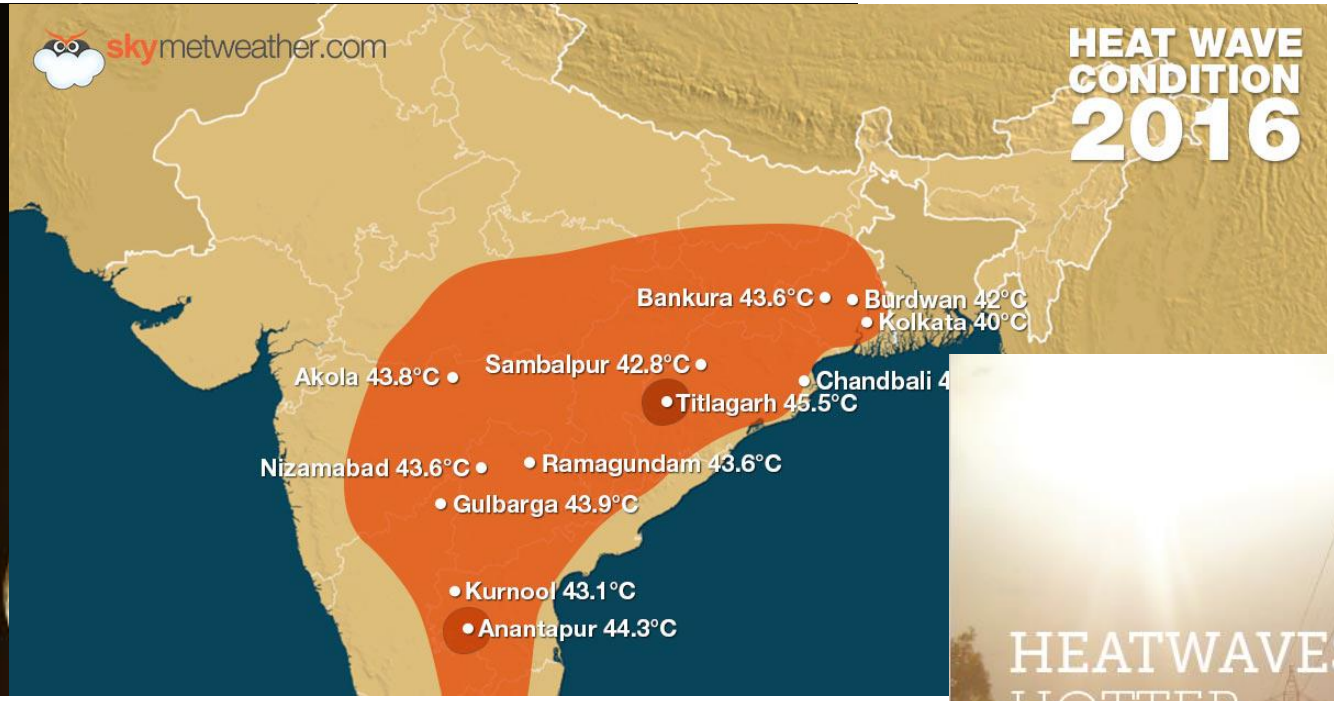
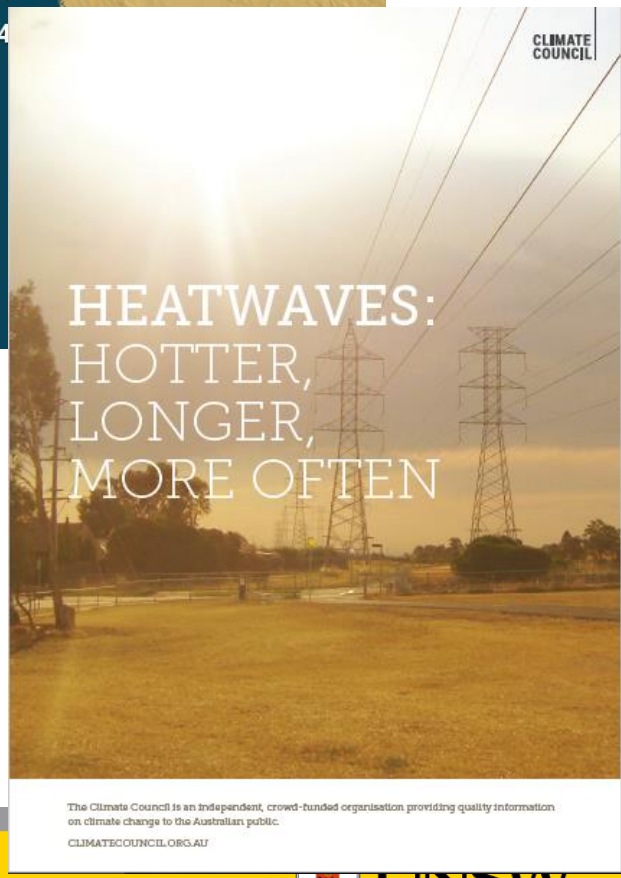
The ‘Smart Cities Mission’ is considered to **make the country’s cities more liveable, sustainable, and resilient**



Heat in India



- Increased air temperatures
- Increased heatwaves
- Increased heat spells



zerohedge.com

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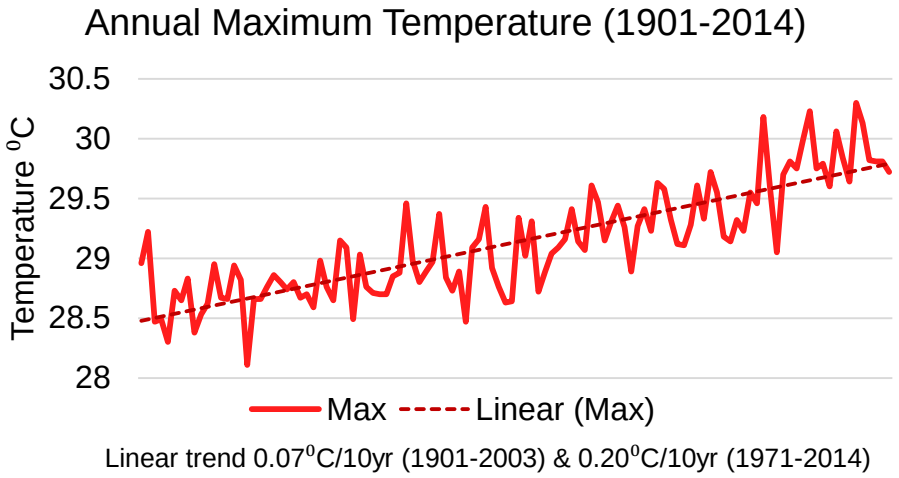
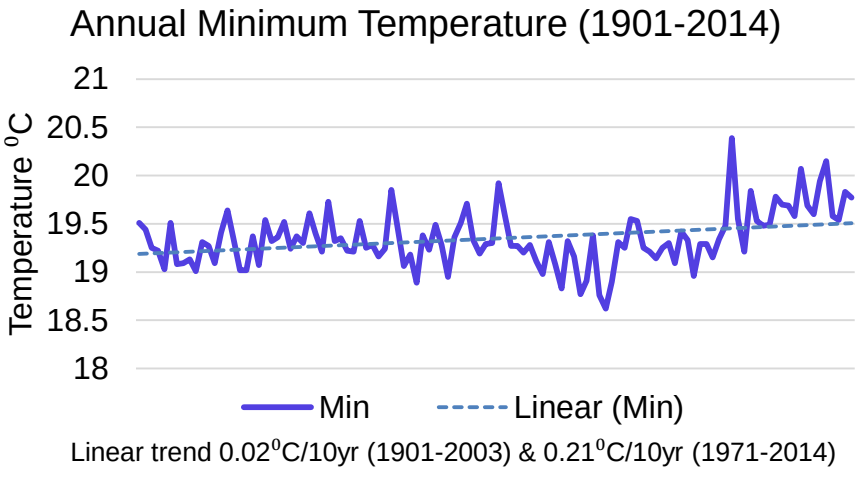
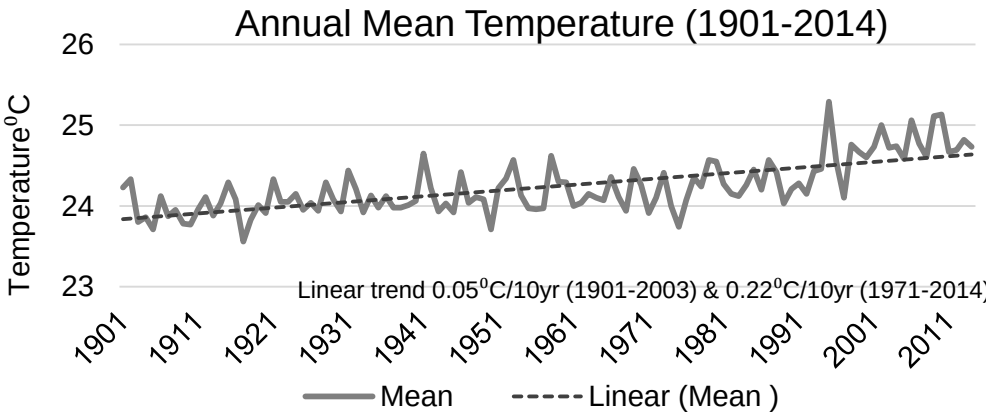
Extreme Temperatures in India





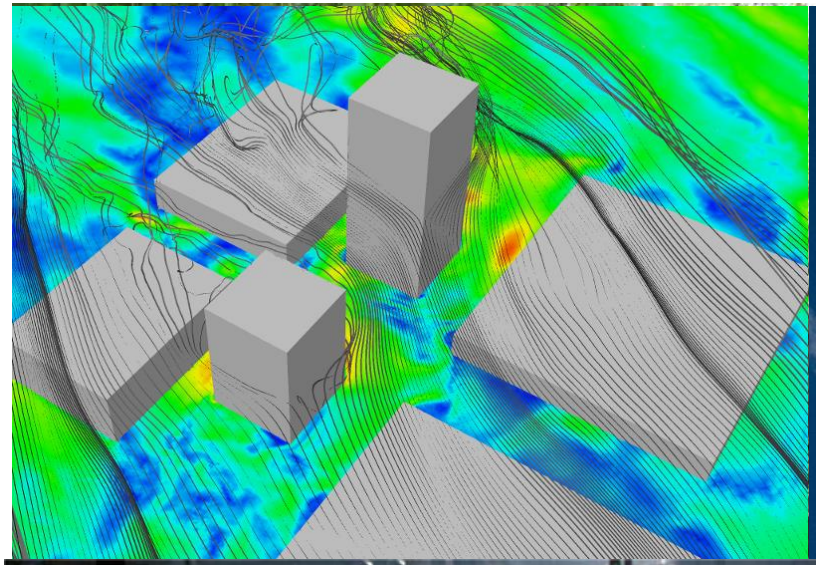


- Annual day time temperatures increased 0.4°C; Annual night time temperatures increased 1.2°C
- Very warm months that occurred 2% of the time between 1951 to 1980 occurred nearly 7% of the time during 1981 to 2010, and over 10% of the time over the past 15 years
- **Projections** - 0.6 to 1.5°C by 2030, 1.4°C to 3.0°C by 2050 and 2.9°C to 4.3°C by end of the present century from the 1961-90 baseline

Yenneti, 2017

Factors for urban climate change

Obstruction of Wind Flow

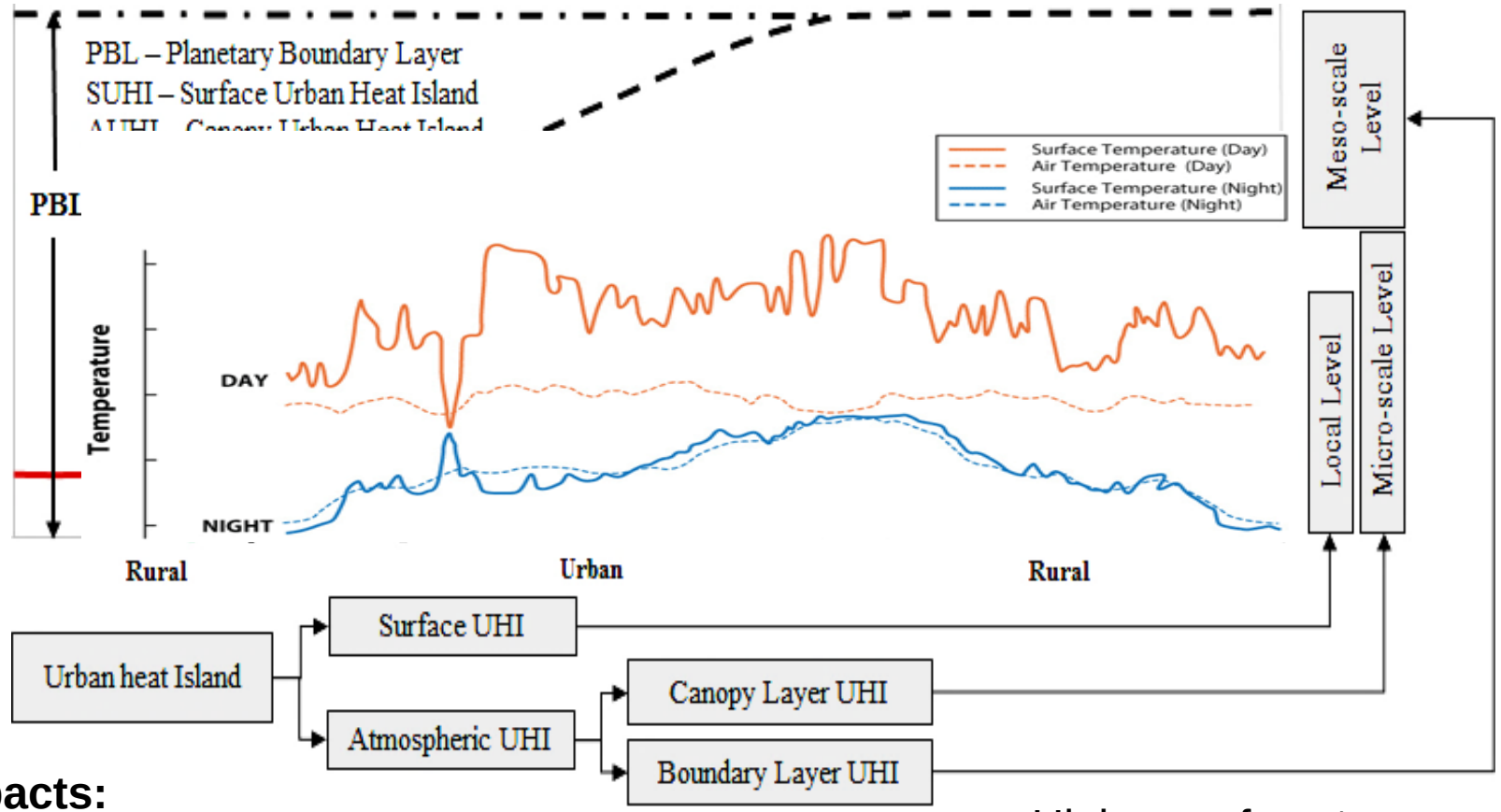


New Materials

Emission of Pollutants

Increase of Anthropogenic Heat

Urban Heat Island (UHI) effect

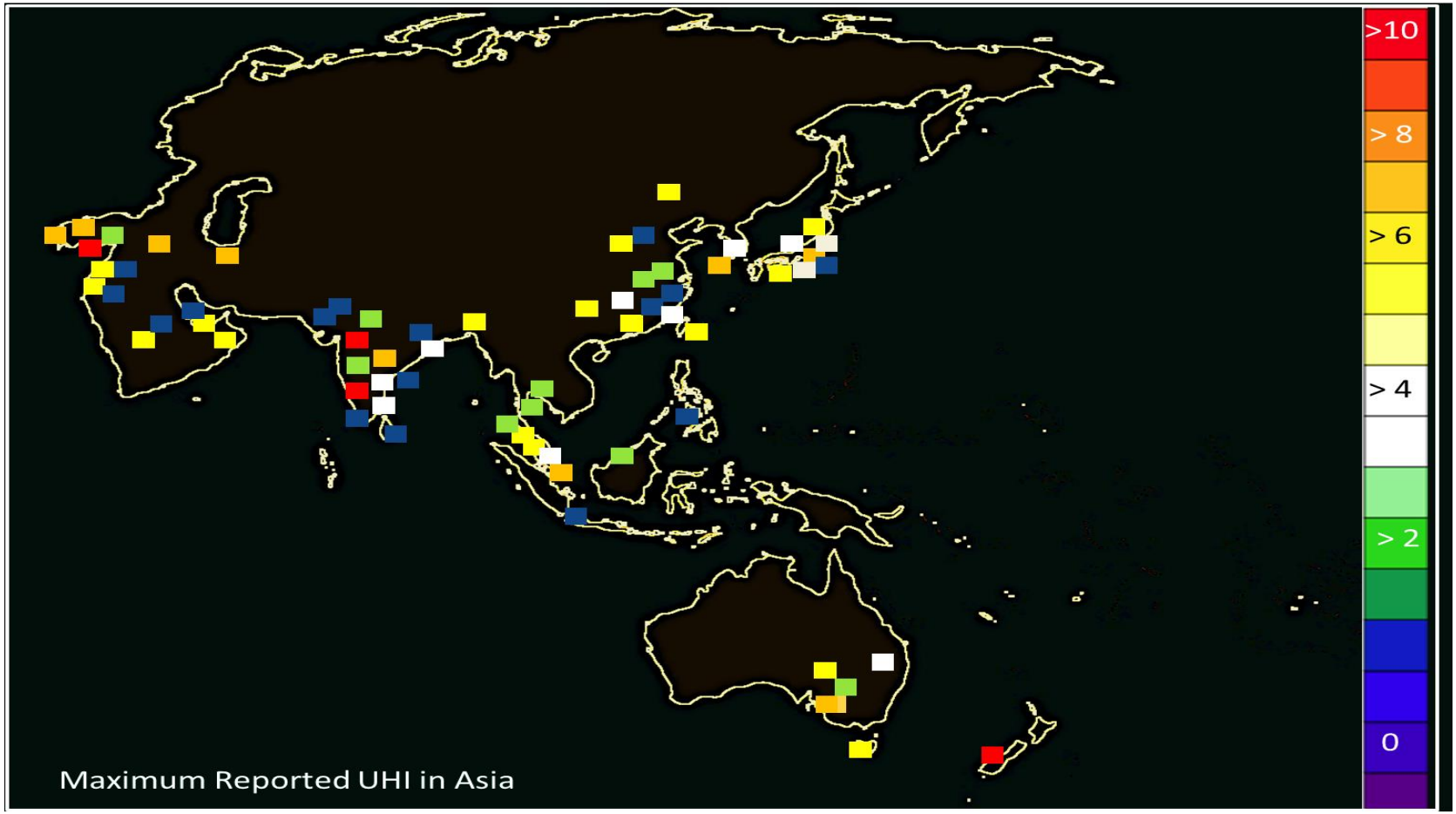


Impacts:

- considerable increase in cooling energy consumption
- decreased air and water quality
- impact on existing eco-systems
- serious threat for human health

- Higher surface temperatures in urban areas – surface
- Warmer air in urban areas – atmospheric

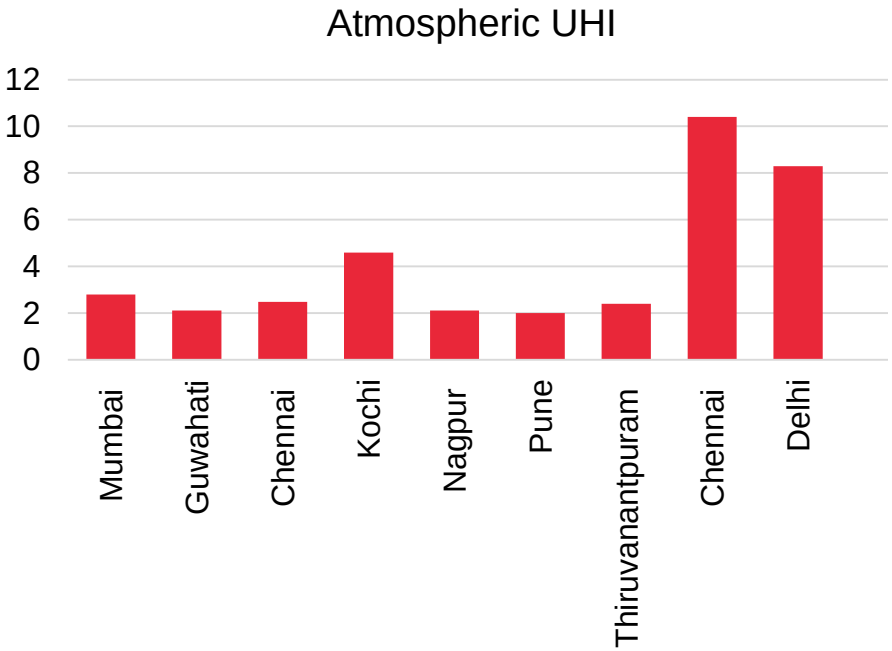
Magnitude of UHI in the Asia Pacific

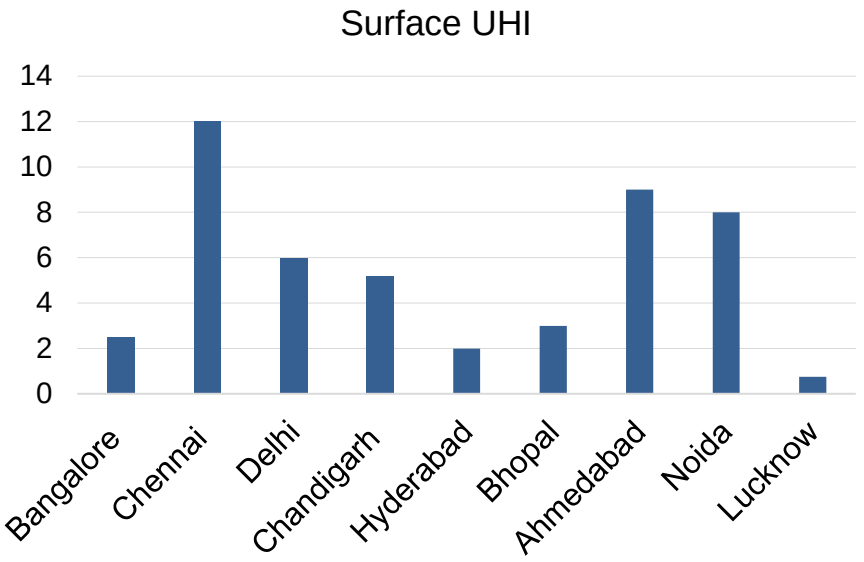


Coastal cities benefit from sea breezes, but a strong UHI can delay and even block the flow of the sea breeze into parts of the city.

Santamouris, 2015

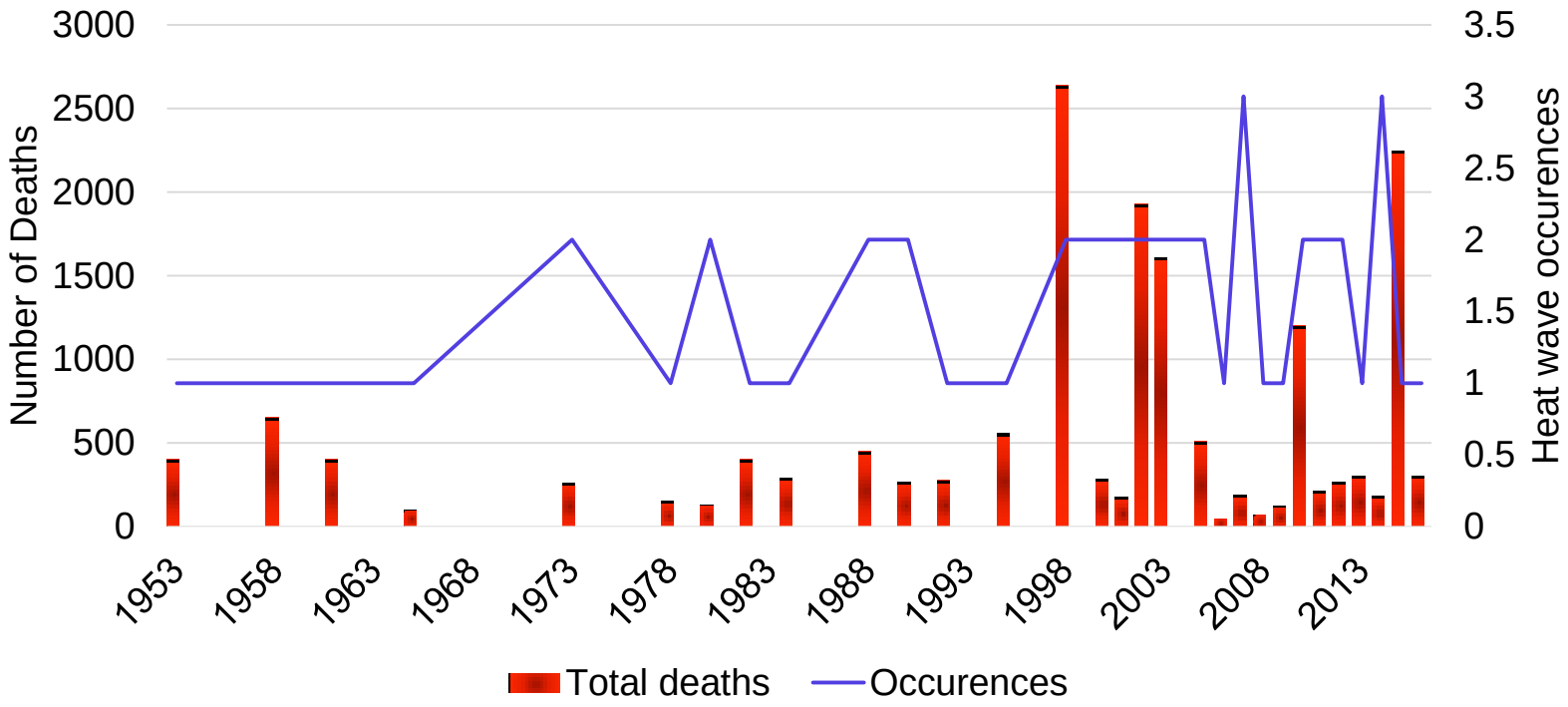
Magnitude of UHI in India





- Standard measuring equipment - between 2.0 - 10.4 ; mobile traverses - between 2.12 K - 2.9 K.
- Non-standard measuring methods (micrometeorological stations and satellite thermal imageries) - between 0.75 K - 12 K.
- Standard measuring stations - the average intensity is 2.4 K
- Non-standard measuring stations and satellite imagery - the average intensity values are 4.17 K and 4.65 K respectively.
- **Surface UHI manifests significantly higher values than that of atmospheric UHI.**

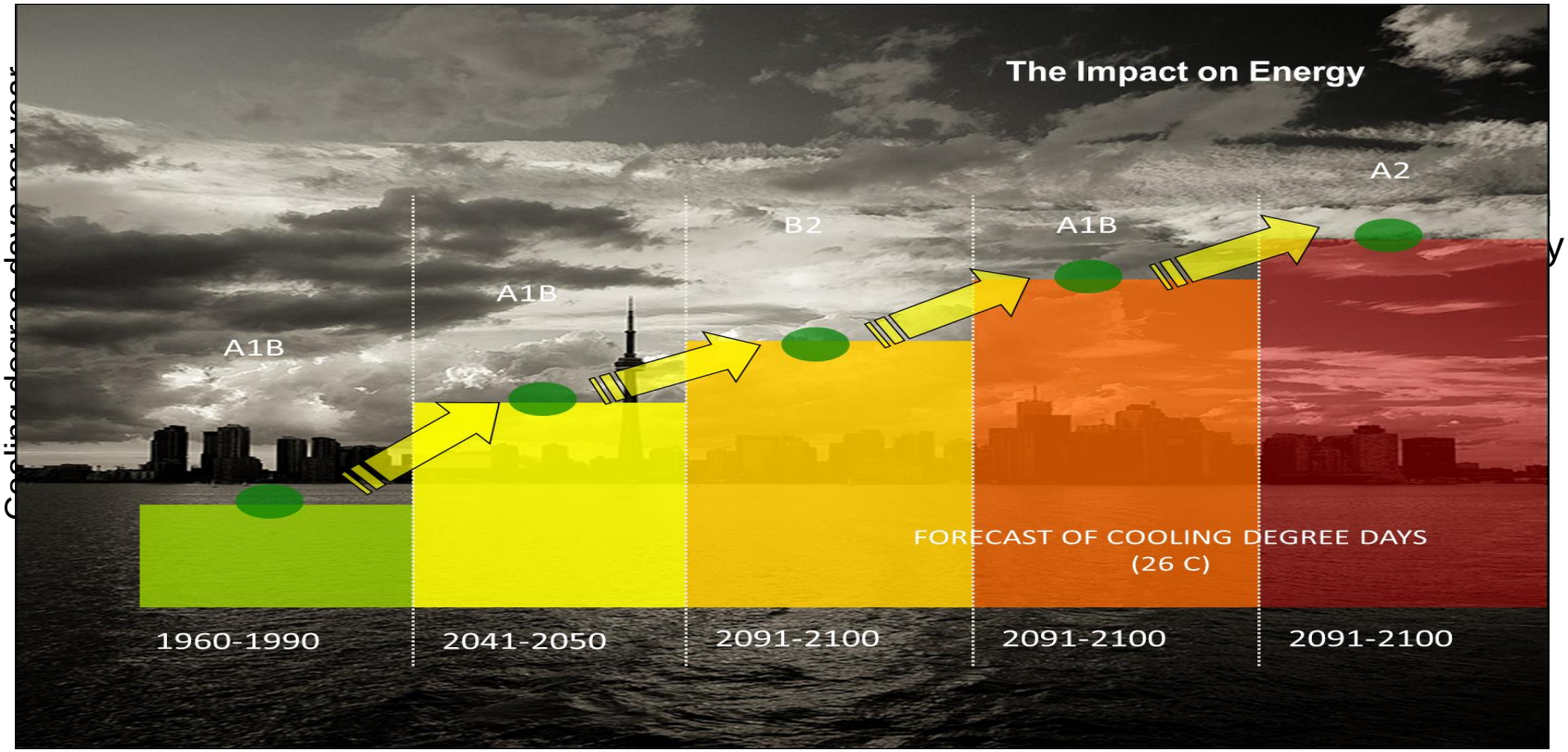
Urban Heat and Impacts on Human Life



- high temperatures and extreme heat events cause serious risk to public health
- average annual loss of human life due to heat wave in India is 153.
- an increasing trend of heat-waves and temperature-related mortality in India over the past two decades
- heat related mortality increases by at least 10 per cent at temperatures of 40°C and above

Yenneti, 2017

Urban Heat and Impact on Energy



- Energy consumption for air conditioning under baseline scenario (without efficiency programs) will be 195 TWh in 2020, 552 TWh in 2030 and ~750 TWh to ~1350 TWh in 2100
- Peak demand increase has serious economic implications for the energy supplier (need to upgrade or build additional infrastructure to expand the network capacity)

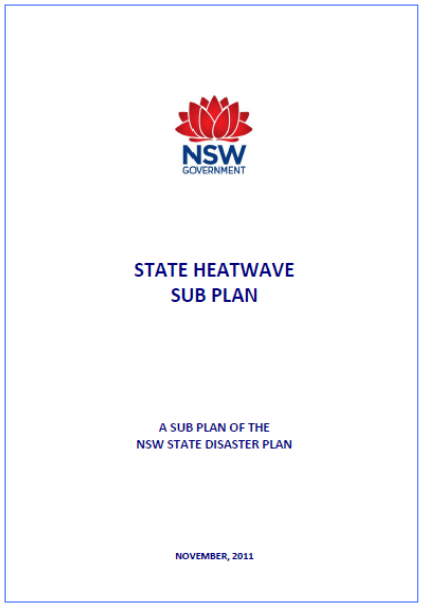
How to Govern urban climate change?

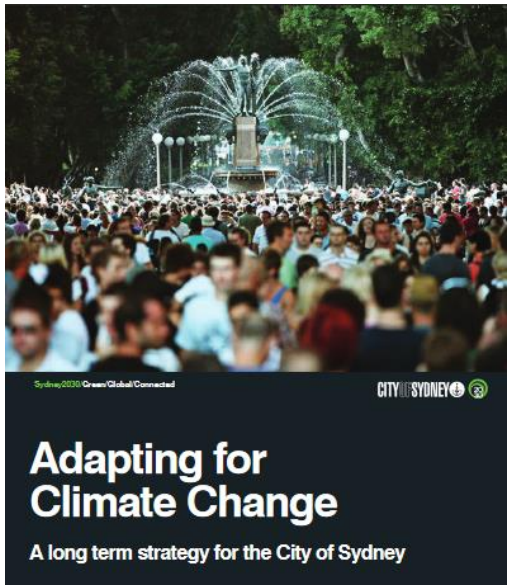
A combination of monitoring, mitigation, adaptation and decision-making

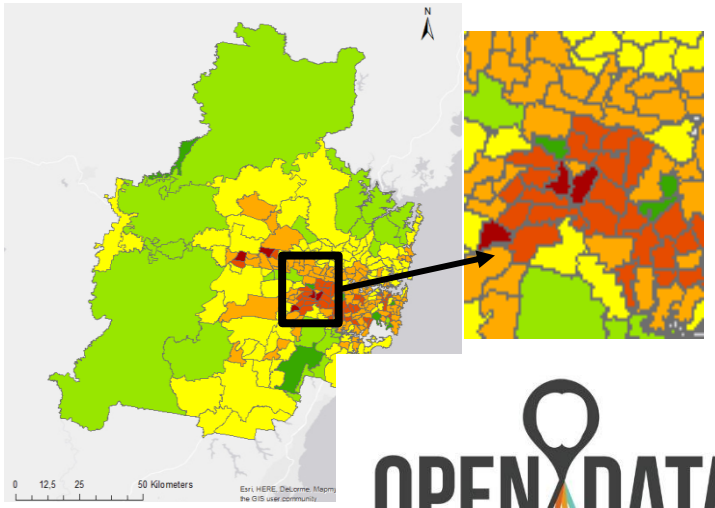
STEP 1 – Vulnerability Assessment

- Largely used for vulnerability to environmental disaster (floods, extreme weather events) because it allows:
  - ❖ A comparative tools to assess different areas
  - ❖ A comprehensive visual, geographic presentation of results.
- Vulnerability to extreme heat has been assessed both at regional and urban-scales (Bai et al. 2016, Reid and Schwartz 2009, Yenneti et al. 2017, Johnson 2012, Loughnan 2013)

From event-based action plans…to place-based ones

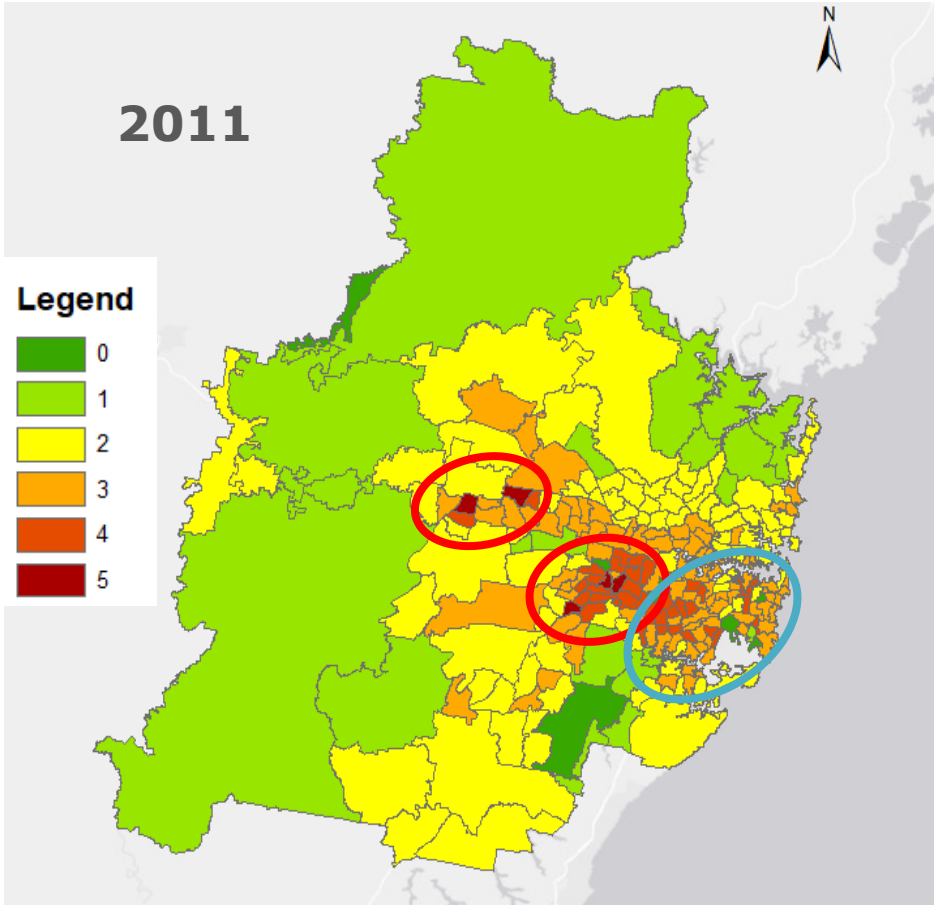


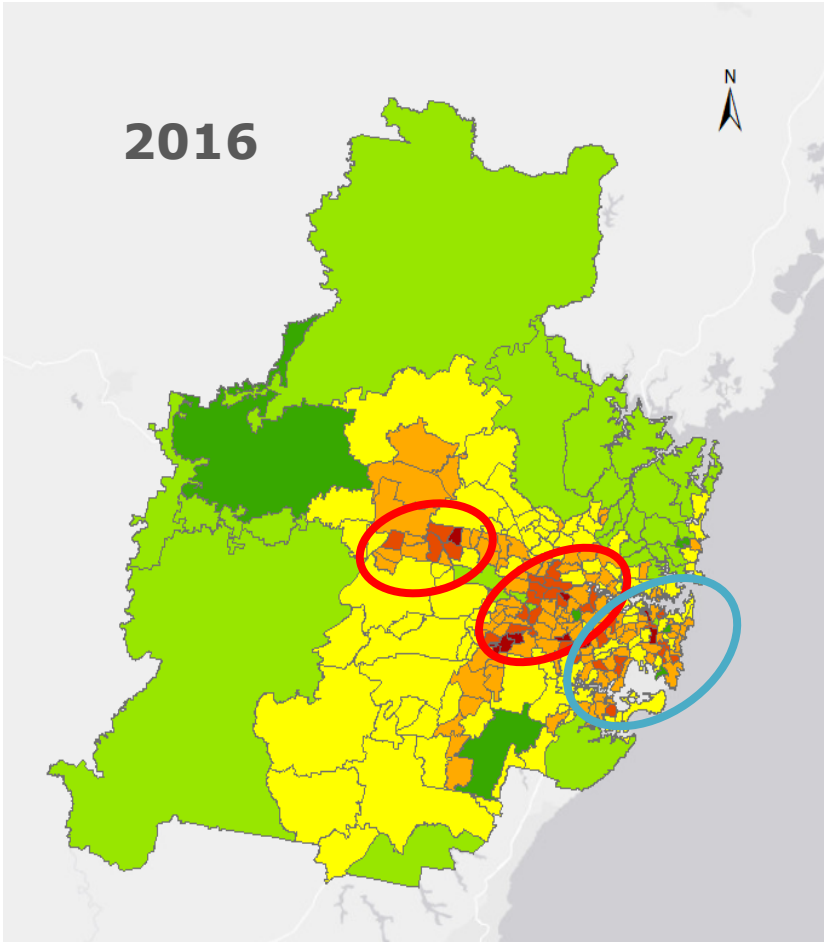




OPEN DATA

STEP 1 – Vulnerability Assessment





https://www.arcgis.com/apps/MapSeries/index.html?appid=dd7e39a138fd4449abe758914c6da801

Yenneti et al 2017

STEP 2 - Urban Heat Mitigation

Urban water based landscape

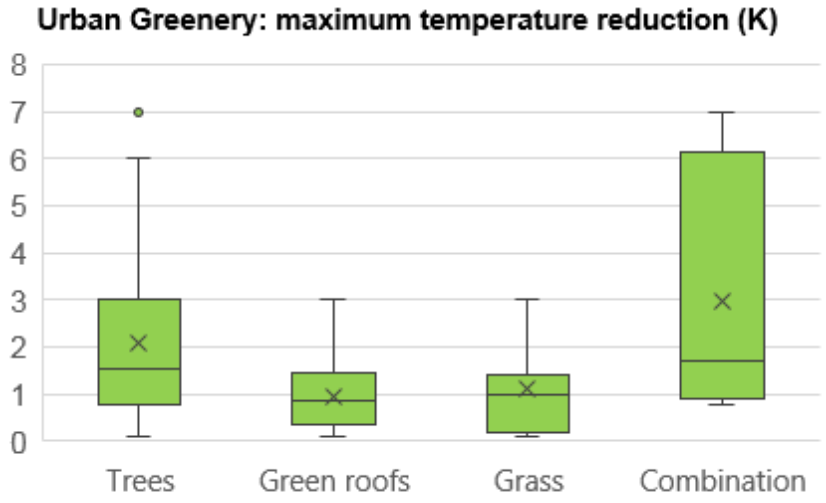
Green infrastructure

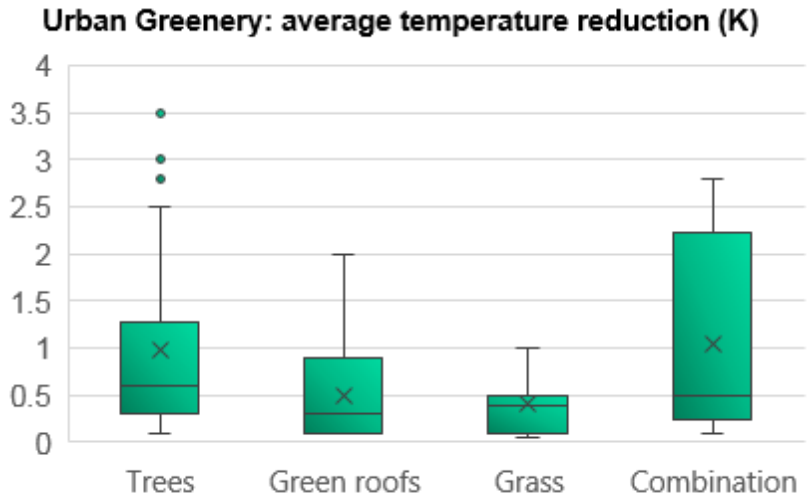
Cool roofs (reflective roof + solar roof)

Building shading features

- the increased use of **green areas**;
- the use of **appropriate materials**, in particular of white and colored high reflective coatings;
- decrease of anthropogenic heat; and use of **cool sinks** for heat dissipation;
- appropriate layout of urban canopies involving the use of solar control, techniques to enhance air flow, etc.;

Green Infrastructure

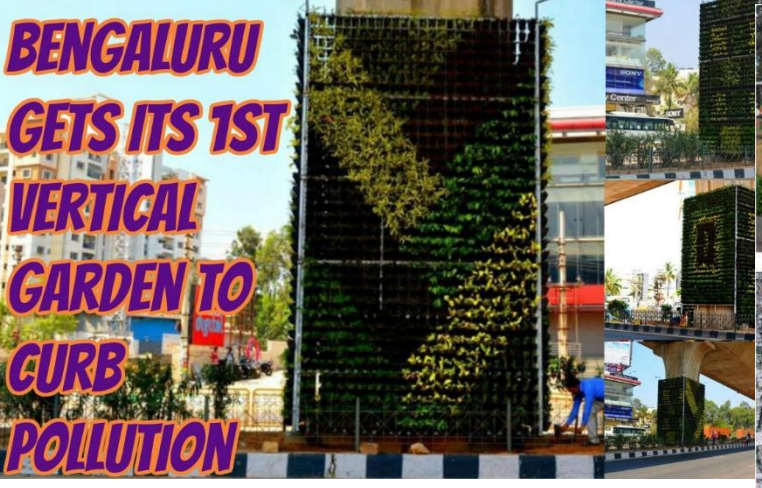




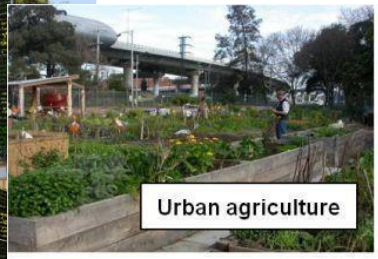
Range of the average and maximum temperature reduction of the urban greenery techniques

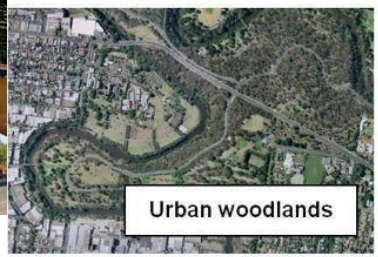
- Urban vegetation, in particular, trees have high mitigation potential.
- Trees and hedges result in **peak temperature reduction close to 2-2.5 ^{0}C**
- The combined use of greenery, green roofs, and green walls is found to lower the average and peak temperature by between 0.6-2.4^{0}C and 0.5-3^{0}C respectively.

Yenneti et al 2017



Urban green infrastructure





Udaipur railway station gets a 'living wall'

Geetha Sunil Pillai | TNN

PLEASANT AND ECO-FRIENDLY: Green wall at Udaipur railway station which not only adds to the aesthetic value of the place, but also shields the building from sunrays, rain and thermal fluctuations

Udaipur: After Sawai Madhopur, the railway station at Udaipur is set to get a facelift. It is the only railway station in the country to have a living or green wall in its premises.

Living walls are self sufficient vertical gardens that are attached to the exterior or interior of a building. The project initiated by the Railway and UIT has covered and converted a barren wall of 1,400 square feet into a beautiful green space. The green wall has not only increased the ambience and aesthetic value of the place, but also would shield the building from sun, rain and thermal fluctuations, experts claim.

It took just 14 days to complete the project. "We had done a green wall of 900 square feet for International Center for Environmental Audit and Sustainable Development in Jaipur. We were approached by the UIT and then Udaipur collector Rohit Gupta visited our green walls in Jaipur. Due diligence was done by the UIT officials after detailed discussions with our team and finally the purchase order was released by Hindustan Zinc," said Ayush Bisht of Living Greens Organics and in-charge of the project.

Metal sheet frames (MS) were installed and then the plants were put in specially designed GI panels (Galvanized iron) and hung on MS frame. Instead of soil, organic fertilizers have been used to grow plants to avoid overweight on the wall. " We have used hardy and some seasonal flowering plants for the green wall. Semi automatic drip irrigation system have been installed for the panel to avoid wastage of water and so that plants get water automatically, one just need to open the tap" Bisht said.

The project has cost approximately Rs 13.5 lakh and the result is soothing. "The feedback we are receiving is encouraging. People coming here are pleased to see the vertical sprawling greenery instead of the usual dull and grey walls which also works as a stress reliever," said S K Verma, the station master.

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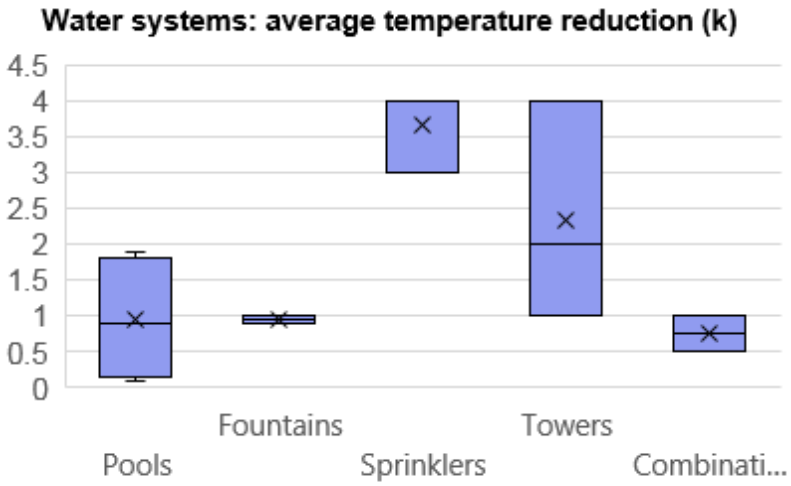
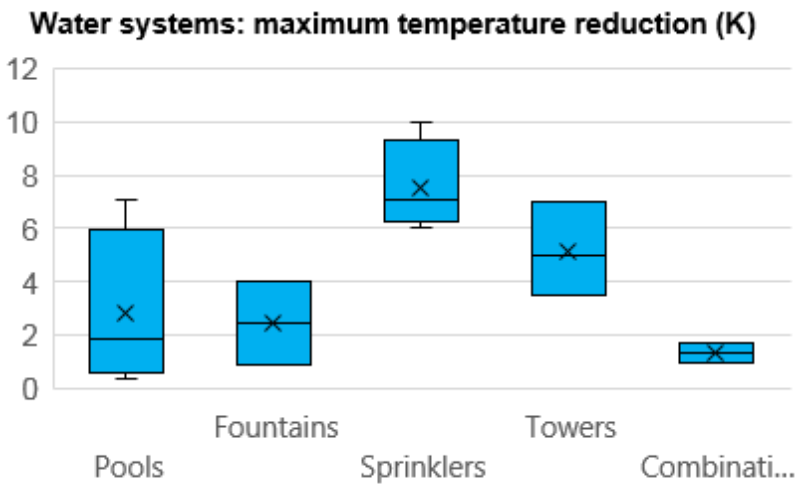
Blue Infrastructure

Evaporation of water utilised in hot and arid regions can achieve a drop of about 10^0C below ambient temperature in still air

Water-based urban landscape can contribute to ‘urban cooling islands’ and may decrease **city’s ambient temperature by 3-8^{0}C (humidity<50%), 1-2^{0}C (humidity>50%)**

Green - Blue Infrastructure





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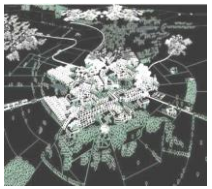
Interconnected Green Networks

Neighbourhood Scale

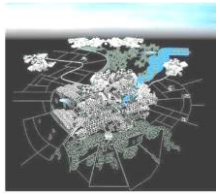
Street Trees / Home Zones → Green roofs → Pocket Parks → Gardens → Play Areas → Ponds & small woodlands → Institutional Open Spaces → Local Rights of Way → Urban Plazas

Town / City /District Scale



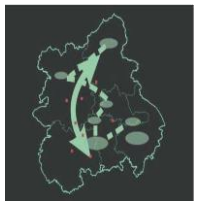
City Parks → Canals & Waterways → Green Networks → Multi-user routes → Forest Parks → Continuous waterfront → Municipal Plazas → Lakes → recreational spaces

City-regional Scale



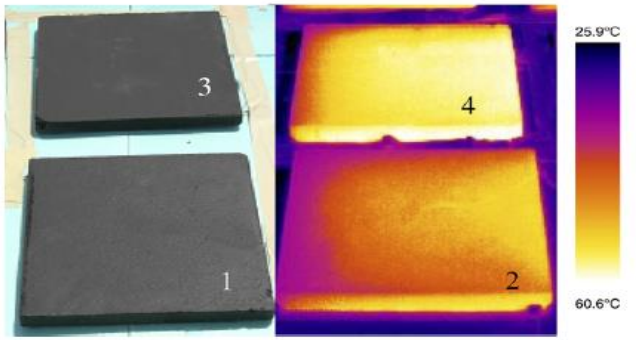
Regional Parks → Rivers/ floodplains → Shoreline & Waterfront → Long-distance Trails → Major woodlands → Community Forests → Landmarks & Vistas → Reservoirs → Strategic Corridors

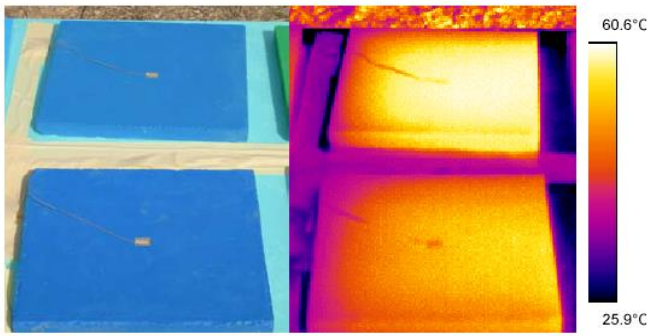
Strategic Scale

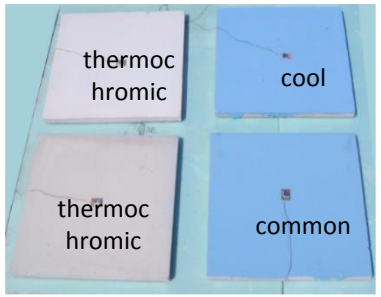


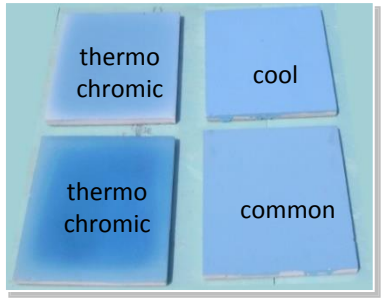
Coastline Management → Cross-boundary networks → Strategic River Catchment Plans → National trails → Strategic corridors → Sub-regional strategies → National policy statements → Behavioural & Societal Change

Cool materials

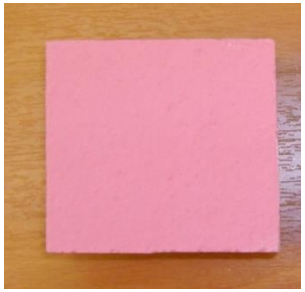




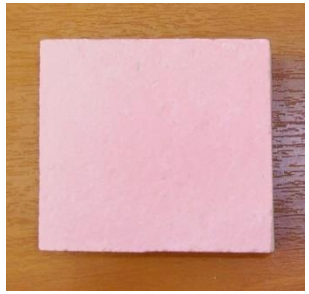




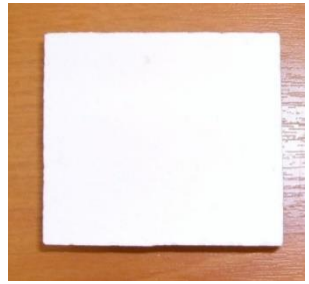
Full coloration



Intermediate phase

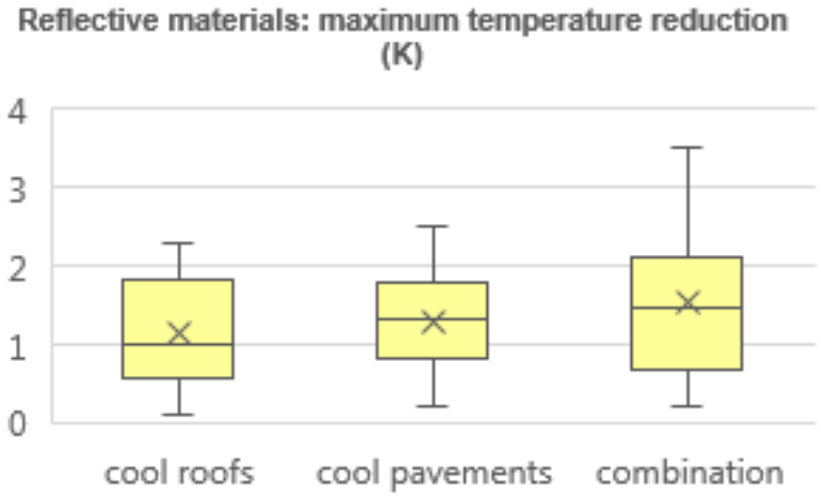


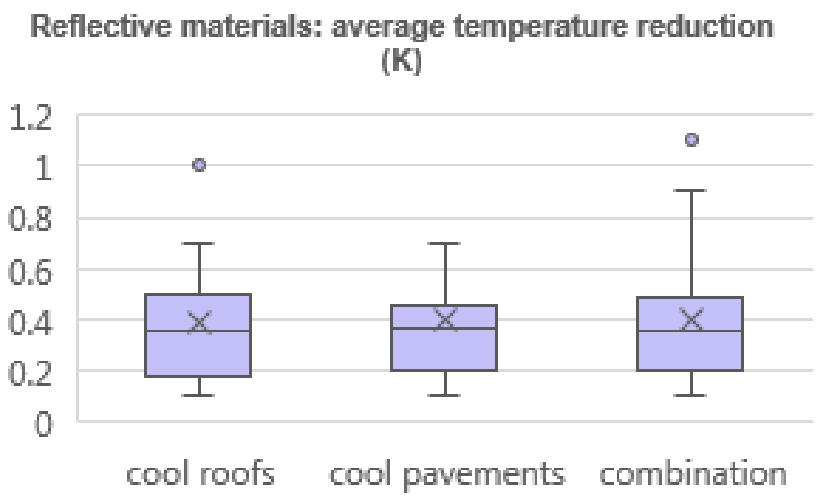
Full decoloration



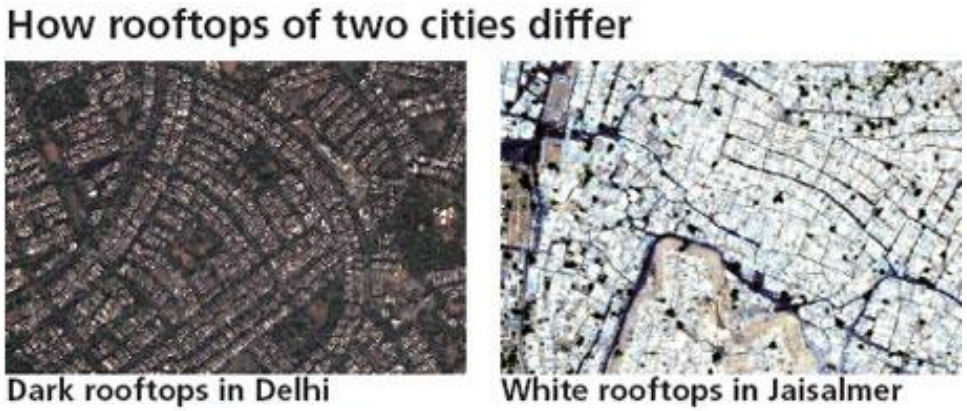
Cool materials

Use of relective materials





- Cool roofs, cool facades and cool pavements - can contribute to reduction of average and peak summer indoor temperatures up to 2 K - 5 K.
- reduce cooling-energy use in air conditioned buildings, increase comfort in unconditioned buildings



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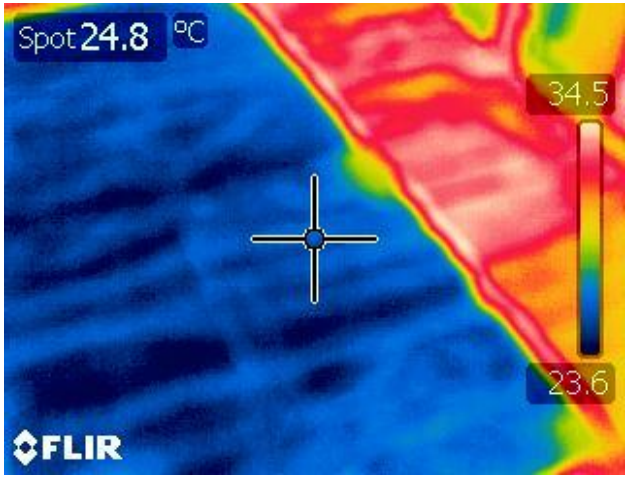
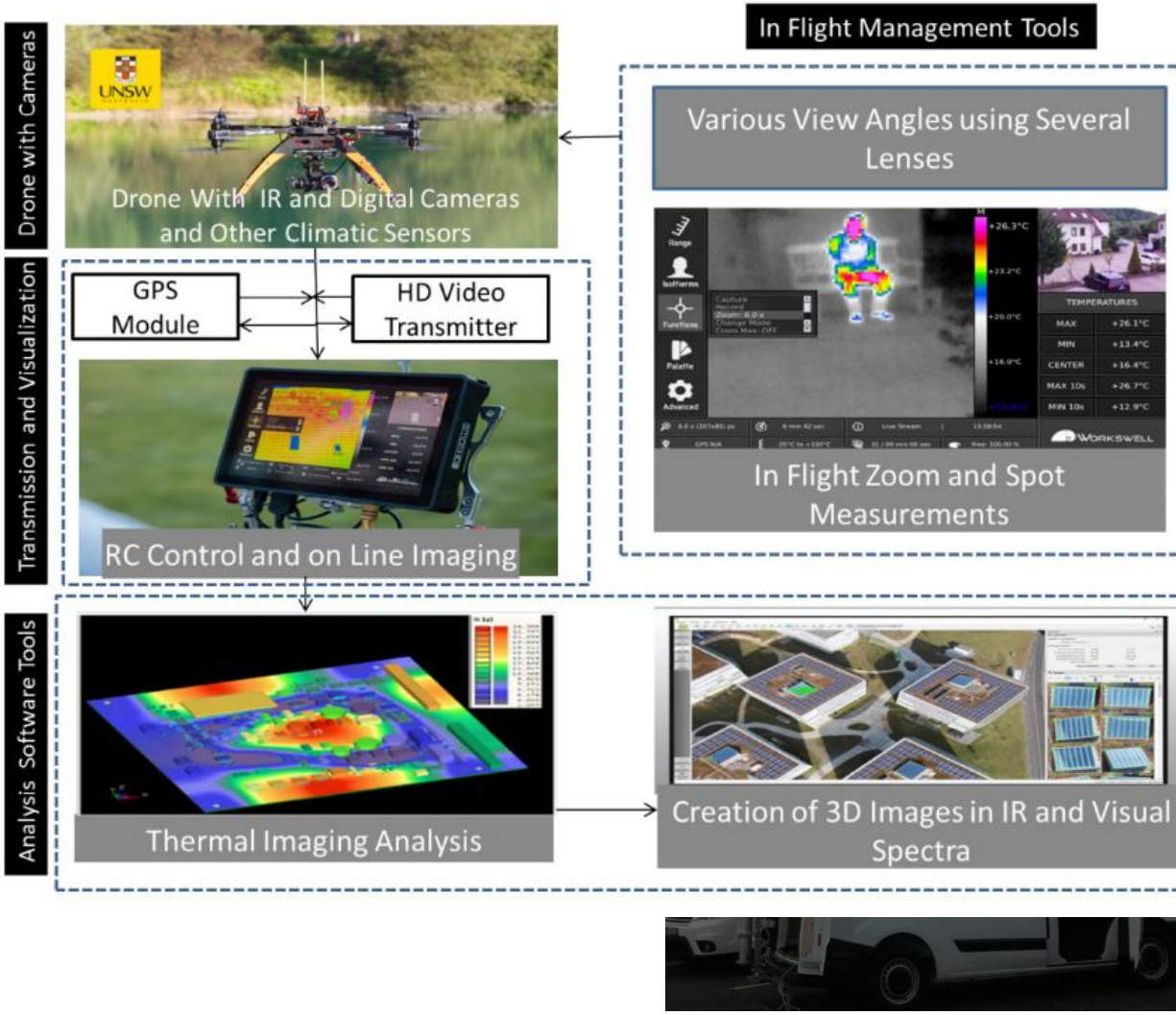
Cool Materials



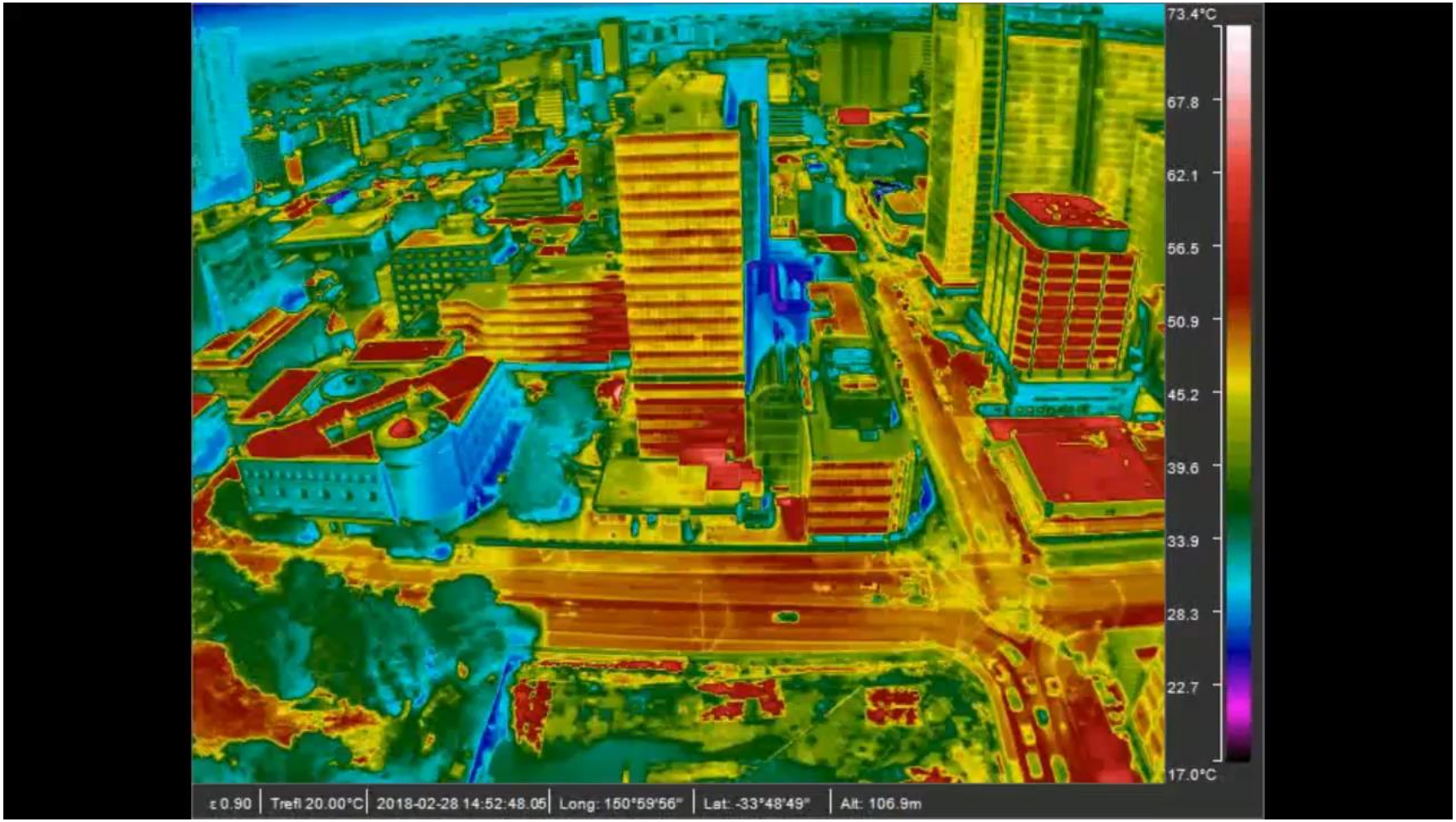
- Cool roof project implemented in a low-income community in India.
- Indoor environment in the households with cool roof installations was monitored using smart sensors to test the reduction in indoor temperatures and humidity.
- Findings indicate an **average surface temperature reduction of 10-15^{0}C and ambient temperature reduction of around 2-3^{0}C.**
- The cool roofs also have significantly reduced humidity, as they are helping to keep out rain water.

STEP 3 – Decision-making

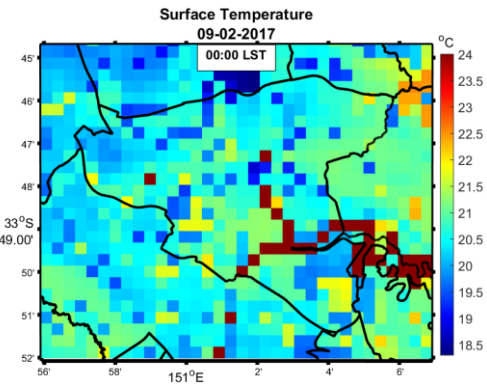
- Energy Bus
- DJI S900 Hexacopter Drone Frame
- Workswell WIRIS – thermal imaging camera for drones (thermal & digital camera)

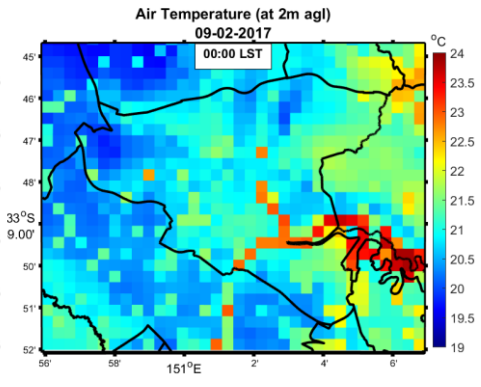


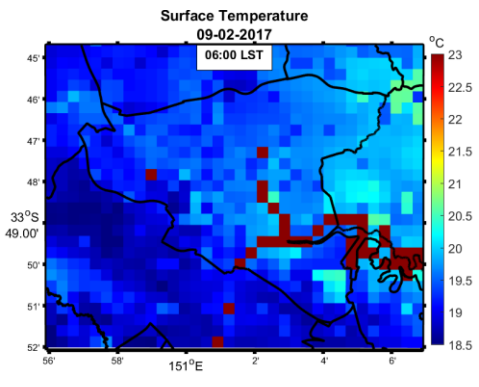
Parramatta Heat Mitigation Tool

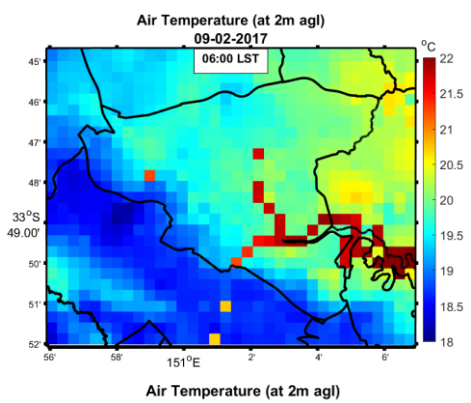


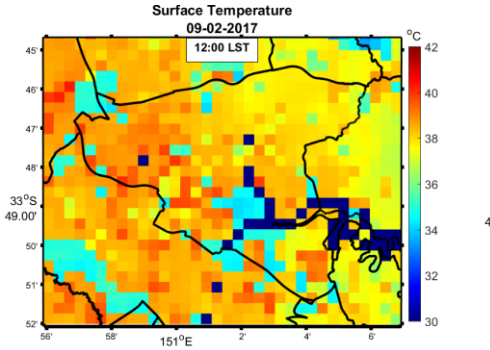
Future climate scenarios

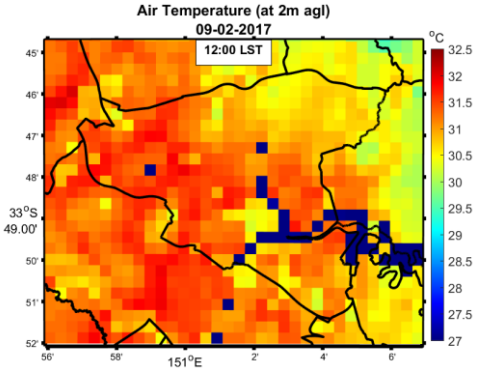


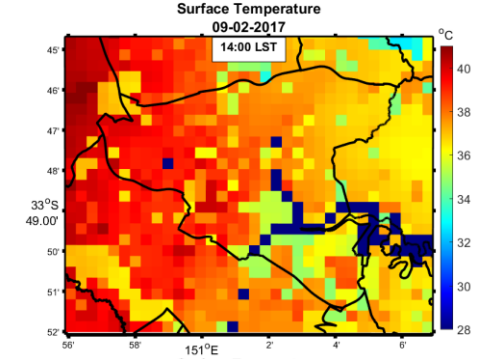


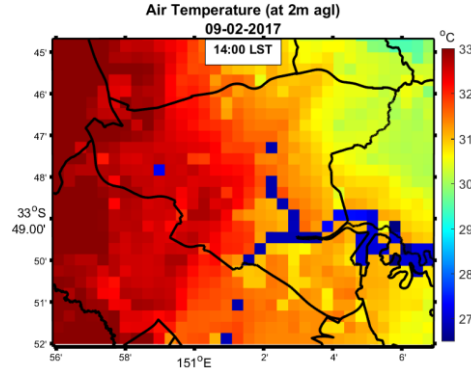


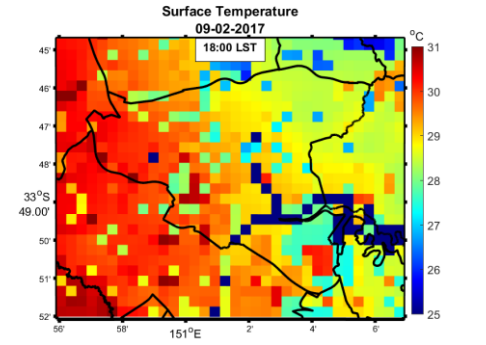


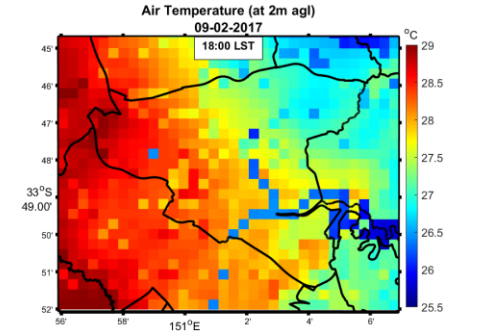


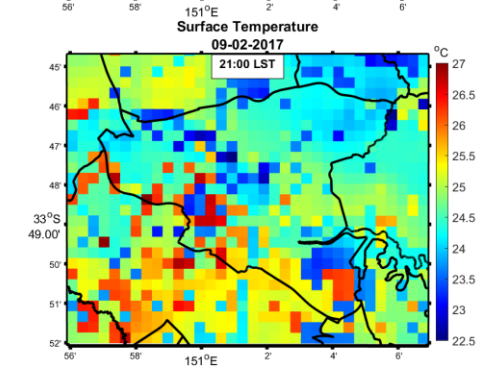


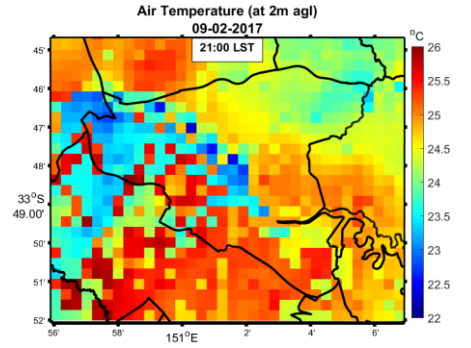












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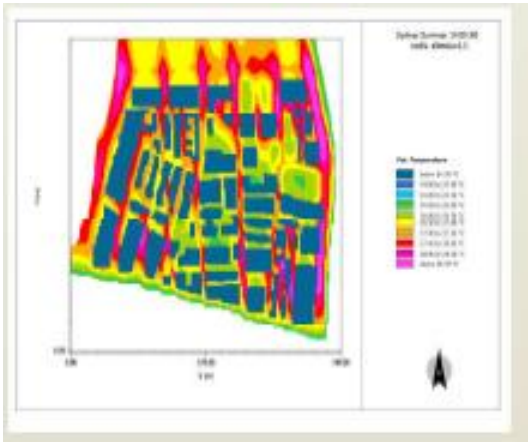
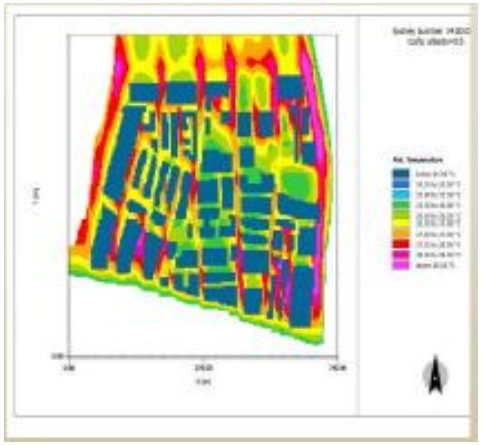
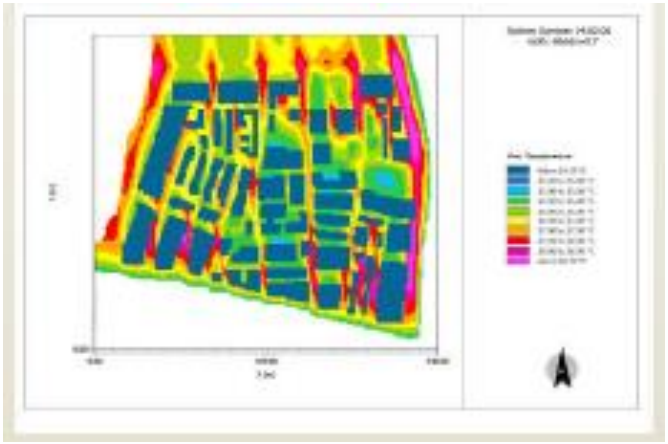
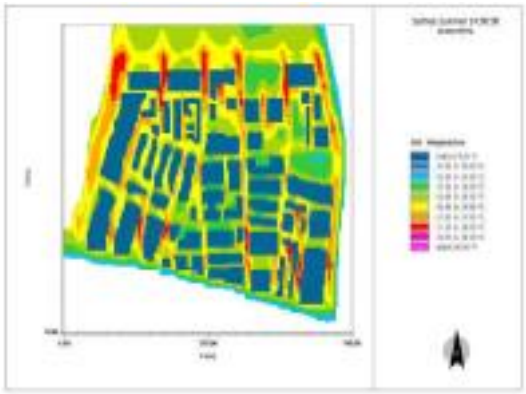
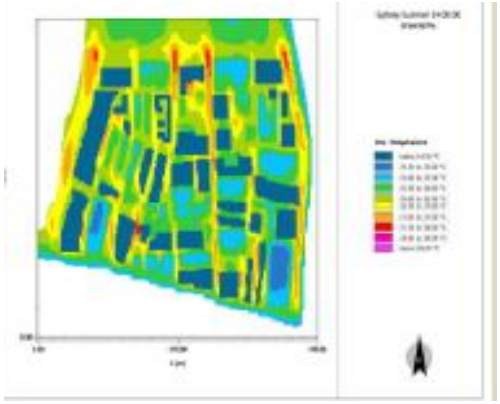
Heat Mitigation Scenarios

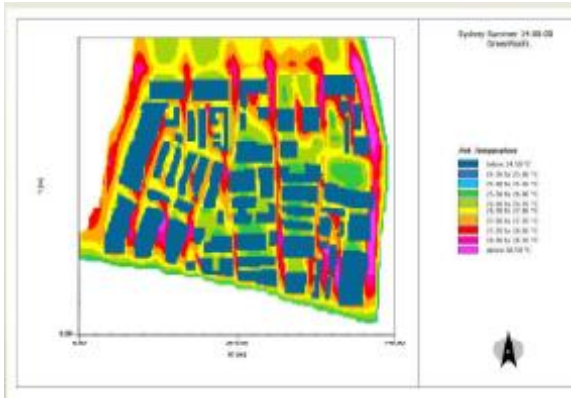






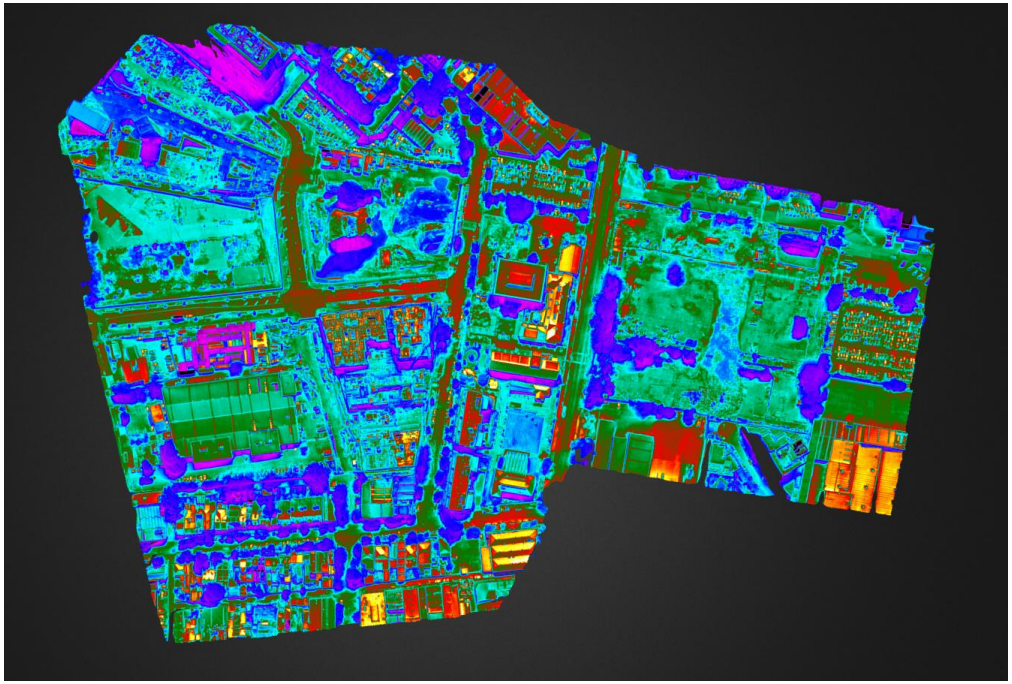






Urban Heat Island (UHI) Mitigation Decision Making Tool

Initial analysis of Urban Heat characteristics of existing ‘Green Square’ precinct



A number of hot spots, chiefly along hard surfaces such as Geddes Avenue, Joynton Avenue, and Portman Street.

Urban Heat Island (UHI) Mitigation Decision Making Tool

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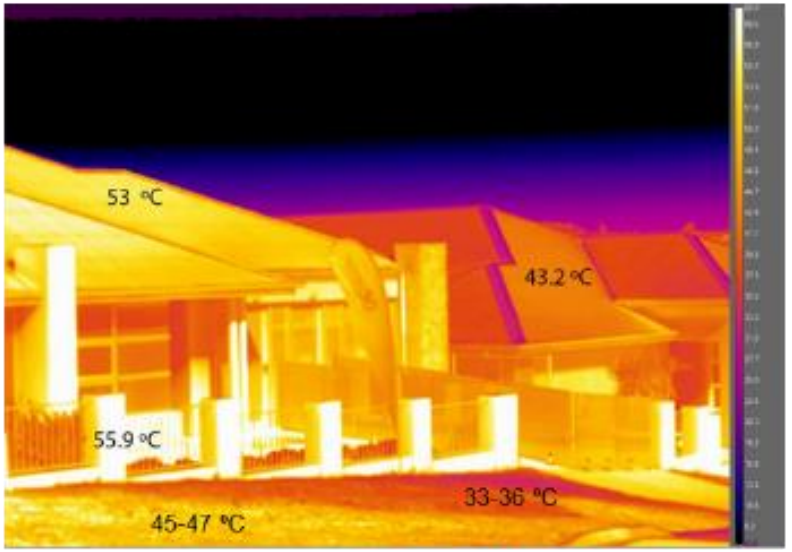
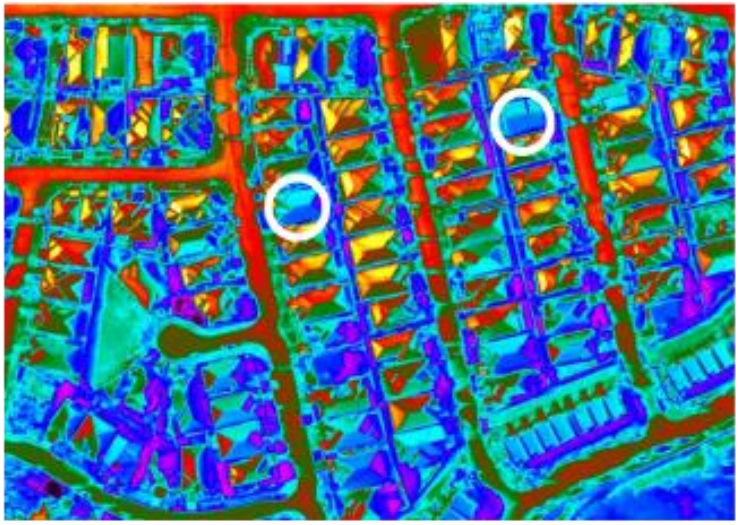
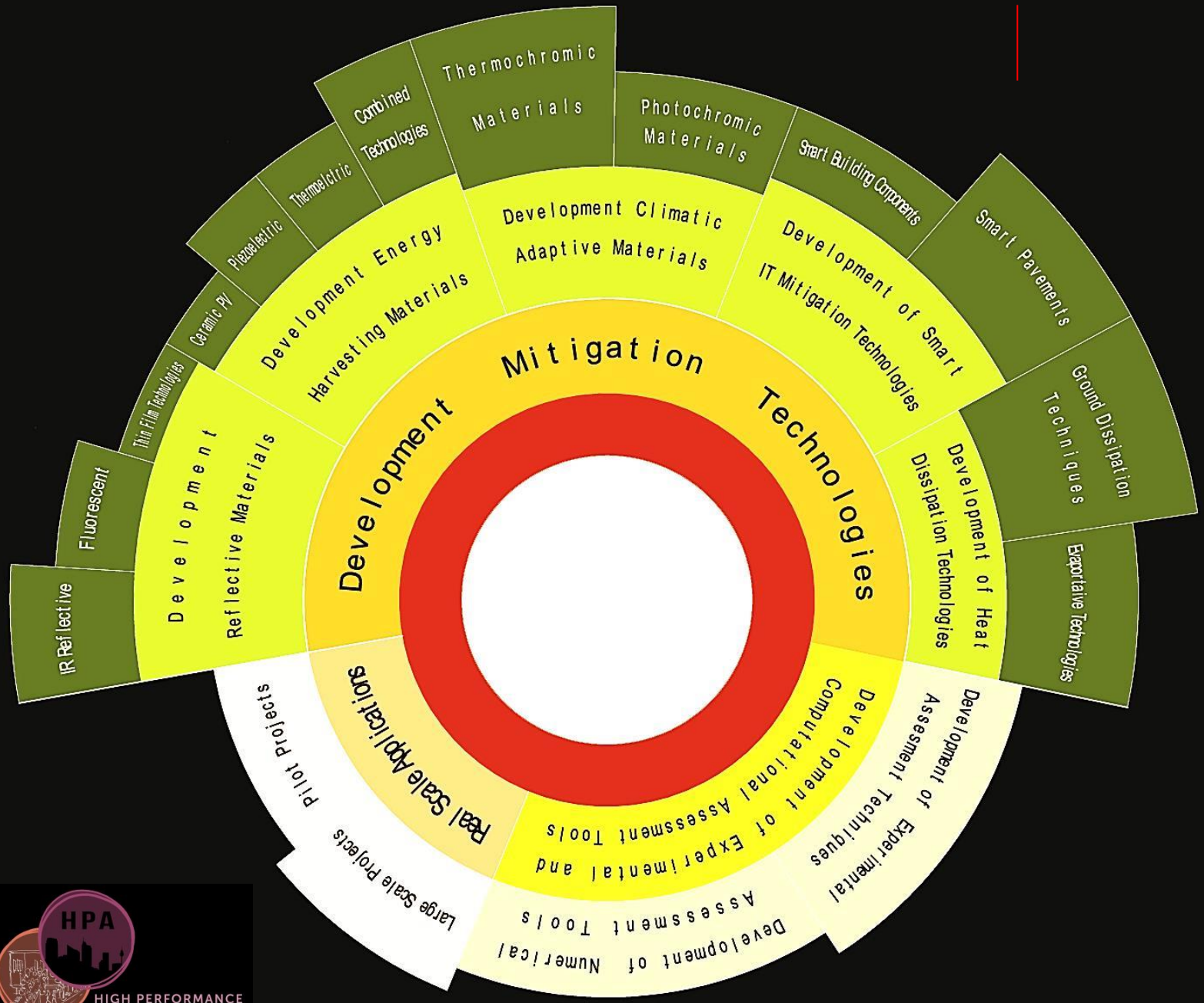




80 °C

20 °C



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THANK YOU...