# Extreme Heat In Cities

## Emerging Lessons from World Bank Engagements



**Prepared for joint World Bank TDLC - KDI workshop**

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WORLD BANK GROUP

City Resilience Program

GFDRR Global Facility for Disaster Reduction and Recovery

Administered by THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

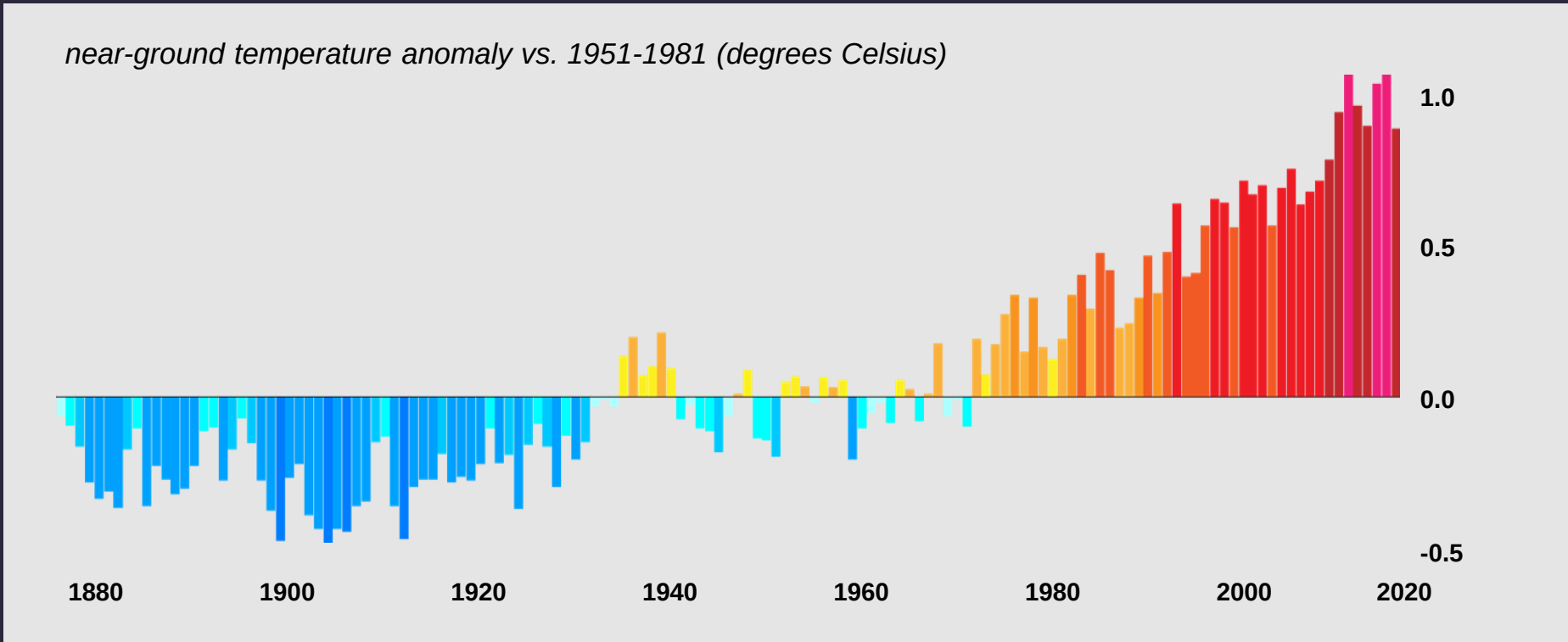
# Presentation Outline: Extreme Heat in Cities

1. **The challenge:** Why care about extreme heat in cities?
2. **Measuring heat in cities**: 200 years of innovation
3. **Emerging lessons** from Technical Assistance engagements
4. **From assessment to action:** Extreme heat actions by cities



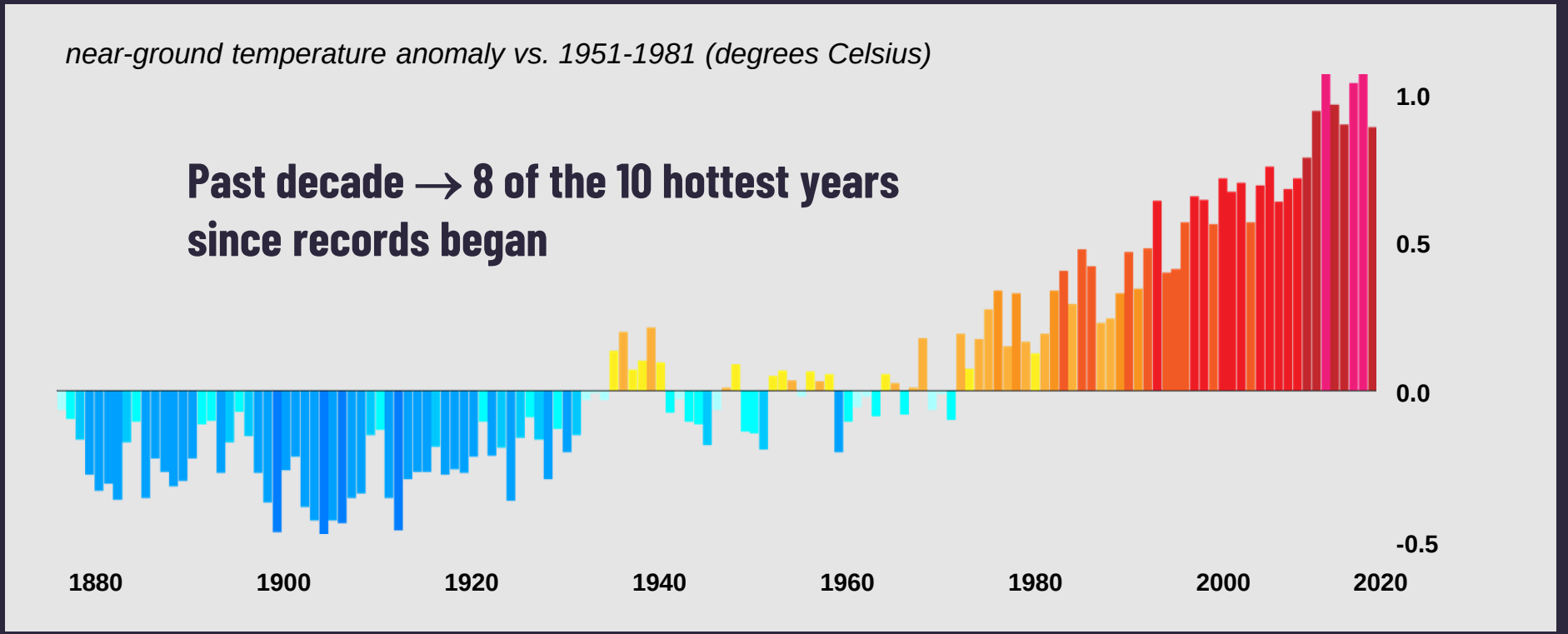
# 1. Why address extreme heat in cities?

# Global temperatures are soaring

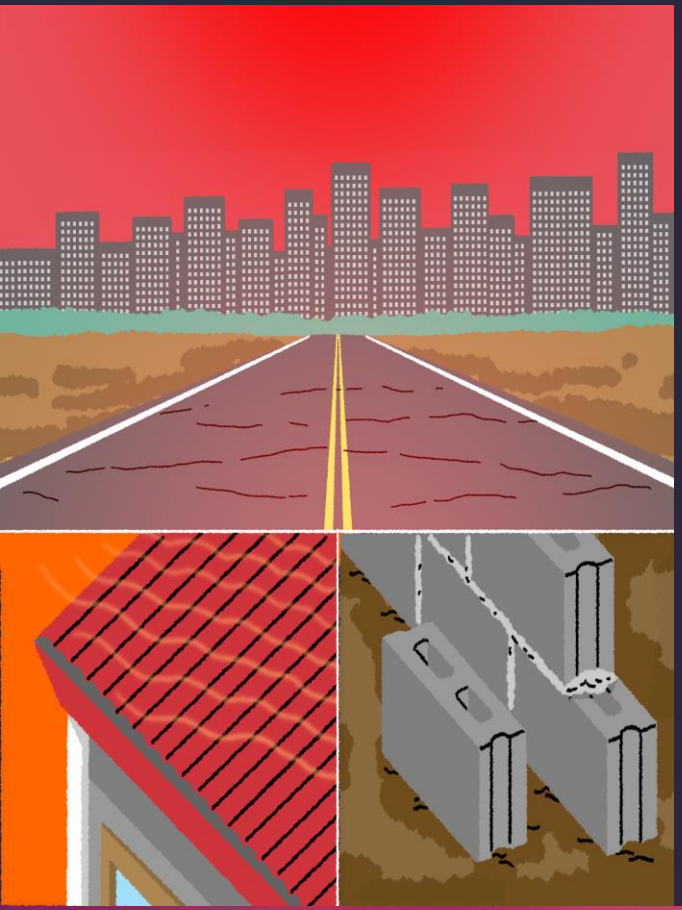



Note: Figure shows global near-ground atmospheric temperatures since 1880. Source: ERA-5.

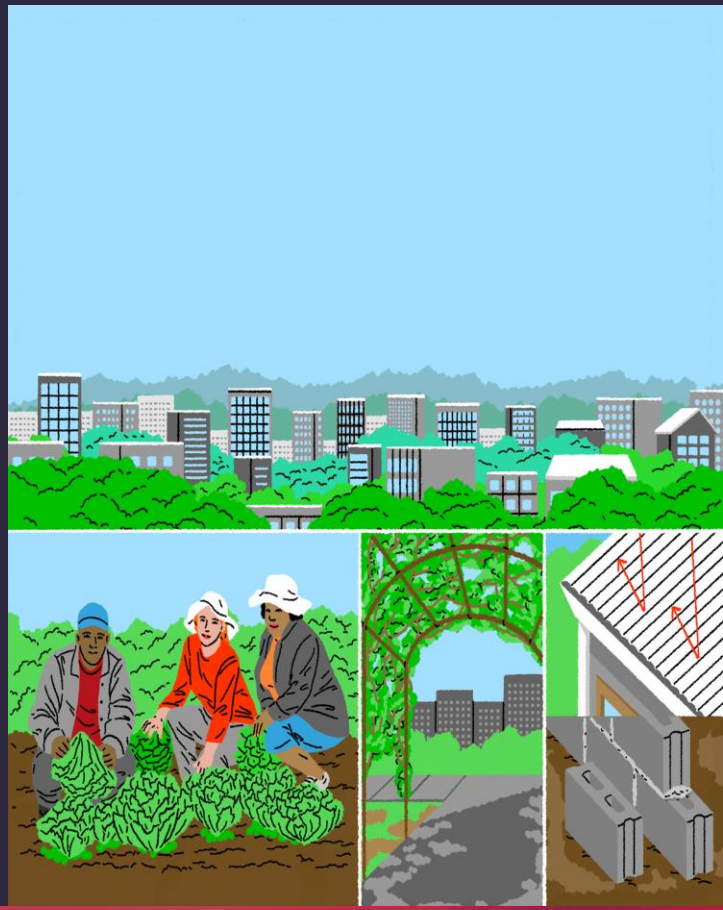
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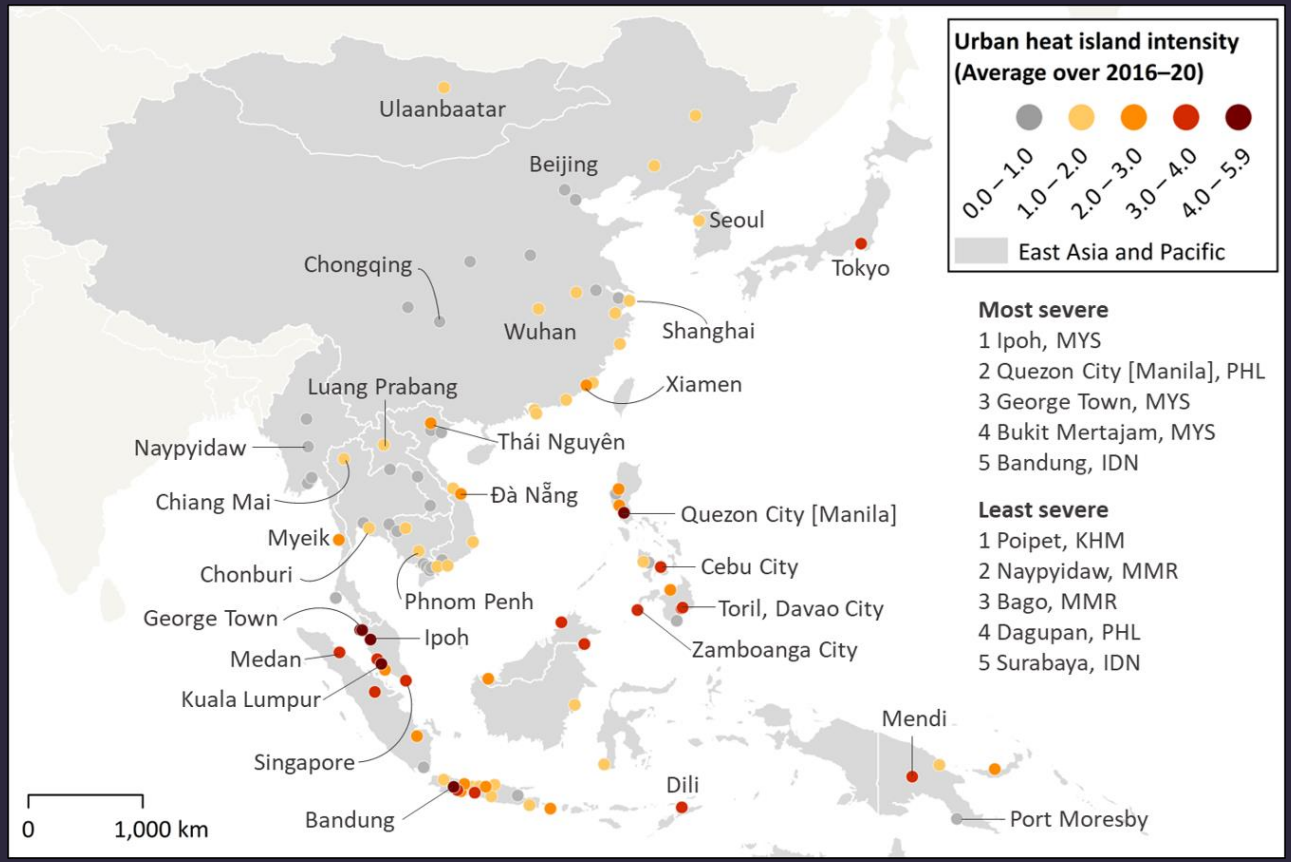



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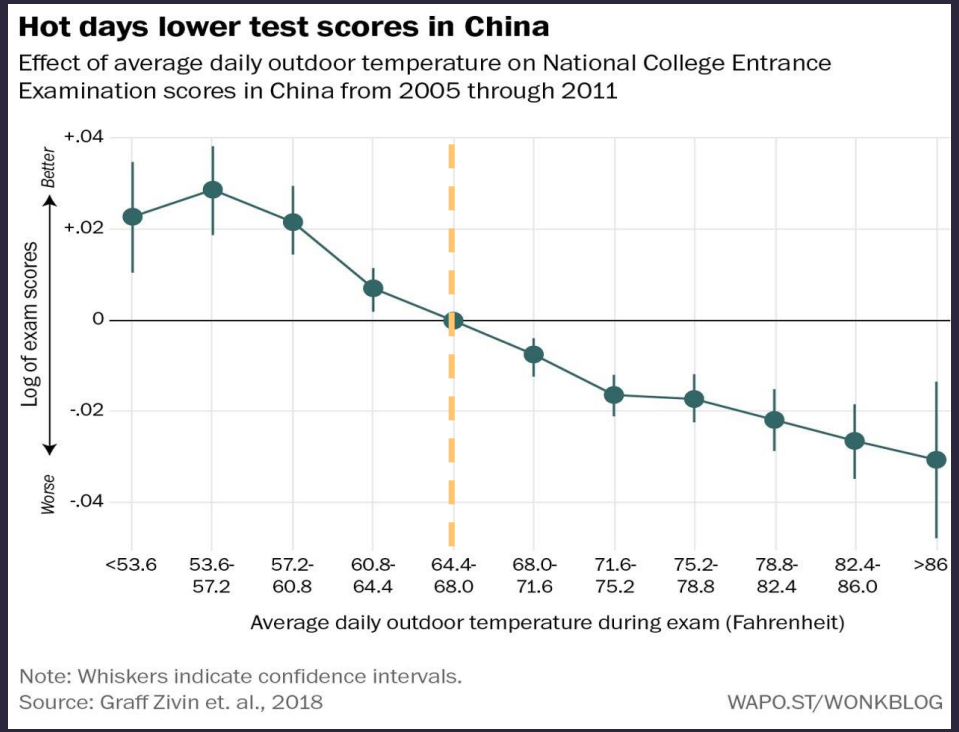
But temperatures rising faster in cities, where materials absorb & radiate the sun's energy



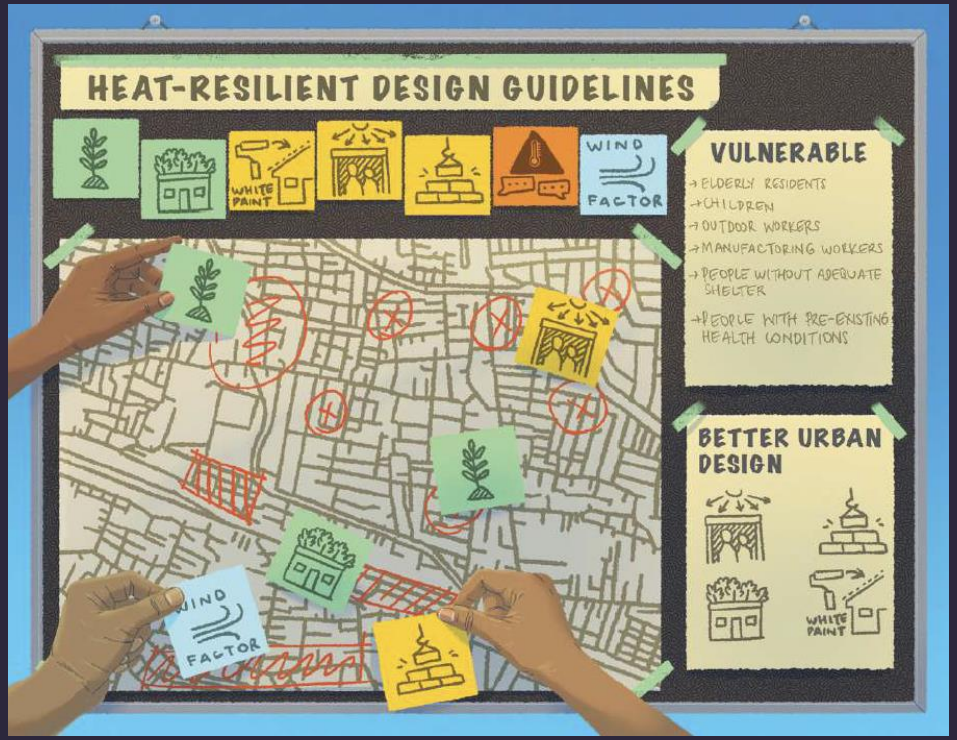



# Urban heat island (UHI) effect can add as much as 6°C to year-round average surface temperatures

Note: The figure shows Surface Urban Heat Island (SUHI) effect measured for 100 East Asian cities through LandSat satellite imagery (analysis by 4EI for World Bank's Unlivable report). Reported UHI intensities are year-round averages. Under peak weather conditions, night-time urban heat island intensity can reach 12°C.




# Extreme heat impacts health, prosperity & livability




Climate change is a global problem that local solutions alone won't solve

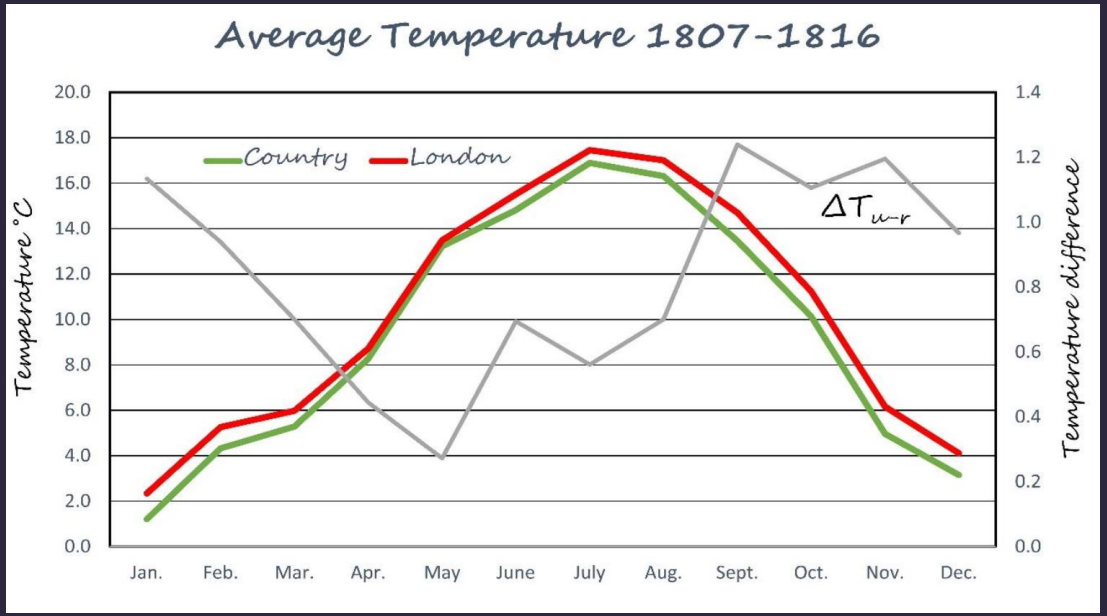
UHI effect is a local problem that cities can act decisively to address



# 2. Measuring heat in cities: 200 years of innovation

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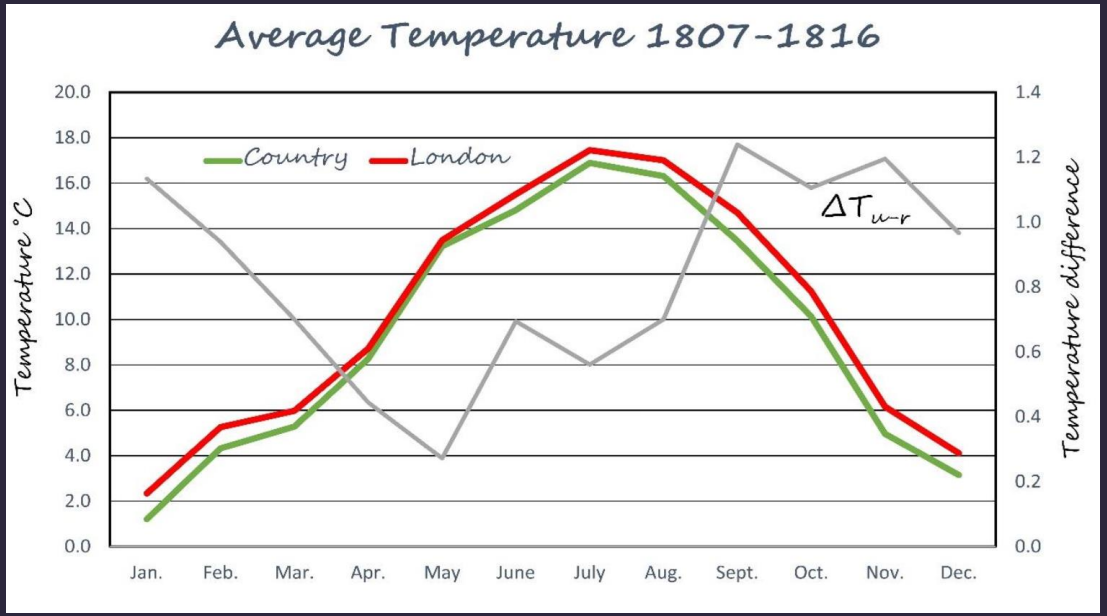



Luke Howard took twice-daily measurements of temperatures in London's periphery. By comparing these with temperature measurements for central London from the Royal Society, he estimated the strength of the UHI effect

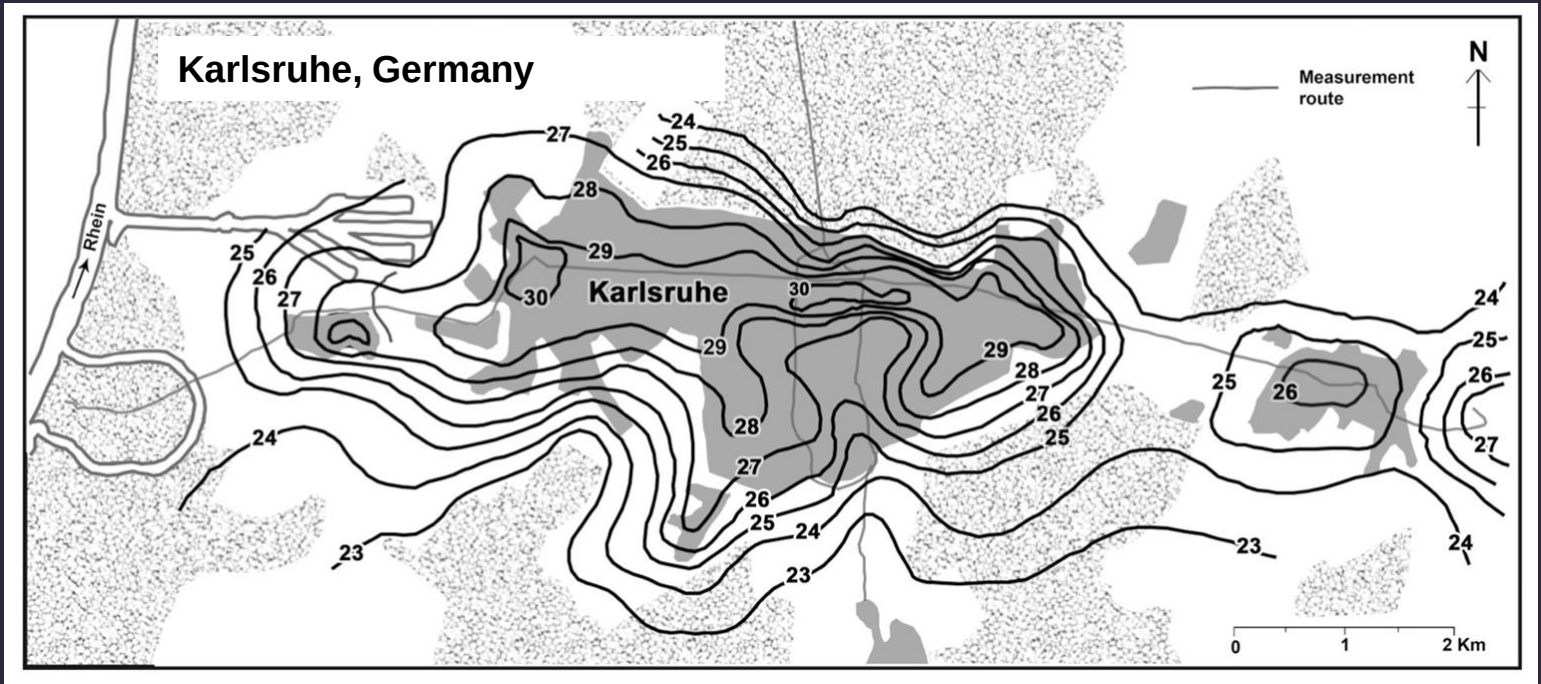
# Measuring heat in cities: 200 years of innovation




*"... we find London always warmer than the country, the average excess of its temperature being 1.579°F [0.88°C] ..."* (Luke Howard, *The Climate of London*)

# Measuring heat in cities: 200 years of innovation




Hand-drawn map by Albert Peppler (1933) based on 45 measurements taken by vehicle traverse using a therometer attached to his car. Using isolines (°C), Peppler was the first to use the analogy of an island (*'städtisch heatinsel'*)

# Measuring heat in cities: 200 years of innovation







Key innovations made by Japanese researchers:
Fleet of motorcars first used to measure temperatures across Tokyo, Osaka & Nagoya in 1949 (Fukui & Wada)

# Investigation methods: Pros and cons




**Stationary sensors**
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(-) Single site; time & cost; installation & experimental control challenges

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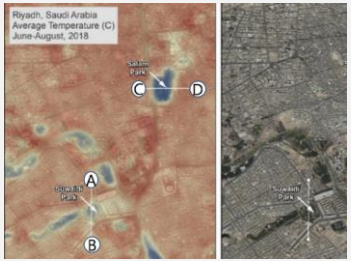
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**Satellite imagery**
(+) Rapid implementation
(-) Land Surface Temp is poor proxy for air temperature

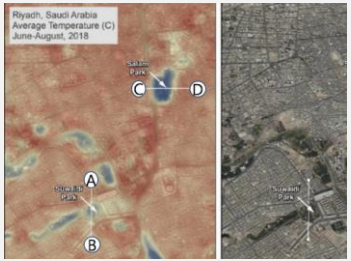
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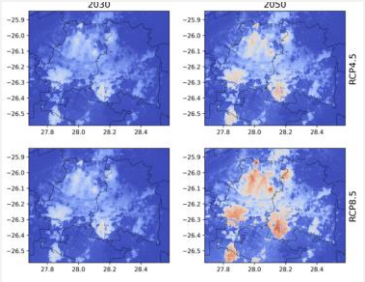

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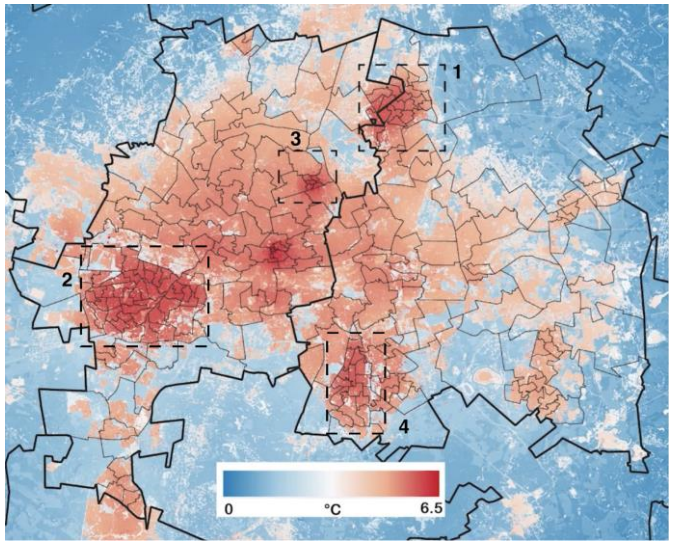



**Urban climate modeling**
(+) Forward-looking, scientifically validated
(-) Cost



# 3. Emerging lessons from World Bank extreme heat engagements

# 1 Residents of Johannesburg face ‘thermal inequalities’ of 6°C+ that mirror social divisions

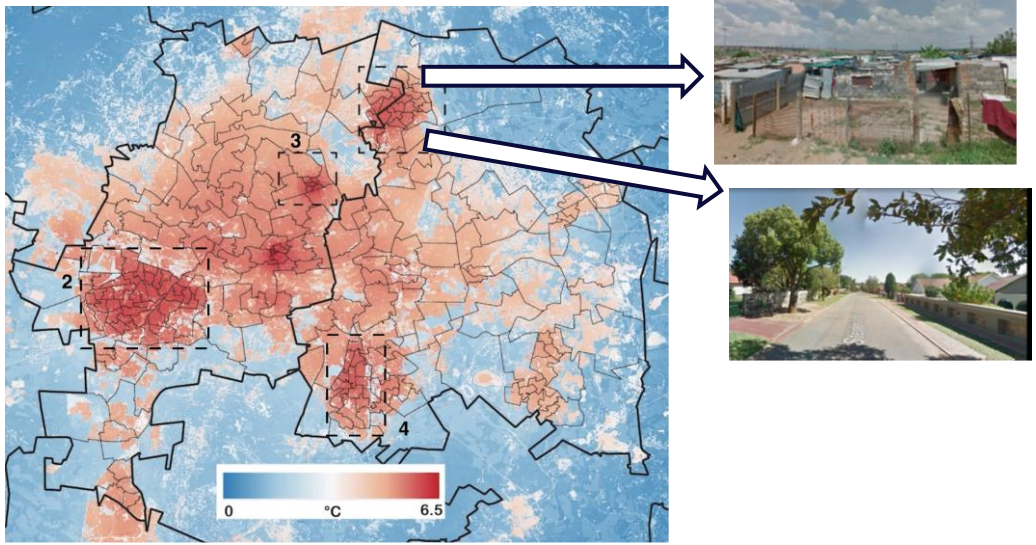



## Context

Extreme Heat in South African Cities programmatic support to eight metro areas (2021-present) informing Heat Action Plan development

[TTL: Nick Jones/Eric Dickson; partners: Vito, PlanAct]

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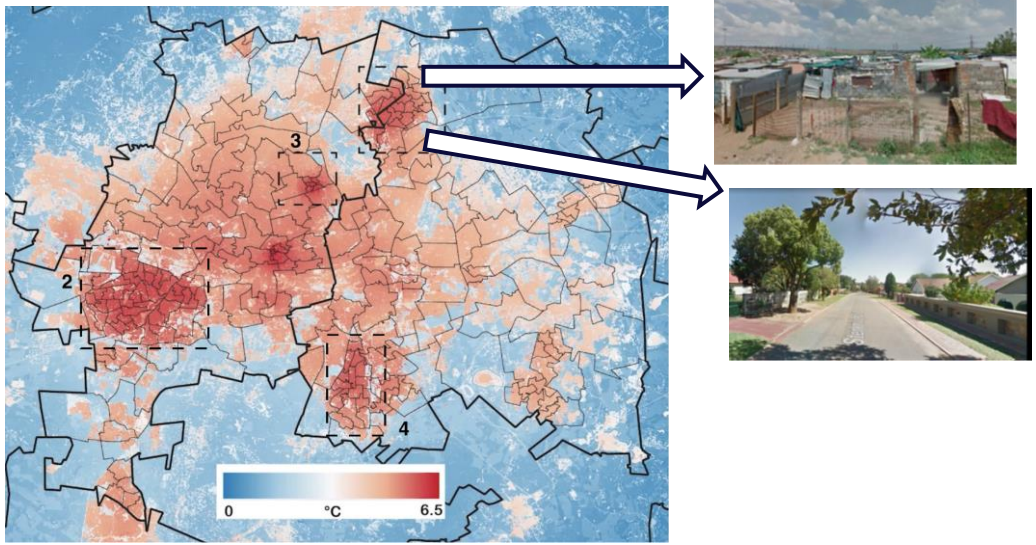
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## Key conclusion?

Apartheid-era spatial planning resulted in heat-promoting urban landscapes in historically black townships - such as Soweto and Alexandra - making them substantially hotter than elite suburbs.

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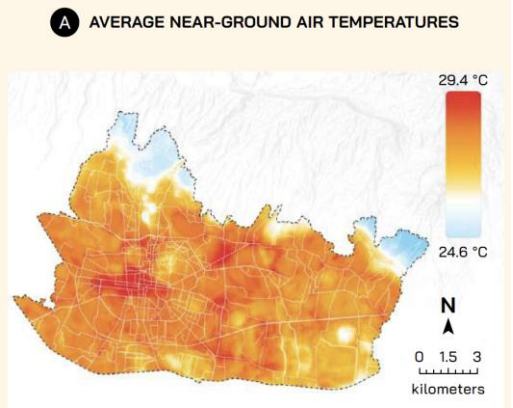
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## Lessons?

Citizen-based mapping of urban heat can generate insights about climate change impacts on local society & galvanize responses.

[TTL: Nick Jones/Eric Dickson; partners: Vito, PlanAct]

# 2 Dense neighborhoods with few trees are systematically hotter

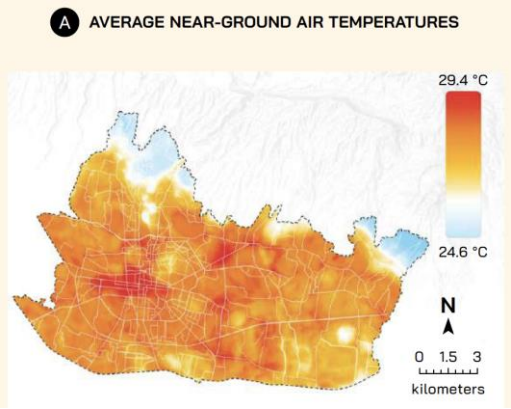


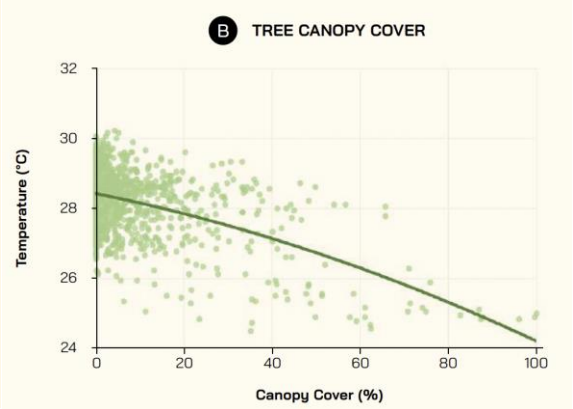

## Context

Citizen science heat measurements in Bandung, Indonesia conducted for 'Unlivable: What the UHI Effect Means for East Asia's Cities'.

[TTL: Mark Roberts/Chandan Deuskar; partners: CAPA, ITB]

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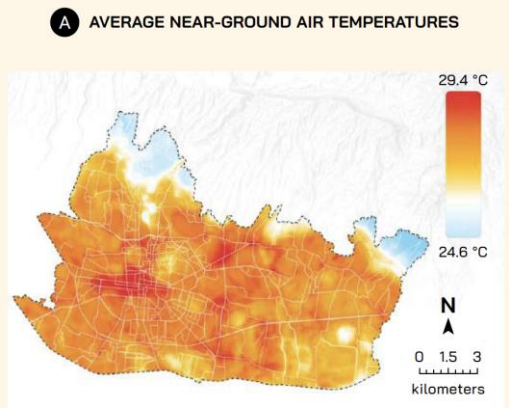
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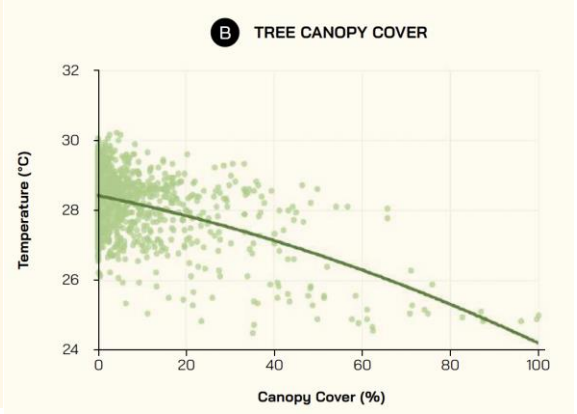
## Key conclusion?

Poorer subdistricts & those with high density & limited vegetation are hotter.

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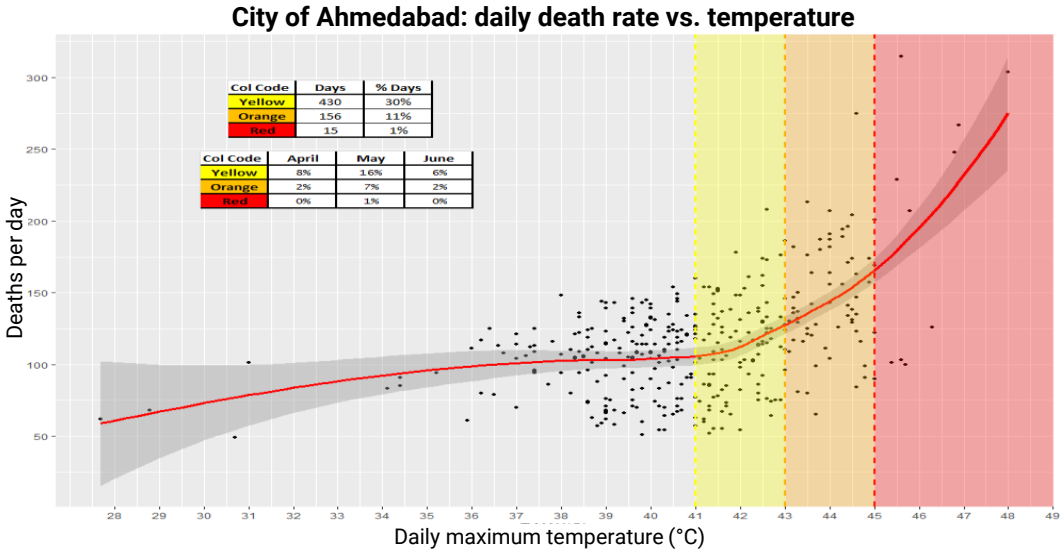
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## Lessons?

Extreme heat responses should focus on vulnerable populations & incorporate strategic plans for urban greening.

[TTL: Mark Roberts/Chandan Deuskar; partners: CAPA, ITB]

# 3 Threshold-based early warning systems can save lives during heat waves




| Col Code | Days | % Days |
|---|---|---|
| Yellow | 430 | 30% |
| Orange | 156 | 11% |
| Red | 15 | 1% |

| Col Code | April | May | June |
|---|---|---|---|
| Yellow | 8% | 16% | 6% |
| Orange | 2% | 7% | 2% |
| Red | 0% | 1% | 0% |

## Context

GFDRR team working with Indian Institute of Public Health-Gandinagar to share knowledge from Ahmedabad City.

## Key conclusion?

Set up 'traffic light' heat alerts - ie. yellow, orange & red warnings - based on temperatures that correspond to a significant increase in the city's daily death rate.

## Lessons ?

Local data on all-cause mortality can be combined with weather station data to set thresholds for early warnings & health protection actions in sectors from construction to education.

[Lead: Dileep Mavalankar, GFDRR/IIPHG]

# 3 Threshold-based early warning systems can save lives during heat waves

| | | |
|---|---|---|
| YELLOW ALERT | Hot Day Advisory | 41.1˚C – 43˚C |
| ORANGE ALERT | Heat Alert Day | 43.1˚C – 44.9˚C |
| RED ALERT | Extreme Heat Alert Day | ≥ 45˚C |







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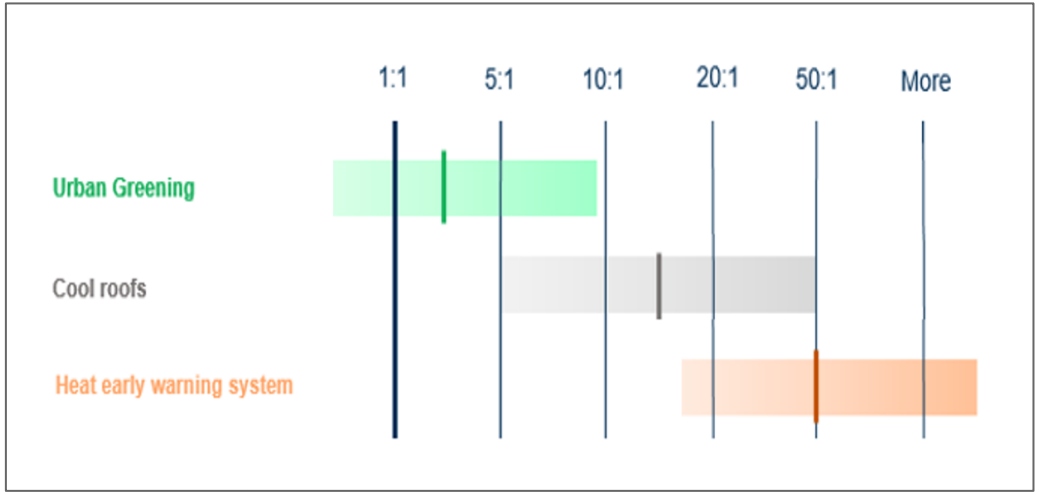
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[Lead: Dileep Mavalankar, GFDRR/IIPHG]

# 4 Benefit-cost ratios of city heat mitigation actions are compelling




## Context

A deep-dive on urban heat for India Climate Change & Development Report (CCDR).

## Key conclusion?

Economic modeling of health & labor productivity benefits from introducing city-level packages of heat mitigation actions. Heat wave deaths assumed to equate to 8 lost life years.

## Lessons?

Urban greening has a benefit-cost ratio exceeding 1:1. Cool roofs & heat-health early warning systems have high benefit-cost ratios suggesting they are 'low hanging fruit.'

[Lead: Nick Jones, Asmita Tiwari, Sacha Takacs]

# 5 ‘Citizen science’ can unlock action









## What is the TA/knowledge product?

Participatory heat mapping in Albania & Bosnia-Hercegovina.

## How did it innovate?

Vehicle traverse campaigns with local community volunteers created area-wide heat maps; thermal imaging cameras and local knowledge used to shortlist site-specific cooling interventions.

## Lessons for other teams/regions?

A ‘citizen science’ approach creates communications benefits and gives added legitimacy to data products, unlocking action.

[Lead: Nuala Cowen, Megha Mukim, Nick Jones]



# 4. From assessment to action

# Resilient Urban Sierra Leone Project (RUSLP)

RUSLP: $40 million IDA grant (FY21-FY26)
Estimated investment in nature-based solutions: $11.2m

Under this ongoing investment project, > 898 residents mobilized, trained and paid to plant trees, shrubs & mangroves - supported by a 'TreeTracker' app.

Freetown lost 12% of its tree canopy cover from 2011 to 2018. The $40m IDA grant is supporting the city's goal to plant 1 million trees addressing heat, slope stabilization & flood risk.








# Piloting Nature Based Solutions for Urban Cooling: Guangzhou, China

**Cooling solutions** piloted as part of the Yongqing Fan neighborhood renewal investment (old town Guangzhou)




Project tested cooling measures as part of neighborhood renewal that retains original architectural styles. Cooling measures applicable for traditional buildings were tested including ventilation, shading & insulation. Features inspired by traditional Lingnan architecture - including cool alleys, patios, and flexible door & window structures to enhance indoor ventilation - were incorporated.

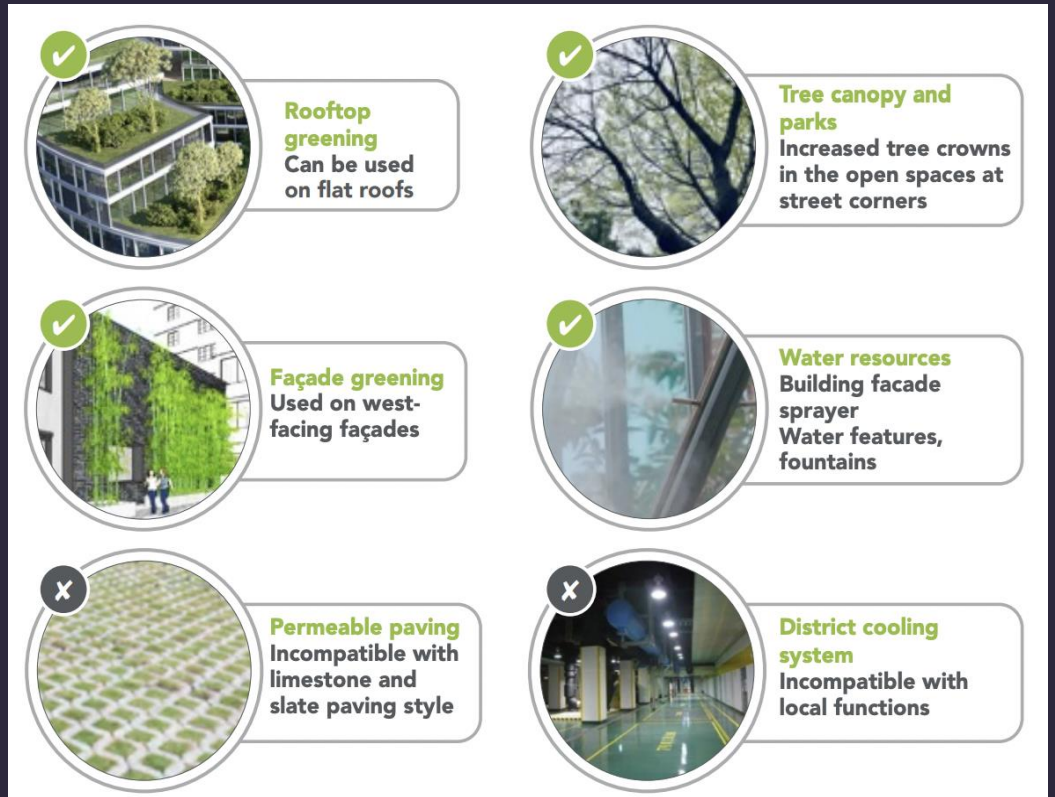



Figure: Cooling Interventions Tested at the Yongqing Fan pilot site [Source: Piloting Nature Based Solutions for Urban Cooling (link)]

# Piloting Nature Based Solutions for Urban Cooling: Guangzhou, China

**Wind corridors**, **cool pavements** and **vertical greening** integrated into Knowledge Green Valley development



China-Singapore Knowledge City is a new town under planning. Jiulong Lake district (above) is 12.6km$^2$ pilot area situated at the heart of the Knowledge City expected to accommodate 120,000 people. The Knowledge Green Valley plan (*right*) aims to maximize site ventilation through building design, layout, and wind corridors.

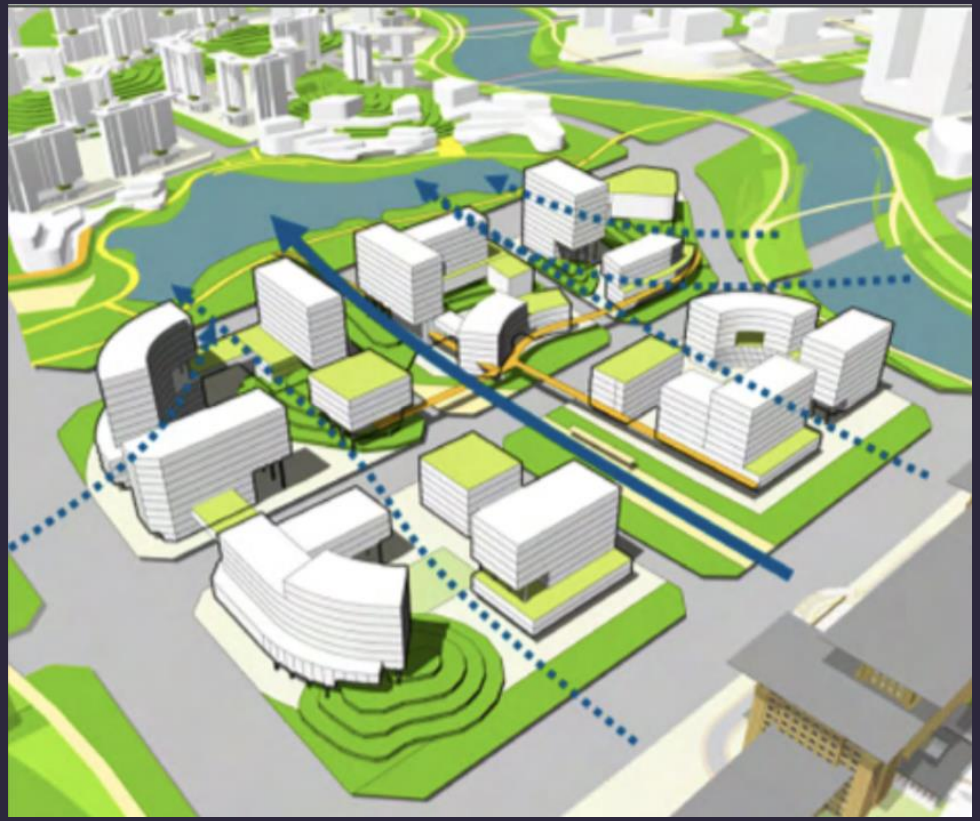


Figure: Illustration of wind corridor concept for Knowledge Green Valley
[Source: Piloting Nature Based Solutions for Urban Cooling (link)]


Thank you