Remotely Sensing Cities and Environments

Lecture 8: Temperature and policy

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PDF presentation

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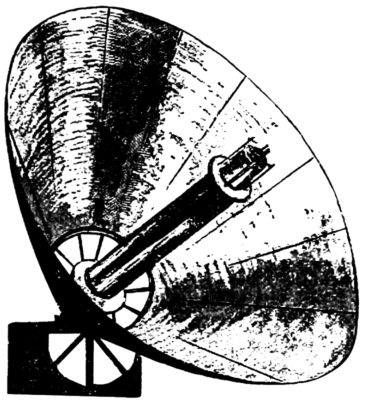
Lecture outline

Part 1: Temperature and policy

Part 2: Extracting temperature from satellite data



Source:Original from the British Library. Digitally enhanced by rawpixel.

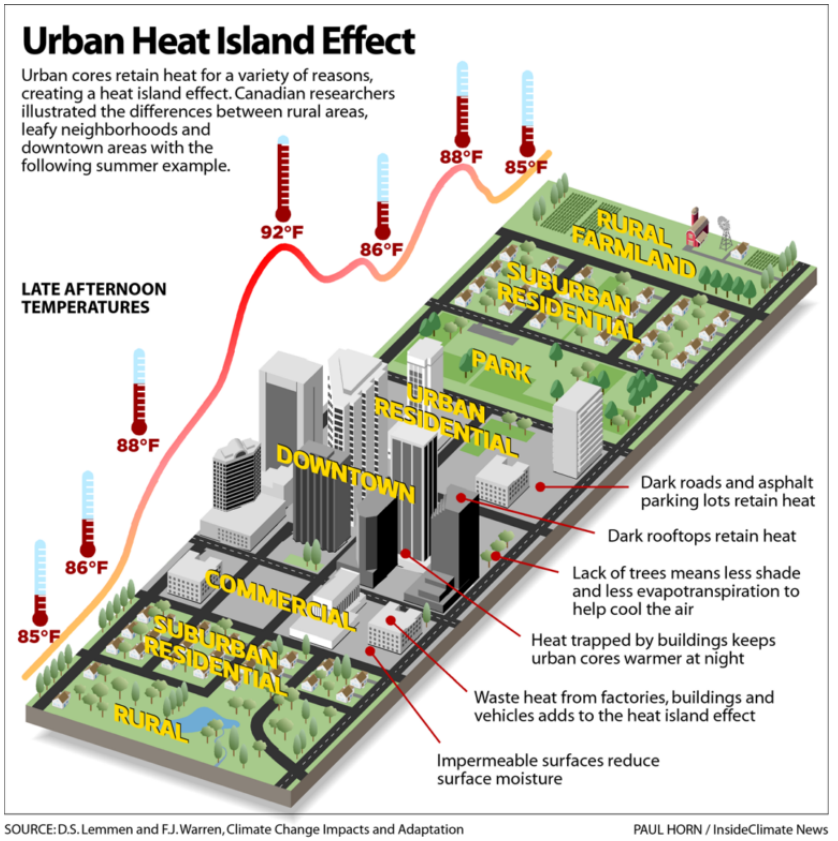
Let's recall some policy we looked at...with a focus on the Urban Heat Island (or temperature)

What is the Urban Heat Island

What is the problem?

What is the Urban Heat Island

> urban areas obtain comparatively higher atmospheric and surface temperatures than surrounding rural areas



Source:EARTH.ORG

What is the Urban Heat Island 2

What is the Urban Heat Island 3

Two main factors:

1. More dark surfaces that retain heat
2. Less vegetation that cools the environment (evapotranspiration and solar blocking)

But other factors include:

- A low Sky View Factor (SVF)
  - radiation received (or emitted) by a planar surface to the radiation emitted (or received) by the entire hemispheric environment
- air speed, cloud cover, cyclic solar radiation, building material type and anthropogenic energy

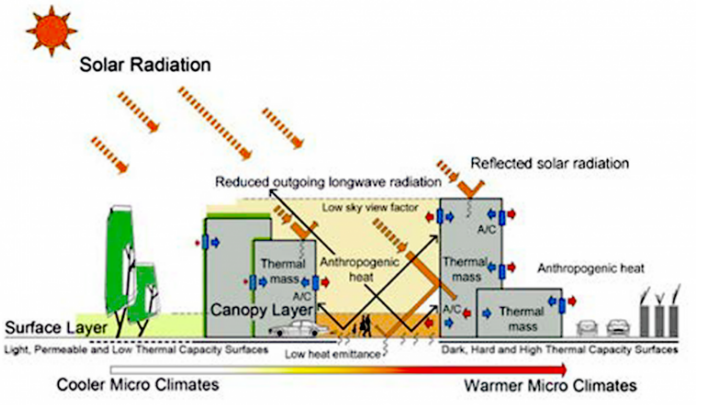


Fig 1: Factors responsible for Urban Heat Island Effect. (Source – Osmond, 2017) Source here:Cidco Smartcity

How much does it cost

Social

- Population adjusted excess mortality rates during the 1998 Shanghai heatwave were estimated at **27.3 per 100,000 within the urban area** compared to only **7 per 100,000 in the exurban** districts Tan et al. 2009

Environmental

- Each degree of ambient temperature rise the increase in peak electricity load has been estimated between 0.45 and 4.6%, corresponding to around 21 W per degree rise per person Santamouris et al. 2015
- Fossil fuel + pollution

Buffalo - August 3, 2002. Source:Earth Observatory, NASA

Providence - July 31, 2002. Source:Earth Observatory, NASA

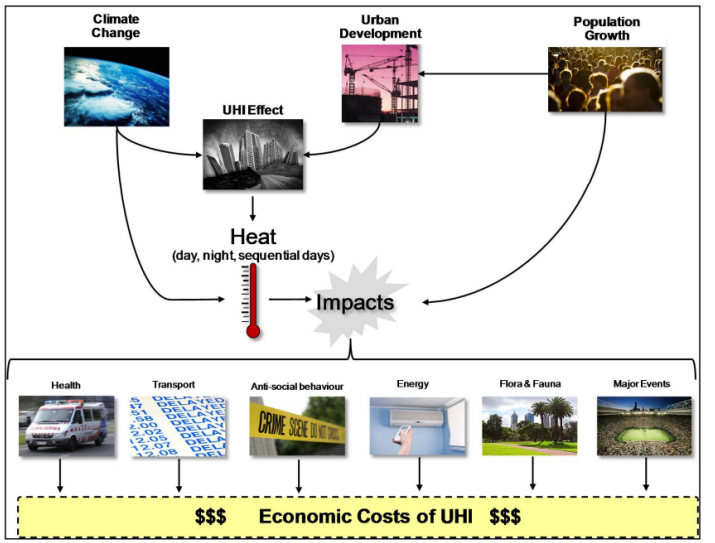
How much does it cost 2

Economic

Local GDP

- Melbourne first assessment $300 million (AUD) of which health $282. Other factors:
  - transport
  - energy
  - anti-social behavior
  - AECOM, 2012

Figure 15 Assessment methodology



Source:AECOM, 2012

Hope

- reduction in economic damages through policies...

Table 3 | Change in urban impacts from global stabilization scenarios and local urban heat island mitigation policies.

	RCP8.5	RCP6	RCP4.5
550 ppm			
Policy A	−51.60% [1.50]	−31.50% [4.34]	−27.60% [13.50]
Policy B	−43.10% [1.25]	−19.50% [2.69]	−15.00% [7.32]
Policy C	−45.50% [1.32]	−22.80% [3.15]	−18.50% [9.04]
Policy D	−40.20% [1.17]	−15.40% [2.13]	−10.70% [5.22]
450 ppm			
Policy A	−59.00% [1.37]	−42.00% [2.17]	−38.80% [2.60]
Policy B	−51.10% [1.19]	−30.90% [1.59]	−27.00% [1.81]
Policy C	−53.30% [1.24]	−34.00% [1.75]	−30.30% [2.03]
Policy D	−48.50% [1.13]	−27.00% [1.39]	−23.00% [1.54]
RCP3PD			
Policy A	−64.00% [1.32]	−48.70% [1.80]	−46.00% [2.00]
Policy B	−56.20% [1.16]	−38.00% [1.41]	−34.50% [1.51]
Policy C	−58.30% [1.20]	−41.00% [1.52]	−37.70% [1.64]
Policy D	−53.60% [1.11]	−34.40% [1.27]	−30.70% [1.34]
350 ppm			
Policy A	−64.80% [1.30]	−50.20% [1.73]	−47.40% [1.90]
Policy B	−57.40% [1.15]	−39.80% [1.37]	−36.40% [1.46]
Policy C	−59.50% [1.19]	−42.70% [1.47]	−39.50% [1.58]
Policy D	−54.90% [1.10]	−36.20% [1.25]	−32.60% [1.31]

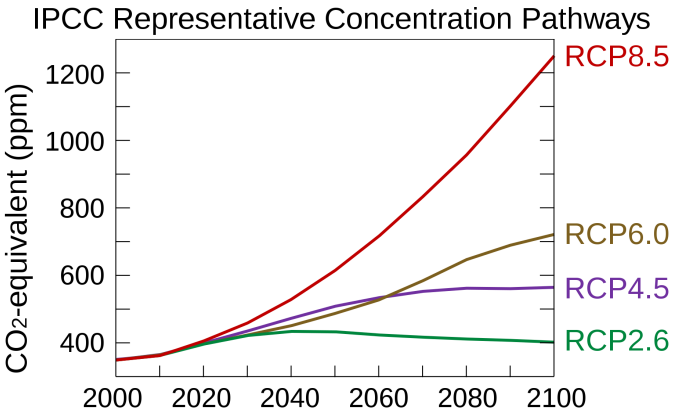
Figures represent the percentage of reduction in impacts achieved by the implementation of the selected global and local policies with respect to the impacts produced under the different reference scenarios. Numbers in brackets express avoided damages of both local and global policies as a fraction of the avoided losses that would be obtained from stabilization scenarios alone. Policies: A—Large-scale cool roofs and cool pavements; B—Moderate-scale cool roofs and cool pavements; C—Moderate-scale green and cool roofs and cool pavements; D—Small-scale green and cool roofs and cool pavements. Figures are rounded to three significant digits.

Source:Estrada et al. 2017

Context

Representative Concentration Pathway (RCP):

- 4.5
  - intermediate scenario
  - Co2 declines around 2045
- 6
  - peak emission 2080 then decline
- 8
  - Continued emission rise = worst case scenario



Source:Wikipedia

- Note, in 2017 the RCPs were updated with the Shared Socioeconomic Pathways (SSPs)
- See the carbonbrief explainer

Is policy helping us?

Global

Global policy documents

- New Urban Agenda = standards and principles for planning, construction, development, management and urban improvement

point 54 point 79 point 37

> We commit ourselves to the generation and use of renewable and affordable energy and sustainable and efficient transport infrastructure and services, where possible,
>
> achieving the **benefits of connectivity and reducing the financial, environmental and public health costs of inefficient mobility, congestion, air pollution, urban heat island effects and noise**.
>
> We also commit ourselves to giving particular attention to the energy and transport needs of all people, particularly the poor and those living in informal settlements. We also note that reductions in renewable energy costs give cities and human settlements an effective tool to lower energy supply costs.

Global policy documents

- Sustainable Development Goals (SDG) = targets with measurable indicators for monitoring

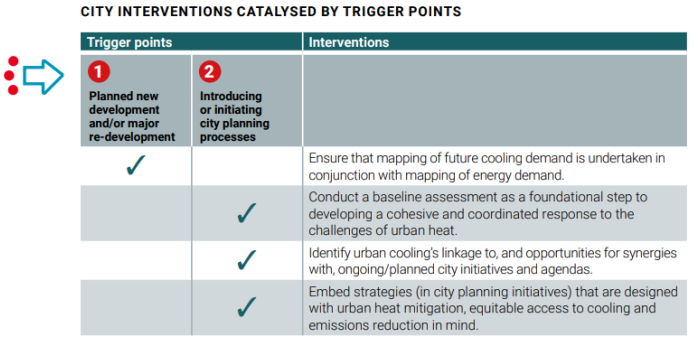
Goal 11 Target COP26

- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Beat The Heat Handbook

- This handbook contains a **lot** of information and it's easy to get lost

- Would a city planner engage with all **208 pages?**
- If is the first full guide on UHI that suggests
    - Baseline assessment
    - Key factors to consider(p. 60) such as albedo, urban form, city zoning, green cover, heat maps (that mention satellite data) - **Chapter 5**
- First major document that calls for specific integration into policy



CITY INTERVENTIONS CATALYSED BY TRIGGER POINTS

Trigger points		Interventions
1 Planned new development and/or major re-development	2 Introducing or initiating city planning processes	
✓		Ensure that mapping of future cooling demand is undertaken in conjunction with mapping of energy demand.
	✓	Conduct a baseline assessment as a foundational step to developing a cohesive and coordinated response to the challenges of urban heat.
	✓	Identify urban cooling's linkage to, and opportunities for synergies with, ongoing/planned city initiatives and agendas.
	✓	Embed strategies (in city planning initiatives) that are designed with urban heat mitigation, equitable access to cooling and emissions reduction in mind.

Source:Beating the Heat: A Sustainable Cooling Handbook for Cities

Beat The Heat Handbook 2

Figure 4.3 Matrix to support strategic assessment of city interventions for sustainable urban cooling

■ All Cities
■ Developed cities
■ Developing cites

			EASE OF IMPLEMENTATION: Requirements for human and/or financial resources	EASE OF IMPLEMENTATION: Complexity due to changes in policy, existing conditions, or required pre-conditions
	INTERVENTIONS LEVERAGING THE APPROPRIATE TRIGGER POINTS:			
CHAPTER 5	**City's cooling landscape assessment as the starting point for action**		Medium	NA
CHAPTER 6	**Heat-resilient urban design and infrastructure**	Heat-resilient urban planning	Medium	High
		Cool roofs	Low/Medium	Low/Medium Low
		Expanding green spaces (*e.g.*, parks)	Medium/High Medium	Medium/High Medium
		Street trees	Low/Medium	Low
		Green roofs and walls	Medium/High	Medium Low/Medium
		Reflective streets and pavements	Medium/High	Medium Low/Medium
		Public shading structures	Low	Low/Medium Low
CHAPTER 7	**District cooling**		High	High
CHAPTER 8	**Energy efficient and thermally efficient buildings**	Building energy codes	Medium	Medium High
		Mandatory energy disclosure policies	Low	Low/Medium
CHAPTER 9	**Cities leading by example**		Low/Medium	Low/Medium
CHAPTER 10	**Community-centric initiatives to advance heat-equity & access to cooling**		Medium	Low
CHAPTER 11	**Awareness and capacity building to Support Sustainable Urban Cooling**		Low/Medium Medium	Low Low/Medium
CHAPTER 12	**Funding and Financing Sustainable Urban Cooling Interventions**		Medium	Medium Medium/High

Source:Beating the Heat: A Sustainable Cooling Handbook for Cities

Beat The Heat Handbook 3

BENEFITS/ IMPACTS			
Attributable economic savings or revenue in relation to cost	Public good/ enhancing livability	UHIE mitigation potential	GHG reduction potential
NA	NA	NA	NA
Medium	High	High	NA
High	Medium	Medium/High	Low/Medium
Low/Medium	High	High	Low/Medium
Low/Medium	High	Medium/High	Low/Medium
Low	Medium	Medium/High	Low/Medium
Low	Medium	Low/Medium	Low
Low	Medium	Low/Medium	Low
High	Medium	High	High
High	Medium	Medium/High	High
Low	Medium	Low/Medium	Low/Medium
High	Medium	Medium/High	Medium/High
Low	High	Low	Low
NA	NA	NA	NA
NA	NA	NA	NA

Local

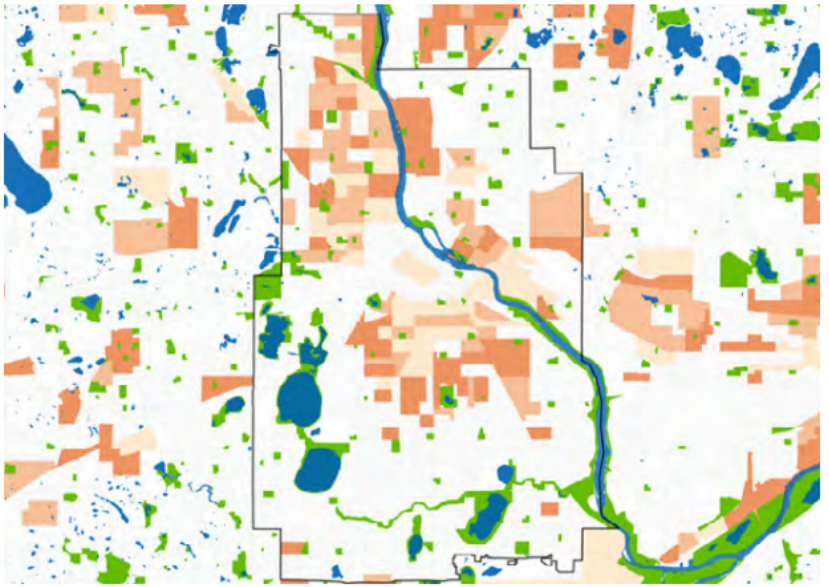
As the Beat The Heat Handbook contains examples of local policy we will start here first then more to metropolitan policy

Beat the Heat Handbook...

...Has many examples of mitigation...**although some aren't in response to the UHI**...they were in place before / an associated benefit is temperature reduction

...i cannot make sense of this...

Figure 6.6 Access to green spaces In Minneapolis, Minnesota

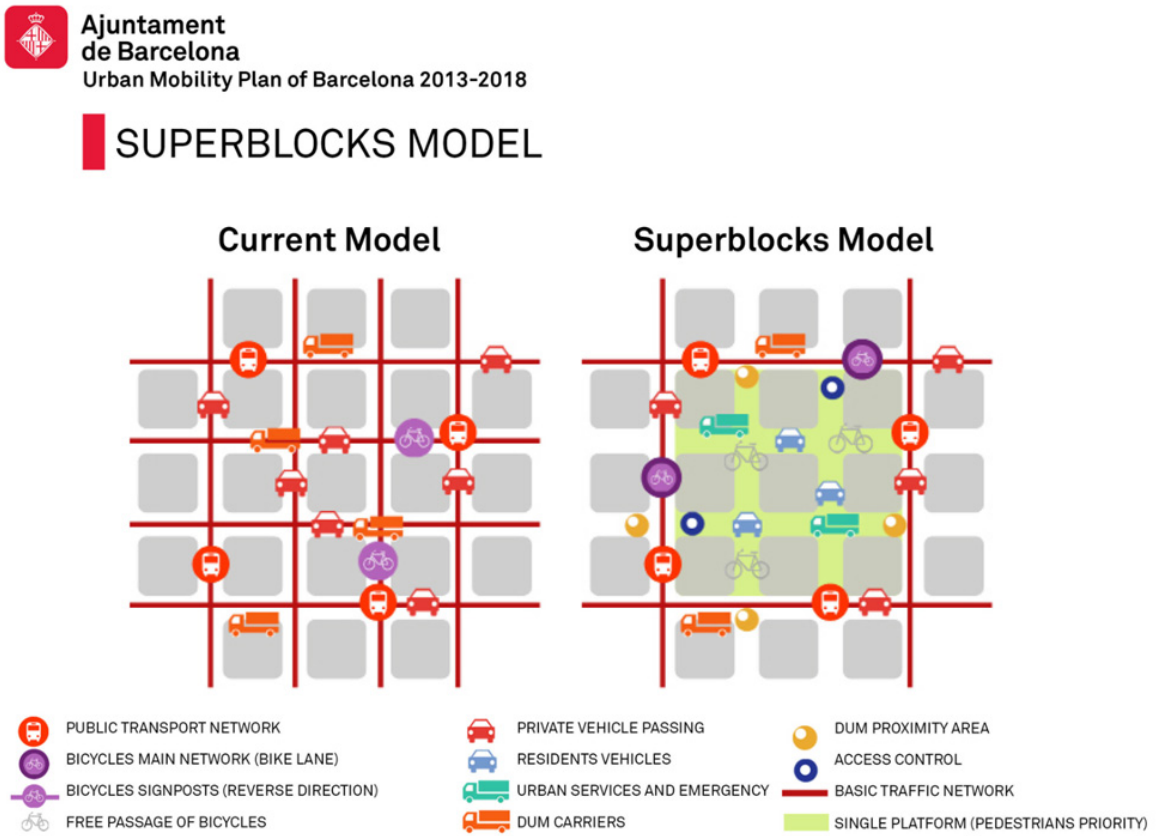


Note: In Minneapolis, 98 per cent of residents live within a 10-minute walk of one of the city's 271 parks (the smallest parks are not visible in the image). Minneapolis has a variety of public green spaces throughout the city, including large parks, lakes, greenways along the river and across town, and small neighbourhood parks. However, the largest green spaces are more accessible to higher-income and white populations. The red circles show approximate locations of where new parks are most needed to improve access, according to the Trust for Public Land.

Source: UrbanFootprint, RMI and Trust for Public Land

Source:Beating the Heat: A Sustainable Cooling Handbook for Cities

Beat the Heat Handbook...



Source:Beating the Heat: A Sustainable Cooling Handbook for Cities. Image: regenerativedesign.world

Superblocks

Background

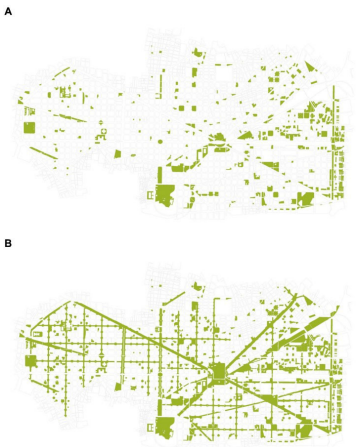
- The idea has been proposed many times - dating back to Barcelona's Plan Macià, 1932, and Josep Lluís Sert and Le Corbusier
- First superblock was in 1993

Superille (2016)

- Community did not want
- Cars = less business...but at that time only 5% used cars
- Gentrification concerns - 15 minute cities?
    - Council used social housing then 120 other places

Future

- Transform mobility (2024 Urban Mobility Plan)
- 67Km more bus lanes that align with superblocks
- **green axes**



Source:Cities Form

Superblocks

Medellín Green Corridors

- Rapid and uncontrolled growth
- 2016-2019 Government Plan = Medellín, Environmental Urbanism
- Restore green corridors
    - 36 corridors
    - along 18 roads and waterways
    - Reduced temperature 4 degrees Celsius
- Is this where people live?

Source:C40 Cities

Medellín Green Corridors

Sydney's western suburbs

- Turn Down the Heat Strategy and Action Plan in 2018.
- An in-depth assessment of the cooling landscape was foundational to the development of this comprehensive Strategy and Action Plan and included aspects such as:
    - assessment of the current state of urban heat in Western Sydney today;
    - the future of urban heat in Western Sydney, highlighting the increasing severity and frequency of heat waves; impacts of urban heat on people, infrastructure, the economy and the environment; ans taking stock of the existing work across Western Sydney to address heat.
- Video appeared online in 2016...yet it is also listed in the Beating the Heat guide..
    - What progress has been made
    - Does **identifying an action plan mean action?**
    - What are we waiting for?

Source:Beating the Heat: A Sustainable Cooling Handbook for Cities.

Sydney's western suburbs

Reflections on this..

- Useful as it is first real guidance that states this should become part of city planning / policy

BUT...

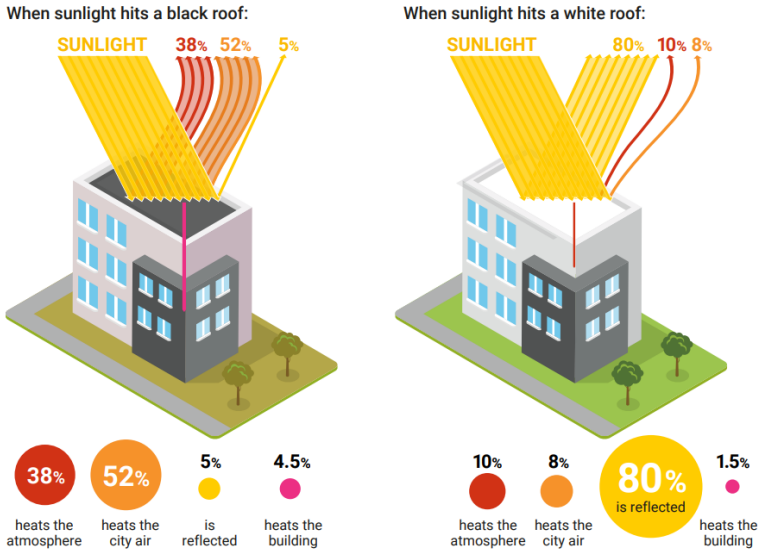
- It **doesn't actually give specifics**
    - How are you meant to use data to solve these problems?
    - What sort of **planning rules** need to be changed
    - Do all cities have appropriate staff (a GIS team?) to solve these challenges
    - Is there sufficient interest within local / metropolitan / national government
    - Is there buy in from the public
- If you are a planner how should you consider applications given this guidance / requirements
- Is it up to metropolitan level / national level and not individual planning applications

What about the data?

Does provide some useful project ideas

- Assessing or determining the potential for reflective roofs / pavements / sidewalks

Figure 6.8 The albedo effect: comparison of a black and a white flat roof on a summer afternoon with an air temperature of 37°C



Note: Numbers do not sum to 100 per cent due to rounding.
Source: Adapted from Global Cool Cities Alliance 2012, and data from LBNL Heat Island Group.

Source:Beating the Heat: A Sustainable Cooling Handbook for Cities.

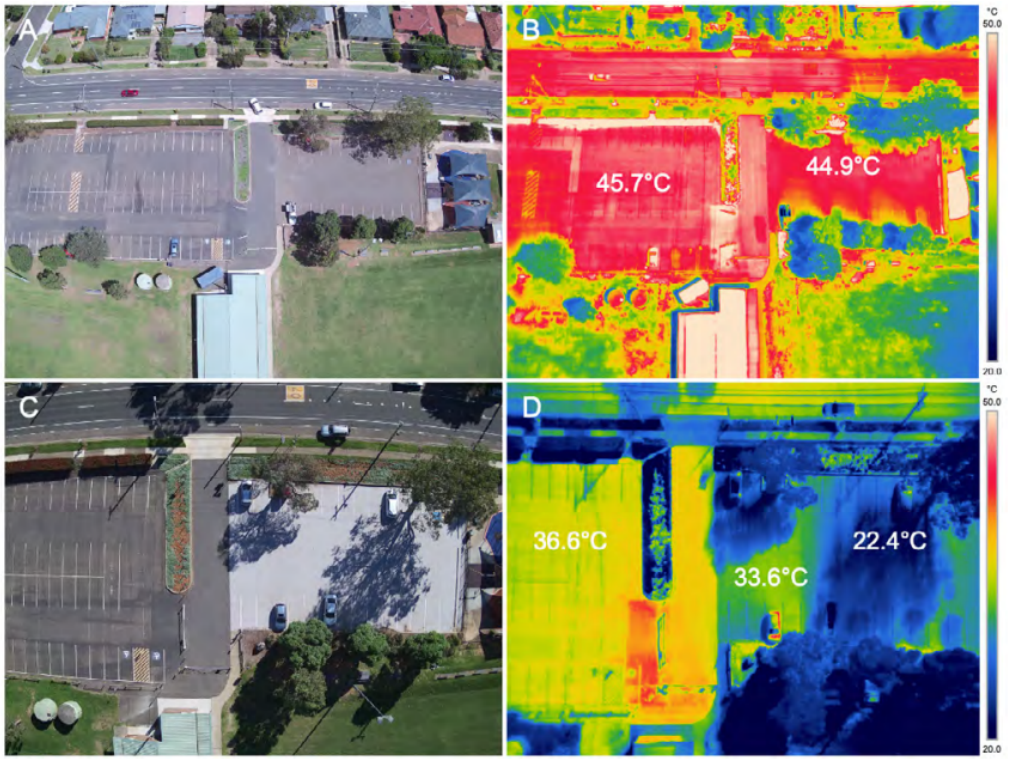
Does provide some useful project ideas

- Community engagement

Source:Sustainable Chippendale

Does provide some useful project ideas

- 2021 Cool Roads Trial in Western Sydney



Source:Pfautsch, S., & Wujeska-Klause, A. (2021). Cool Roads Trial 2021

But...

> “Surface coating did not systematically reduce air temperature during the day or night...
>
> Ambient air temperatures were not lowered as a result of coating roads and carparks, which can potentially be a matter of scale."

> “satellite-derived surface temperature shows very weak relationships with air temperature"
>
> — Chakraborty et al. 2022

Does provide some useful project ideas

- Accessibility to cool or green spaces / heat inequity ..

> "**intra-urban" heat islands, or areas within a city that are hotter than others** due to the uneven distribution of heat-absorbing buildings and pavements, and cooler spaces with trees and greenery. These differences can result from **disparities in the way communities are planned**, developed, and maintained.
>
> — USA Environmental Protection Agency

Does provide some useful project ideas

- **disparities in the way communities are planned, developed, and maintained**

- Chicago 1995 heatwave
  - 700 people died over 5 days
  - Most African Americans, older adults, and low-income residents
  - More men died - thought that women had greater social ties

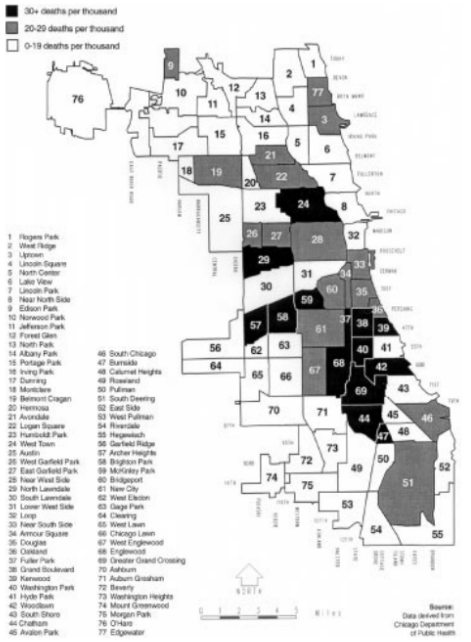


Figure 3. Chicago community areas with highest heat-related death rates.

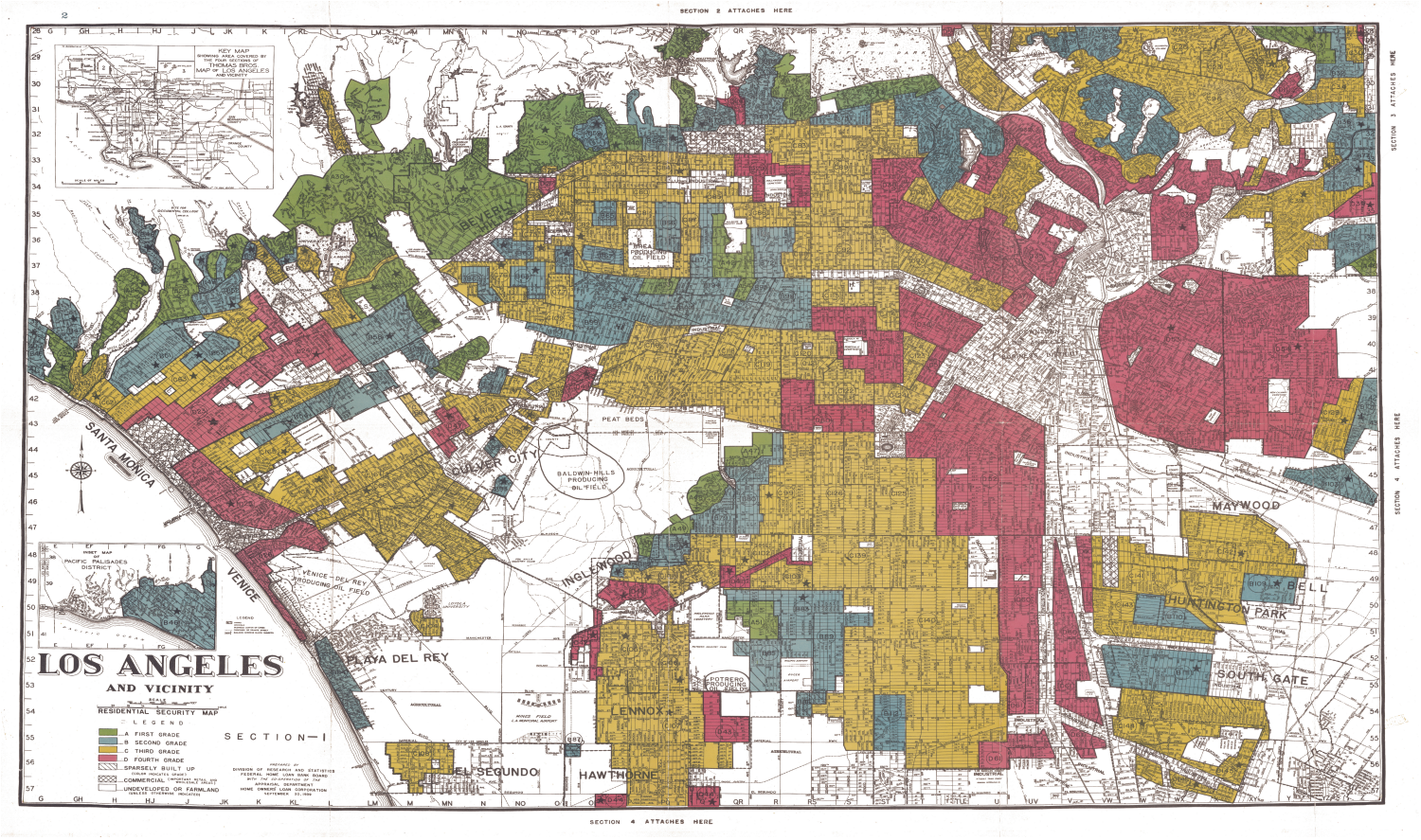
Source:ERIC KLINENBERG. Denaturalizing disaster: A social autopsy of the 1995 Chicago heat wave

Does provide some useful project ideas

- **disparities in the way communities are planned, developed, and maintained**

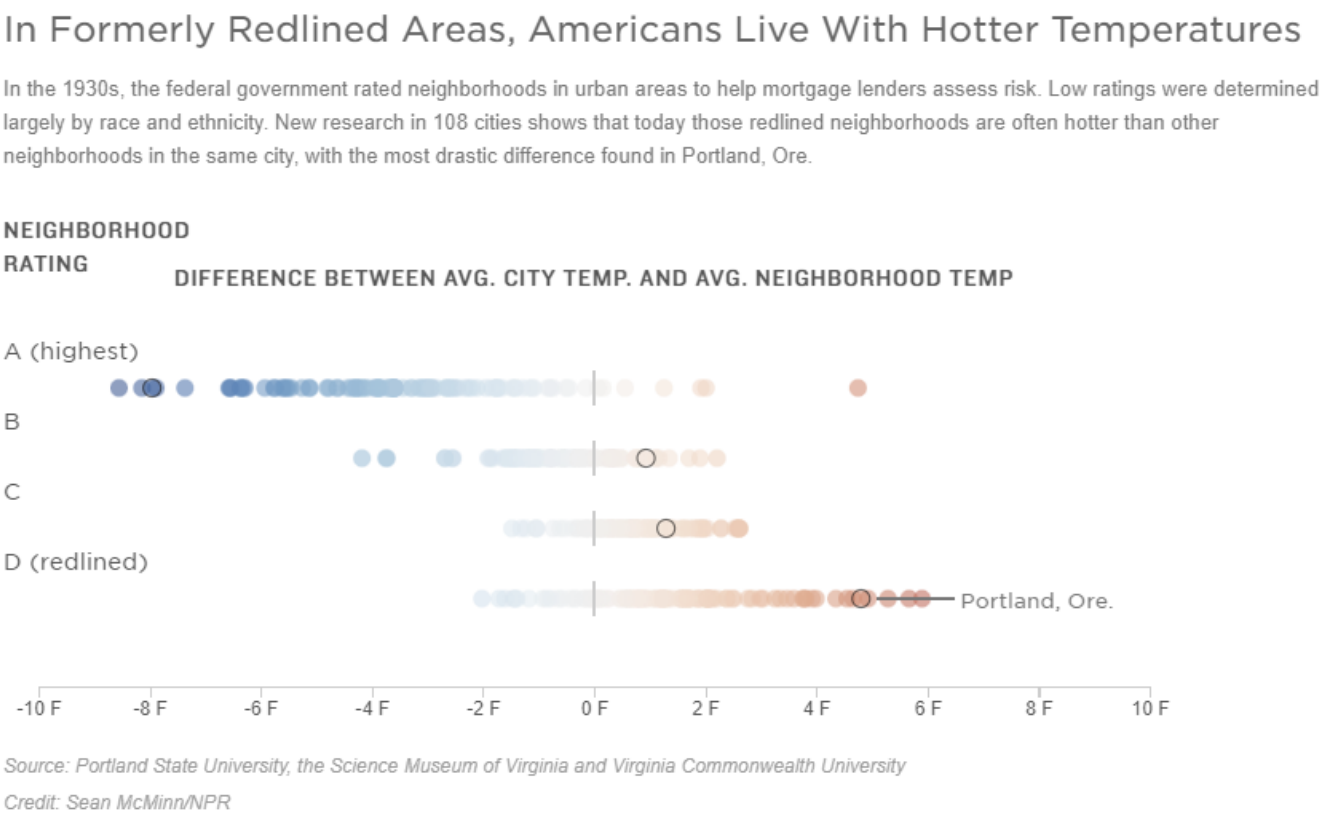
> In the 1930s the American Home Owners' Loan Corporation (HOLC) was tasked with refinancing mortgages on properties to prevent missed payments. To do this the HOLC assessed the **"credit-worthiness" of neighbourhoods, dividing them largely on race into grades between A, considered the "best", and D considered "hazardous"**, drawn around in red, hence the term "redlining". Other services such as healthcare and infrastructure investments were decided in similar way
>
> The Civil Rights Act of 1968 (the Fair Housing Act) made it unlawful to discriminate housing or financing in this manner. However, the redlining legacy has left severe social equity issues across cities, such as access to outdoor space, clean air and trees. .
>
> — Andy MacLachlan, former practice question

Does provide some useful project ideas



Source:Mapping Ineqaulity Redlining in New Deal America

Does provide some useful project ideas



Source:NPR

A short history on redlining (watch later)

Does provide some useful project ideas

- Developing countries, which area has access to cooler spaces?

Mumbai. Source:unequalscenes

Metropolitan (city) policy / temperature reduction activities

Metropolitan UHI reduction activities

- Voluntary
  - Chicago's green roof
  - Baltimore's tree vouchers
- Policy
  - Metropolitan strategies
    - Perth and Peel @3.5 million
    - The London Plan
    - Singapore's Master Plan
  - Local city mandates
    - Seattle's Green Factor
    - Baton Rouge's landscape ordinance
    - Fremantle's Urban Forest: 20% canopy coverage (2020) – AUD 2.57million

Source: The London Plan

Metropolitan UHI reduction activities

- Seattle's policy = Green Factor
  - increases the amount of and improves the quality of landscaping in new development
  - Development standards for certain areas require landscaping that meets a minimum Green Factor score
  - You must reach a **minimum score established by the zoning of your property**
  - e.g. "Commercial and Neighborhood Commercial (NC1, NC2, NC3, C1, C2): Minimum score 0.30"

Green Factor Scoresheet PAGE 1 — SEATTLE green factor

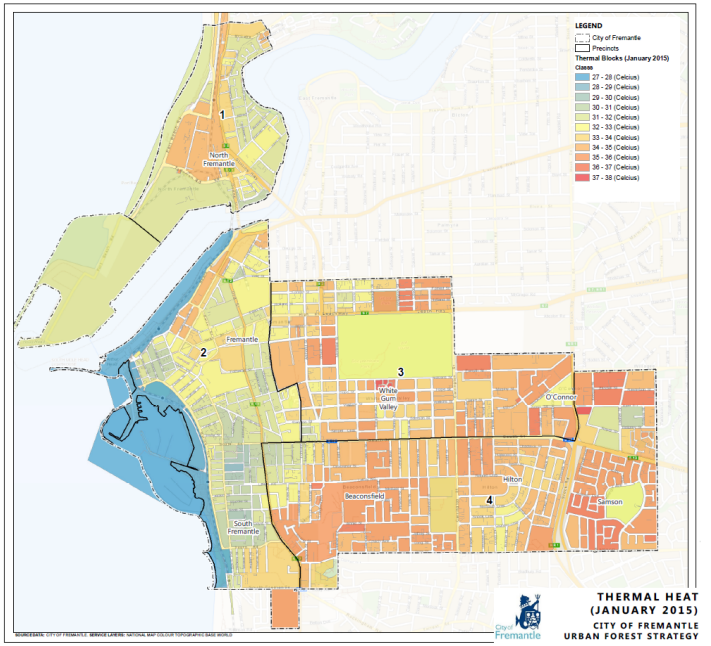
Project title:		Enter sq ft of parcel			
	Parcel size	0		SCORE	#DIV/0!
	Landscape Elements**	Totals calculate from Green Fac	automatically tor Worksheet	Factor	Total
A	**Planted areas**		0	0.6	0
1	Planted areas with a soil depth of 24" or greater		square feet		
2	Bioretention facilities		0	1	0
			square feet		
B	**Plantings (credit for plants in landscaped areas from Section A)**				
1	Mulch, ground covers, or other plants less than 2' tall at maturity		0	0.1	0
			square feet		
2	Medium shrubs or perennials 2'-4' tall maturity - calculated at 9 sq ft per plant (typically planted no closer than 18" on center)	0 plants	0	0.3	0
3	Large shrubs or perennials 4'+ at maturity - calculated at 36 sq ft per plant (typically planted no closer than 24" on center)	0 plants	0	0.3	0
4	**Small Trees** Tree canopy for "Small Trees" or equivalent (canopy spread of 8' to 15') - calculated at 75 sq ft per tree	0 trees	0	0.3	0
5	**Small/Medium Trees** Tree canopy for "Small/Medium Trees" or equivalent (canopy spread 16' to 20') - calculated at 150 sq ft per tree	0 trees	0	0.5	0
6	**Medium/Large Trees** Tree canopy for "Medium/Large Trees" or equivalent (canopy spread of 21' to 25') - calculated at 250 sq ft per tree	0 trees	0	0.7	0
7	**Large Trees** Tree canopy for "Large Trees" or equivalent (canopy spread of 26' or more) - calculated at 350 sq ft per tree	0 trees	0	0.9	0
8	**Preserved Trees** Tree canopy for preservation of existing trees with trunks 6"+ DBH (Diameter at Breast Height, 4.5' above the ground) - calculated at 20 sq ft per inch diameter	0 inches	0	1	0

Source:Seattle.gov

But where [what location] is the vegetation required?

Fremantle's Urban Forest Plan

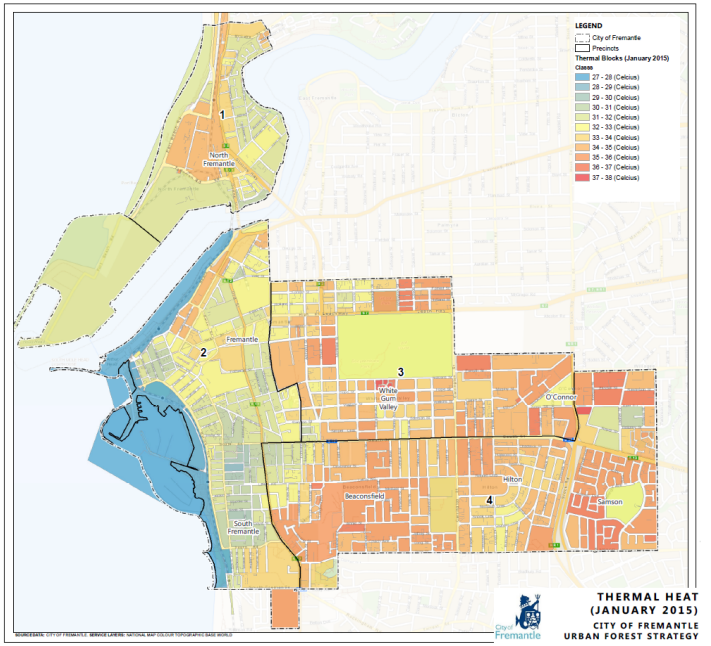
- Maintain and enhance vegetation
- Increase quantity and distribution of green areas/tress (20% canopy coverage)
- Encourage greening of hard surfaces (e.g. parking) and in private realm
- First city to use data to inform their cooling / greening strategy
- But, what are the issues with their approach?



Source:City of Fremantle

Fremantle's Urban Forest Plan

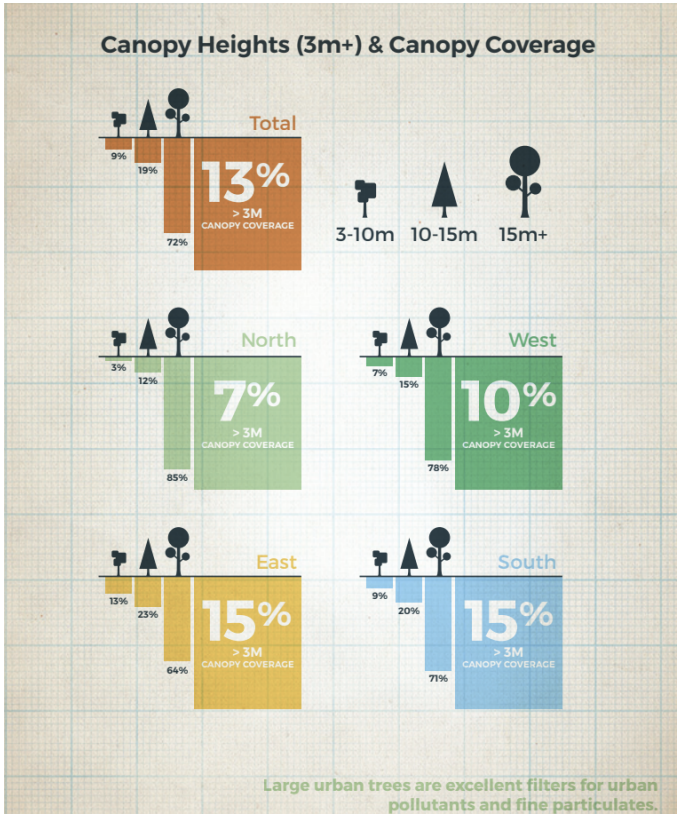
- But, what are the issues with their approach?
  - Temperature image from one day in January
  - Believe this is from Landsat data (see practical)
  - 30 m data that has been aggregated to block (street block level)
  - Not reproducible for other dates / cities
  - What assumptions were made



Source:City of Fremantle

Fremantle's Urban Forest Plan

- Does size of tree matter?



Source:City of Fremantle

Fremantle's Urban Forest Plan (watch later)

Rethinking planning requirements

Perth Metropolitan Area

- Follows the original landscape ordinance of 10% of any gross sub divisible area required for open space
  - Unaltered since Stephenson– Hepburn metropolitan regional plan was legislated in 1955
  - based on population density values, with an assumed number of persons likely to be housed across various residential codes
  - Grose (2017) = gross underestimtation of open space

Singapore

- Singapore's 2011 open space provisioning is defined as 4.05 m2 for every 56.0 m2 of gross floor area
  - detailed landscaping requirements such as grass coverage, tree girth, and minimum branches, yet excludes landscape arrangement conditions

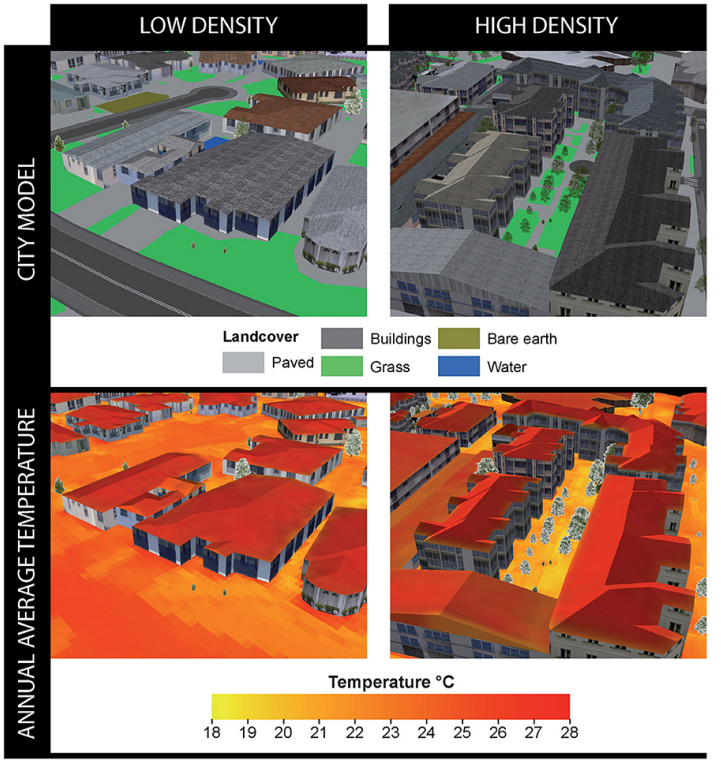
Rethinking planning requirements

Following slides refer to Mean radiant temperature (MRT)

...this is the temperature that surrounds a point

Rethinking planning requirements

- Low density is the statistical area of Currambine – North of Perth.
- High density is from the city of Subiaco, West of Perth. Follows the Subiaco Redevelopment Scheme which supersedes the Metropolitan Region Scheme. It seeks improved social, economic and environmental development outcomes and transformed underutilized industrial land.
- In 2011 – population density was very similar, now Subiaco has more than double the density of Currambine with lower temperatures of between 1 and 0.6 degree Celsius dependent on land cover.

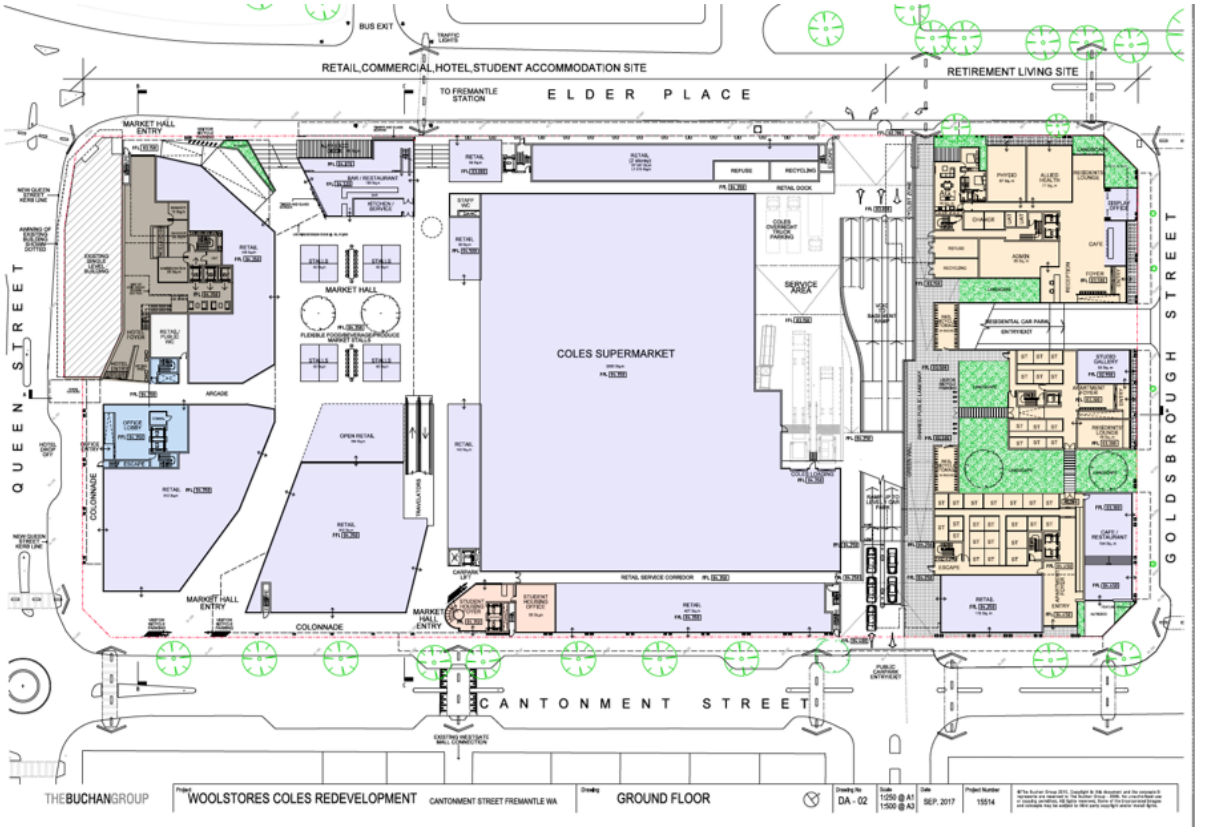


Source:MacLachlan et al. 2021

Rethinking planning requirements

- 11/4/18 denied, too high and does not have distinctive architecture befitting it's location and exceptional design quality.

Rethinking planning requirements

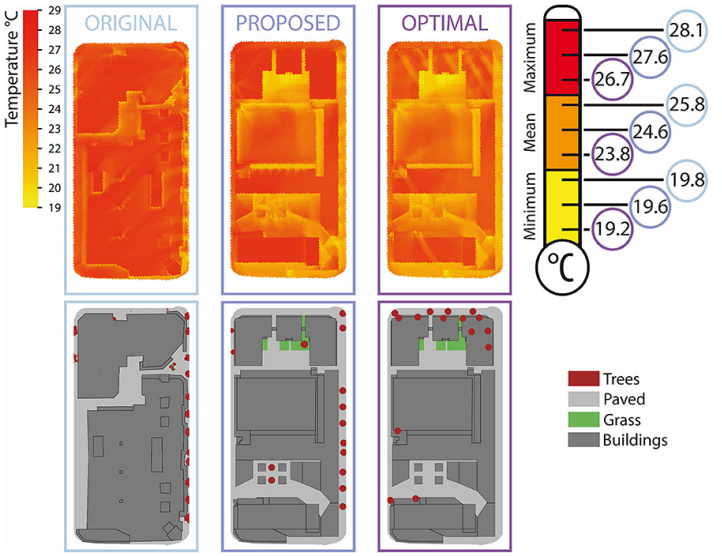


Rethinking planning requirements

Ran 4 scenarios:

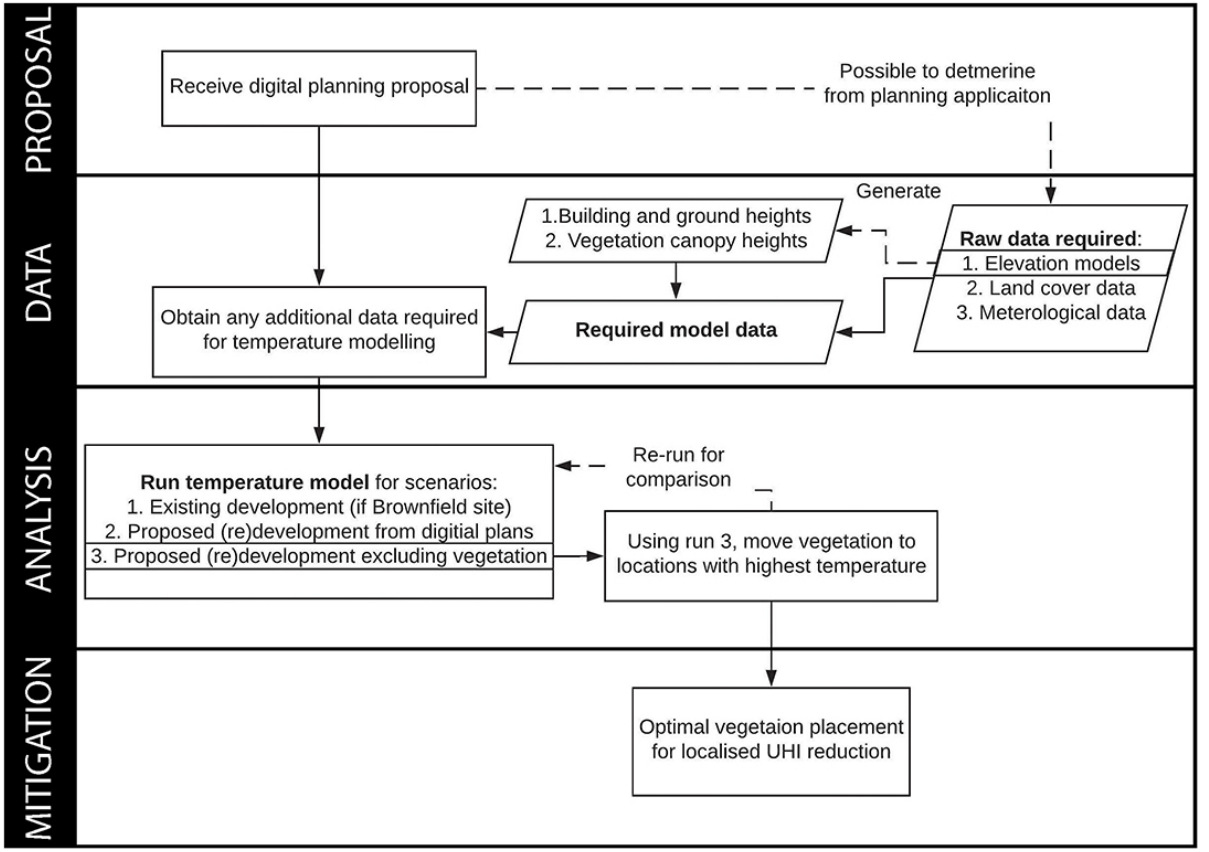
1. Original (existing) development (from satellite imagery)
2. Proposed redevelopment as in the plan
3. Proposed redevelopment removing trees
4. Proposed redevelopment with trees covering the hottest pixels

On average reduced temperature by 0.8 degrees Celsius across the study area.



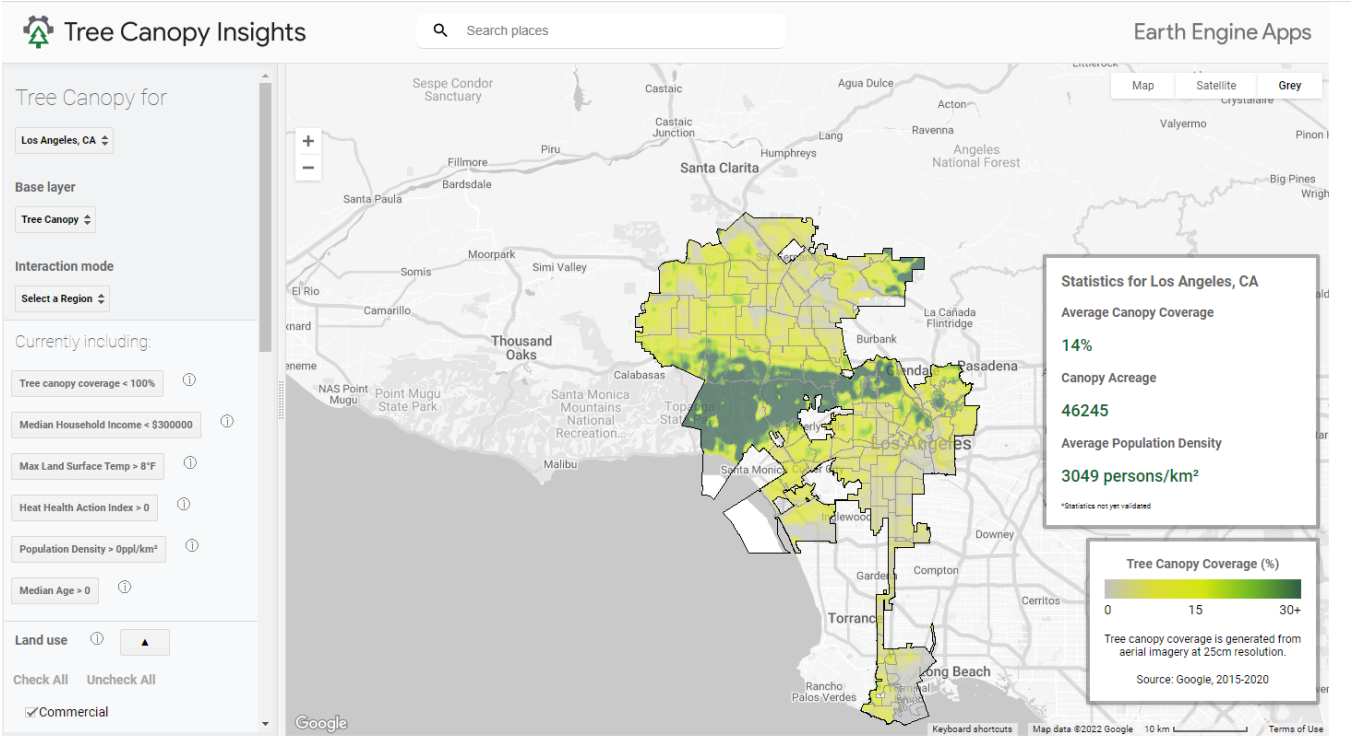
Source:MacLachlan et al. 2021

What is achievable ...



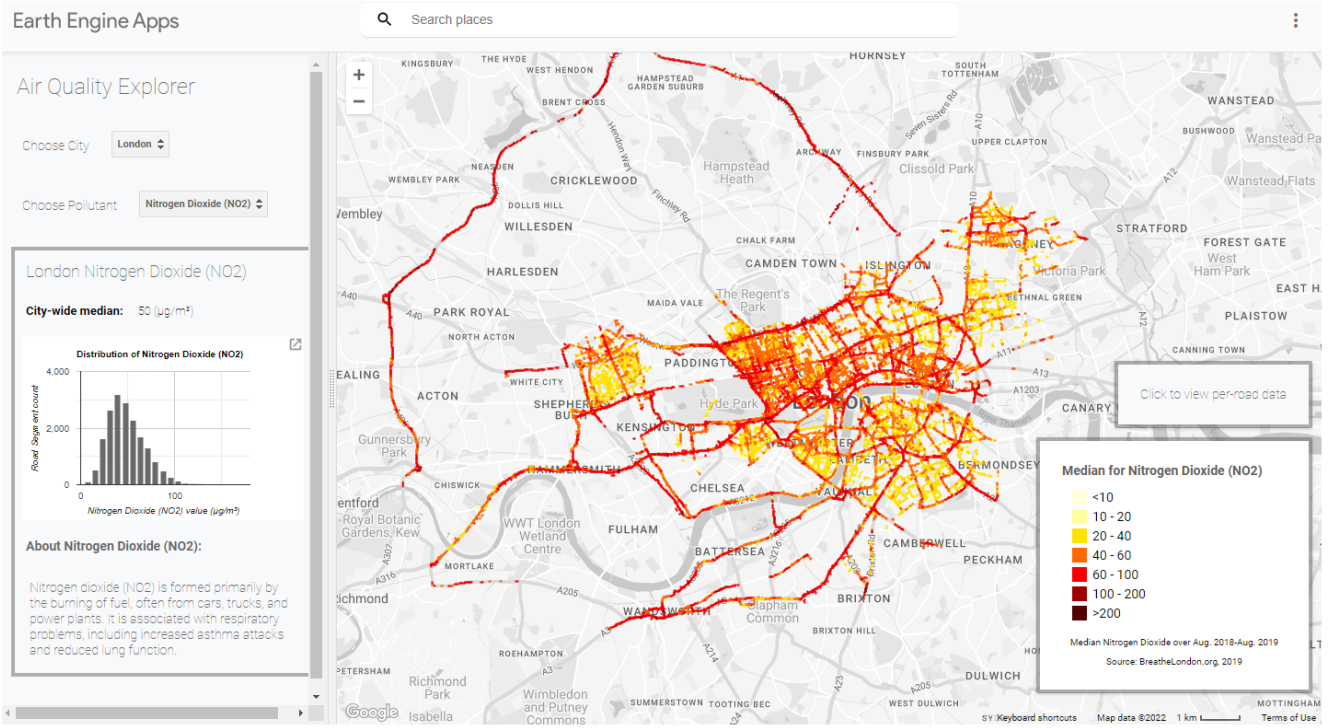
Source:MacLachlan et al. 2021

New datasets



Source:Google Environmental Insights Explorer

New datasets



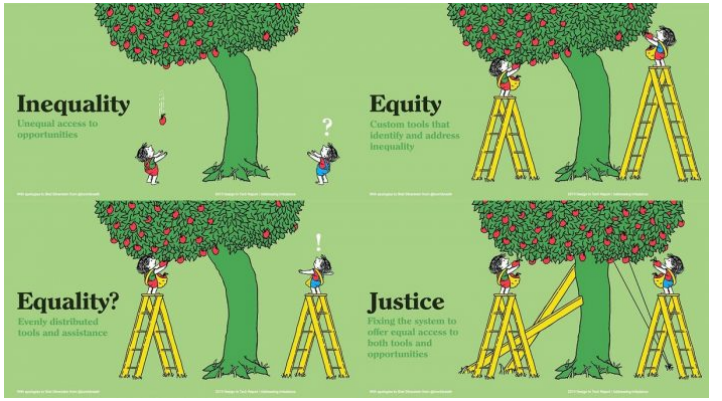
Source:Google Environmental Insights Explorer

Other Google data

Making sense of this

Making sense of this

- There is a gap between global, metropolitan, local policy and data analysis
- The analysis needs to solve the problem and be usable
- Should we focus on **equal** access/ distribution or **equitable** access / distribution or providing environmental **justice**
- Are policies themselves the problem
- How could other cities use the same methods - e.g. could Sydney use the same temperature approach as Fremantle.



Source:Nikki Erdmann

Approaching projects

Approaching projects

First

- Search for EO data...we have seen (or will see) the following data
  - Temperature
  - Landcover
  - Pollution
  - Elevation
  - Texture / Spectral
  - **Not** constrained to this list
- Identify an issue (look at local policy documents)
- Look at global policy documents (to see the link)

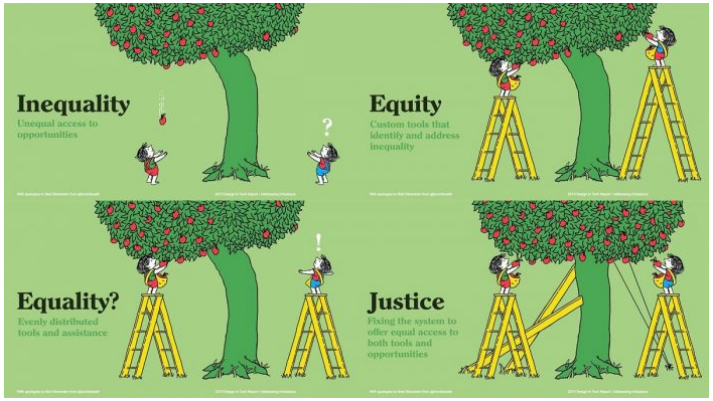
Second

- What can be solved with the data **or**
- What could this data contribute to another question (e.g. including it as a variable) **or**
- How could the remotely sensed data be included within a data workflow **or**
- Anything else as long as it includes EO data (or some sort, at some stage) and analysis for solving a policy question.

You can use ideas presented within the lectures

Summary

- Expanding cities and induce social, economic and environmental pressures
- Previous spatial decisions can dictate how these pressures are distributed across the city / population.
- Global policy can often be vague and ambiguous, lacking clear guidance
    - **How much/what** guidance does a city planner need?
- Approaches can often disregard the **spatial element**...should the policy / plan be
    - Equally distributed (e.g. tree vouchers)
    - Equitably distributed (e.g. reflective streets)
    - Or the system changed (e.g. transforming neighborhoods)



Source:Nikki Erdmann