CRC for
Water Sensitive Cities

4th water sensitive cities conference

Australian Government
Department of Industry and Science

Business
Cooperative Research
Centres Programme

Informing urban planning decisions: Amaravati

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Mosaic Insights

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MOSAIC insights

alluvium

Amaravati

Andhra Pradesh was split in two and a new capital city is being built.

Looking at the potential of urban forests to reduce the urban heat island effect and improve human thermal comfort.

Amaravati presents climatic challenges such as:
– extremely hot
– extremely humid
– large amount of water for 6 months of the year

We model urban forest strategies (including street trees) on the city wide scale, on a typical residential neighbourhood and for a section of the government complex.

Quantitative and qualitative analysis

TARGET model

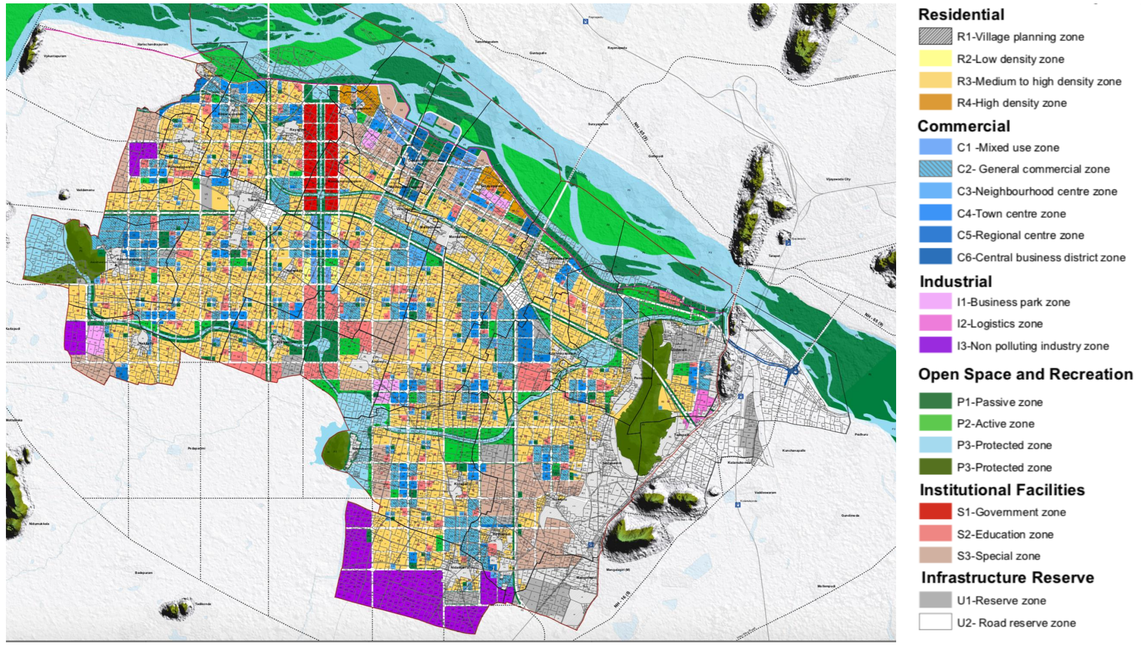
The **A**ir-temperature **R**esponse to **G**reen/blue-infrastructure **E**valuation **T**ool

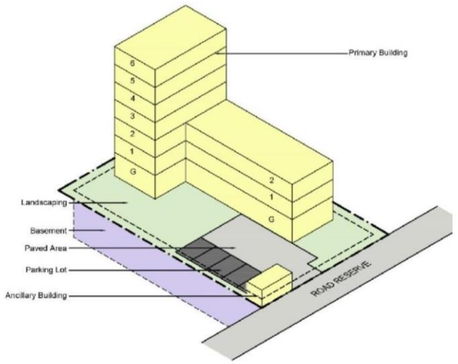
Simple model that enables users to test the cooling effect of adding in water, irrigated grass and trees to the landscape.

Can be used from the micro-scale 10m to the city-wide scale 10s km.

The model input is a GIS layer of the different land surface types. Need to specify the land fractions of:

- Road
- Roof
- Concrete
- Dry grass
- Irrigated grass
- Trees
- Water
- Road width
- Building height



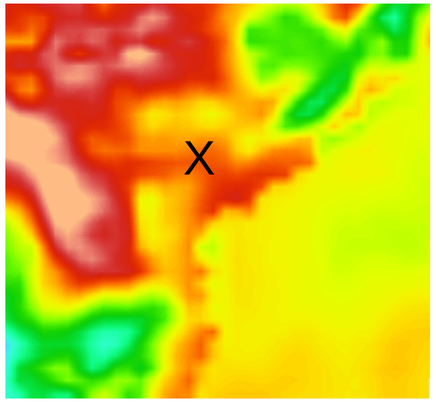


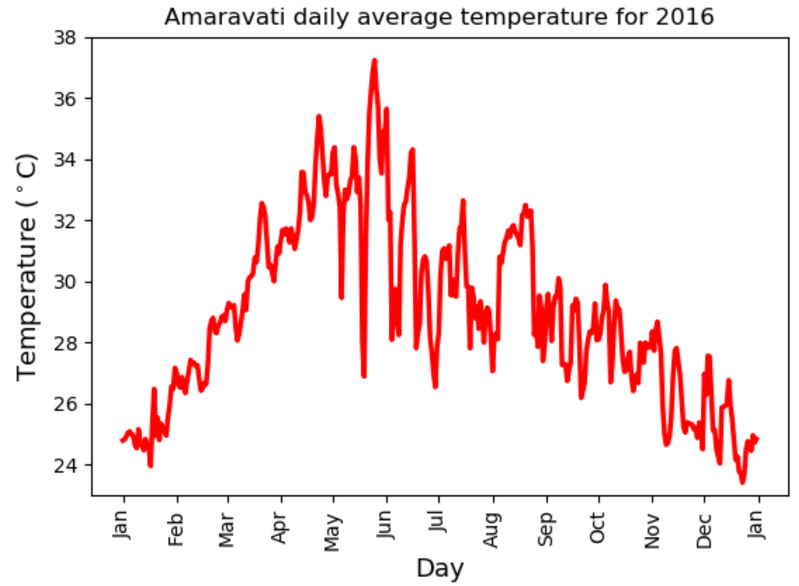
Meteorological input data

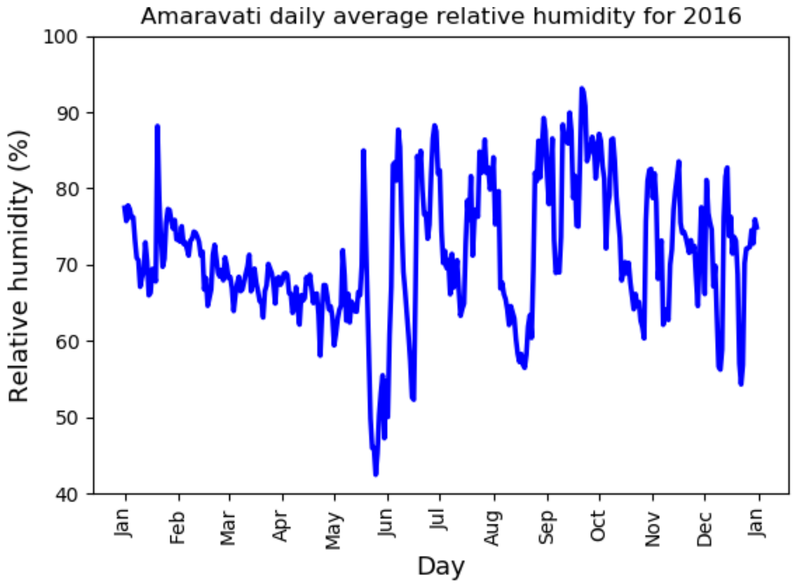
The TARGET model needs weather data:
– Air temperature (˚C)
– Relative humidity (%)
– 10m wind speed (m/s)
– Air pressure (hPa)
– Downward shortwave radiation (Wm^{-2})
– Downward longwave radiation (Wm^{-2})

Weather station data can be hard to source, instead accessed data from ERA5. Data is hourly every 30km.

Accessed closest point to Amaravati.

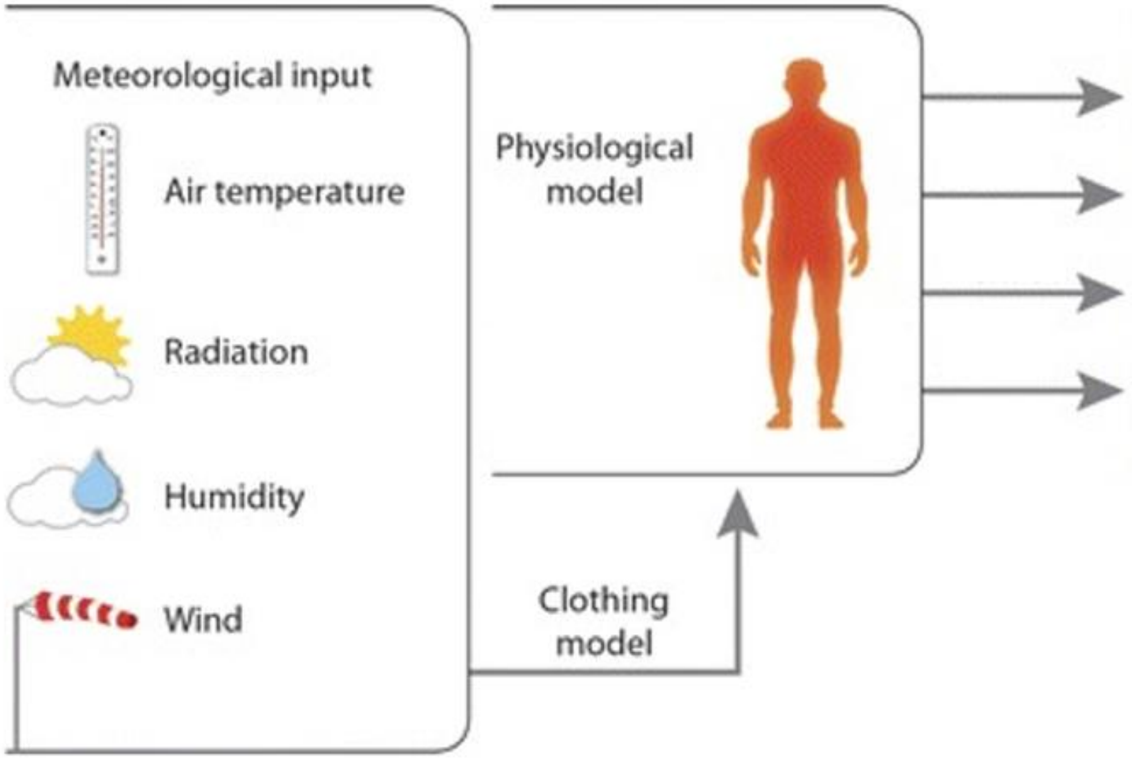






Human thermal comfort

Universal Thermal Climate Index



UTCI (°C) range	Stress Category
above +46	extreme heat stress
+38 to +46	very strong heat stress
+32 to +38	strong heat stress
+26 to +32	moderate heat stress
+9 to +26	no thermal stress
+9 to 0	slight cold stress
0 to -13	moderate cold stress
-13 to -27	strong cold stress
-27 to -40	very strong cold stress
below -40	extreme cold stress

What are we exploring?

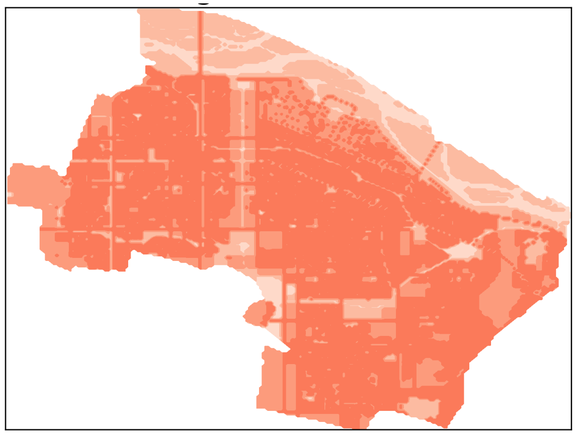
How does the temperature and human thermal comfort change if…

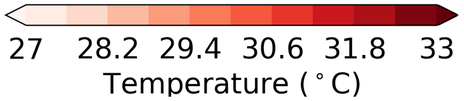
- We have 40% canopy cover on along roads?
- We put green roofs on buildings?
- We irrigate dry grass?
- We increase trees?

Investigating during the morning (7-10am) when people are most likely to be outdoors commuting.

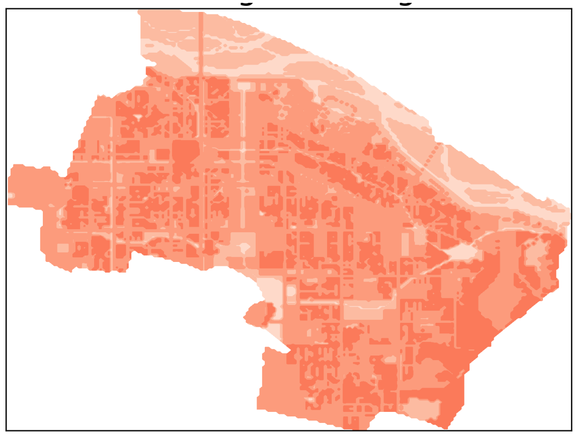
City-wide scale

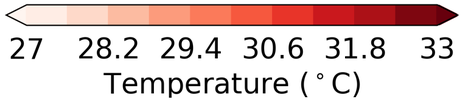
Business as usual

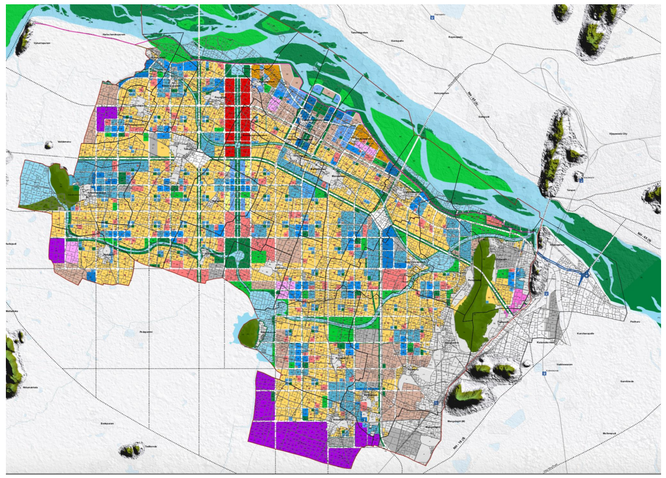




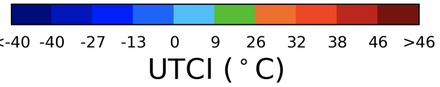
Greening







Business as usual



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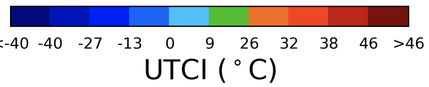

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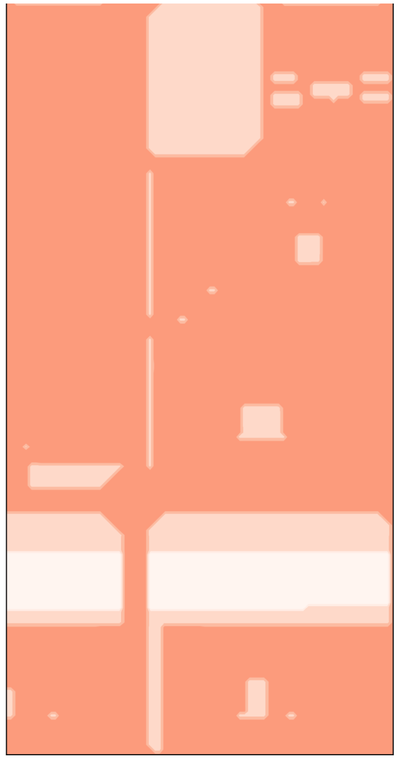
Temperature ↓ with trees, irrigated grass and green roofs

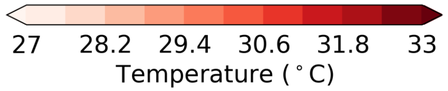
Human thermal comfort improved but not enough to change the heat stress category.

Residential areas

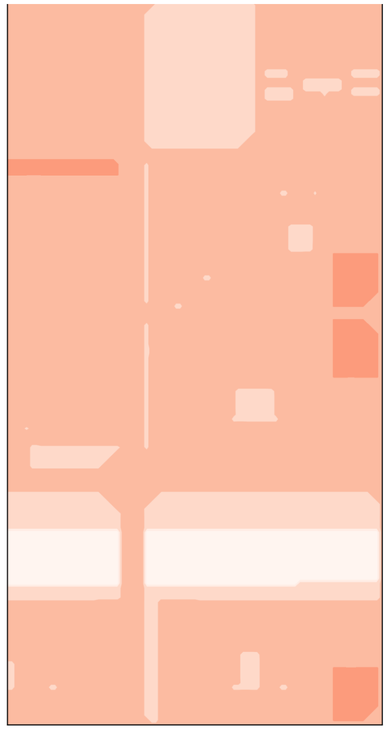
Medium to high density zone – greening effective at reducing the temperature

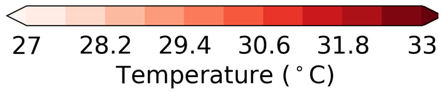
Business as usual



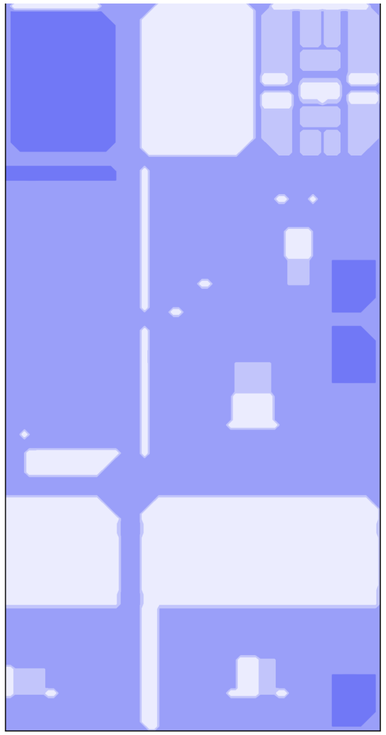


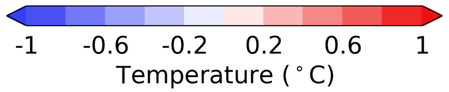
Greening

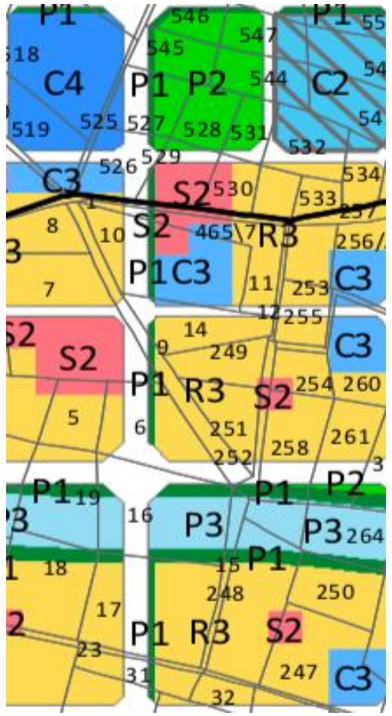




Difference







Residential
- R1-Village planning zone
- R2-Low density zone
- R3-Medium to high density zone
- R4-High density zone

Commercial
- C1 -Mixed use zone
- C2- General commercial zone
- C3-Neighbourhood centre zone
- C4-Town centre zone
- C5-Regional centre zone
- C6-Central business district zone

Industrial
- I1-Business park zone
- I2-Logistics zone
- I3-Non polluting industry zone

Open Space and Recreation
- P1-Passive zone
- P2-Active zone
- P3-Protected zone
- P3-Protected zone

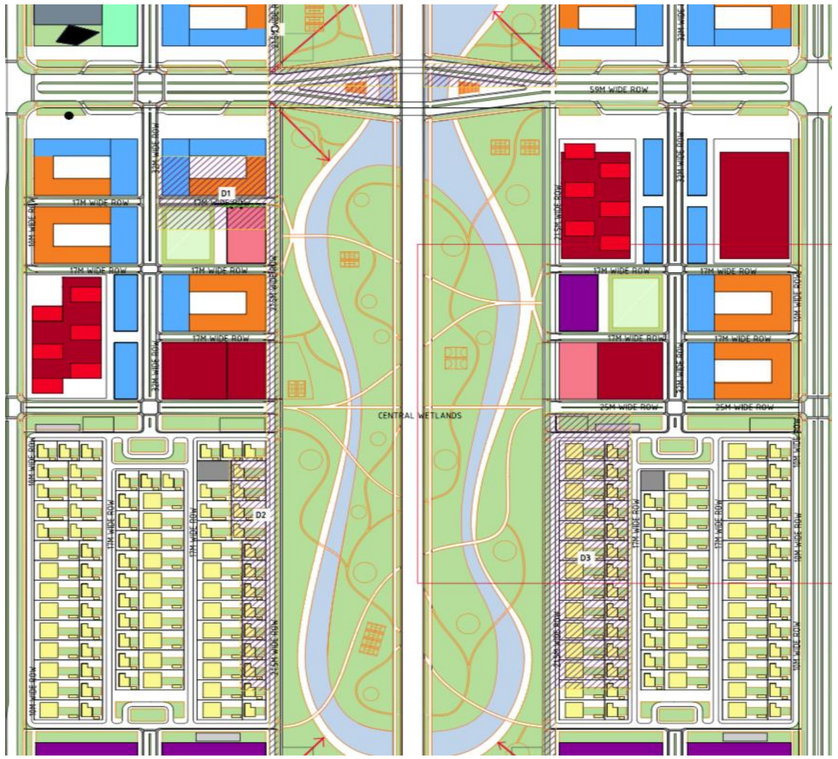
Institutional Facilities
- S1-Government zone
- S2-Education zone
- S3-Special zone

Infrastructure Reserve
- U1-Reserve zone
- U2- Road reserve zone

Government Complex – Superblock D

Will the streets need shading from trees or will the buildings cast a shadow?

Maximum temperature reduction from shading occurs at H:W = 4, if less there are benefits from street trees for shade.



RESIDENTIAL
- SR2a-Low Density Private
- SR2b-Low Density Private
- SR4a-High Density Private

COMMERCIAL
- SC1A-Mixed Use
- SC1B-Mixed Use

OPEN SPACE AND RECREATION
- SP1- Passive Zone
- SP3-Protected Zone
- SP4-Active Zone

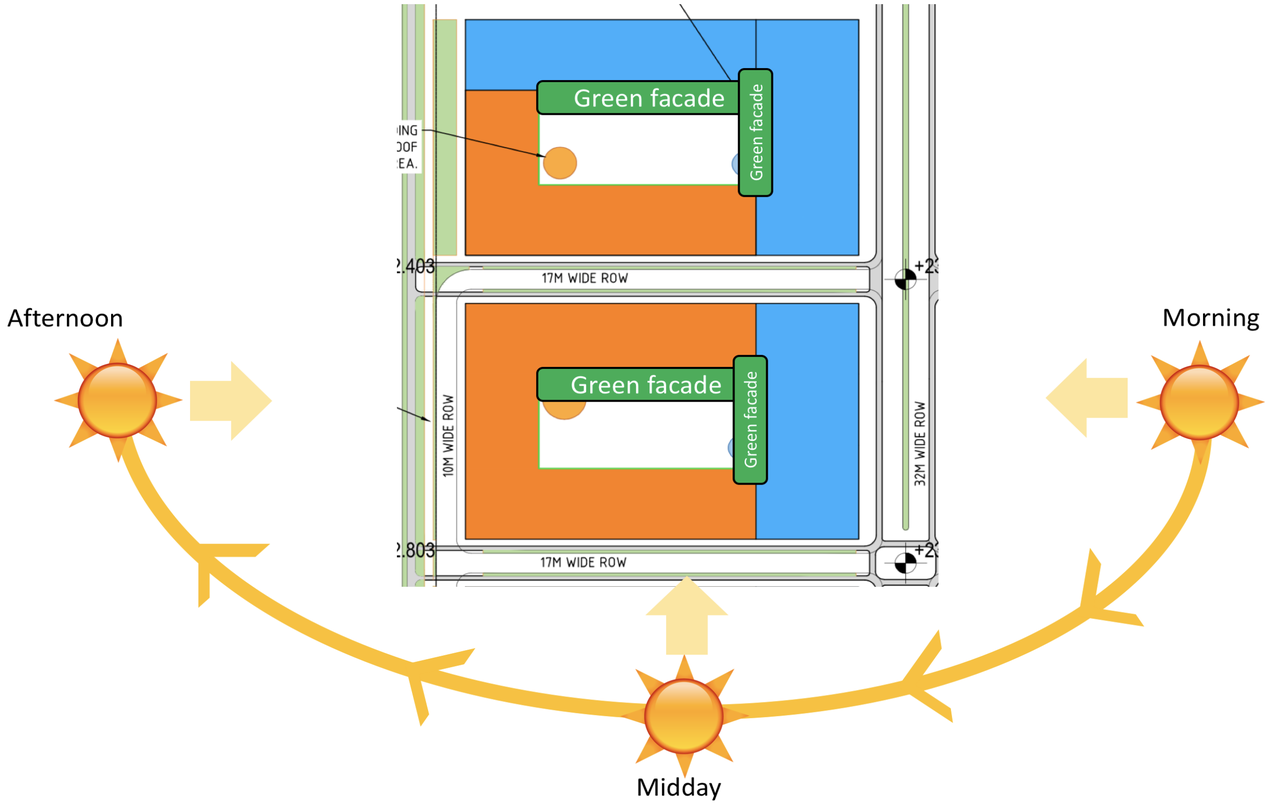
INSTITUTIONAL FACILITIES
- S1-Government Zone
- S2- Education Zone
- S4-Cultural Zone
- S5-Health Zone
- S6-Other Special Zone (Police, Fire,...)

INFRASTRUCTURE RESERVE
- U1-Reserve Zone (Utilites)
- U2a- Road Network Vehicular
- U2b- Road Network Pedestrian

Superblock D				
Type	Road width (m)	Maximum building height (m)	H:W	Threshold building height for tree benefit (m)
SC1a AN	17	18.00	1.06	51.00
SC1a AN	21.5	18.00	0.84	64.50
SC1a AN	25	18.00	0.72	75.00
SC1a AN	32	18.00	0.56	96.00
SC1a AN	59	18.00	0.31	177.00
SR4a AN	**10**	**70.50**	**7.05**	**30.00**
SR4a AN	**17**	**70.50**	**4.15**	**51.00**
SR4a AN	21.5	70.50	3.28	64.50
SR4a AN	25	70.50	2.82	75.00
SR2 SD/D	10	12.60	1.26	30.00
SR2 SD/D	17	12.60	0.74	51.00
SR2 SD/D	21.5	12.60	0.59	64.50
SS2a AN	17	18.00	1.06	51.00
SS2a AN	21.5	18.00	0.84	64.50
SS2a AN	25	18.00	0.72	75.00
SS3 AN	10	18.00	1.80	30.00
SS3 AN	17	18.00	1.06	51.00
SS3 AN	21.5	18.00	0.84	64.50
SS3 AN	25	18.00	0.72	75.00
SS3 AN	32	18.00	0.56	96.00
SS2B AN	17	18.00	1.06	51.00
SS1 AN	**17**	**250.00**	**14.71**	**51.00**
SS1 AN	**21.5**	**250.00**	**11.63**	**64.50**

Green facades, where and why?

Understanding street orientation and sun position means we can prioritise green infrastructure



Conclusions

- **Urban modelling of a city that doesn’t exist yet**
- **Trees ↑ irrigated grass ↑ water ↑ = temperature ↓**
- **Thermal comfort less likely to change during extreme heat**
- **Analysing the H:W ratio can help decide which streets benefit most from trees**
- **Analysing street orientation can help with green infrastructure prioritisation**