



CHALLENGING HEAT

Lawrence Nield
Architect

NT Government





Google

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- The study area





- July was the hottest month ever recorded in Darwin.
- 2°C higher than any other July (BOM)
- The max and min in Darwin have increased by more than 2°C since 1980



- On television every night you hear the temperature at the Airport not the City Centre
- The City Centre is 1 to 2°C hotter!



VITRUVIUS 27BC

The Site of a City: First comes the choice of a very healthy site. (IV,1)

Therefore, if one of these elements, heat, becomes predominant in any body whatsoever, it destroys and dissolves all with its violence. This may be due to violent heat from certain quarters of the sky, pouring into the open pores in too great proportion to admit of a mixture suited to the natural temperament of the body in question. (IV, 6)

It appears, then, in founding towns we must beware of districts from which hot winds can spread abroad over the inhabitants. (IV, 5)















DARWIN AERIAL SURVEY – WOODS ST. & POST OFFICE CARPARK

Wind speed (m/s)

NW winds

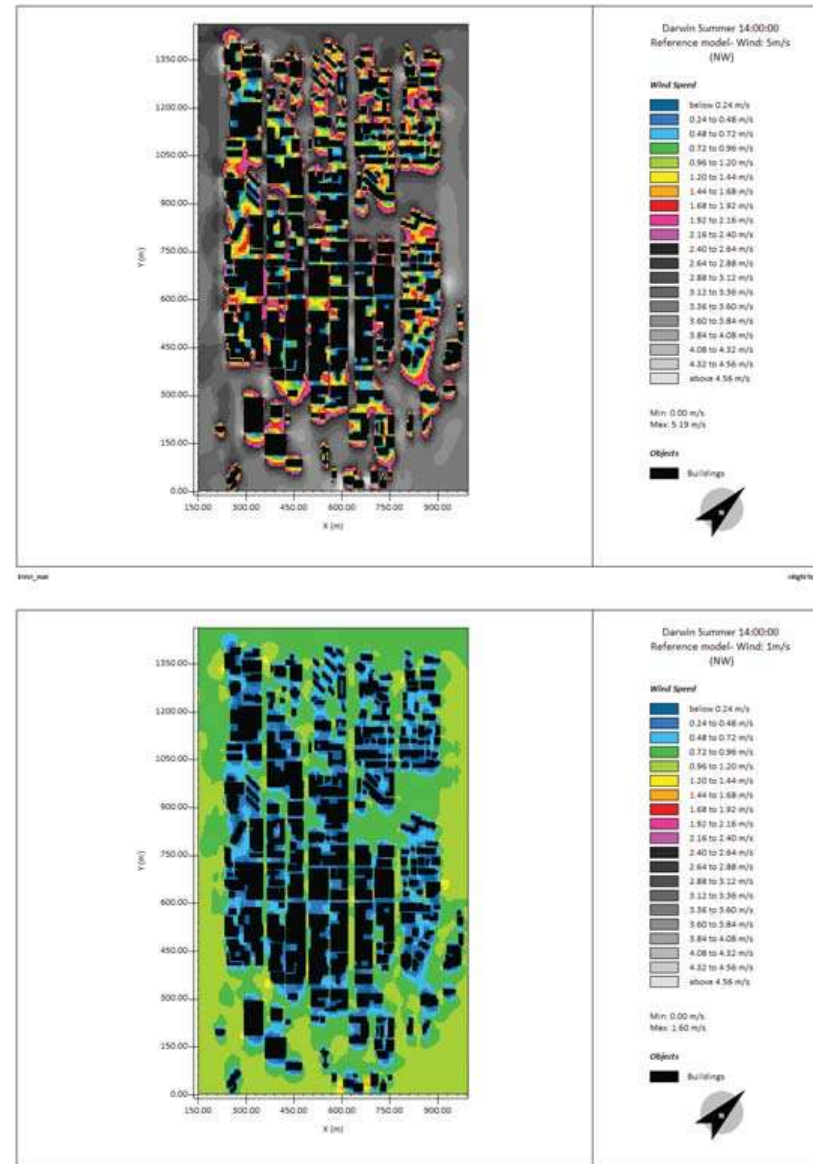


Figure 6. Reference Case: Wind speed in the selected area:5m/s-NW (top), 1m/s-NW (bottom).

SE winds

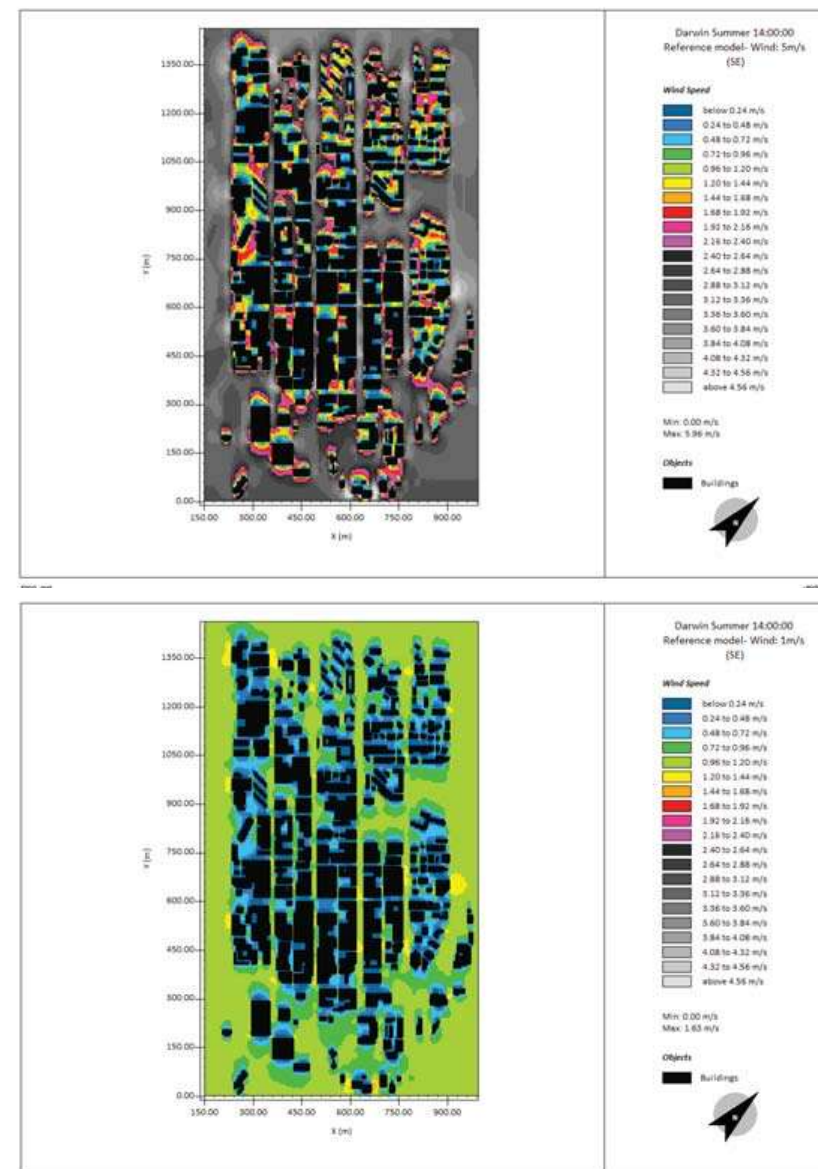


Figure 7. Reference Case: Wind speed in the selected area:5m/s-SE (top), 1m/s-SE (bottom).

Simulation results

Figures 6 and 7 show the wind speed distribution in the simulation of the reference model. The maximum wind speed observed when the model was simulated for the South easterly winds is higher than that for the North westerly winds. It has been shown that the wind speed in open spaces and major car parks of the CBD is mostly above 2.40 m/s and 0.72 m/s in the reference scenario with 5m/s and 1m/s winds, respectively. The maximum wind speed in all conditions occurs in a number of locations, mainly in the Central part of MacMinn street, northern and southern part of Esplanade street, and central part of the Cavenagh street.

Concluding remarks

The reference scenario investigated here, reflects the current situation in the city of Darwin under two wind speeds and prevailing wind directions during summer. The results of the reference scenario are used to evaluate the potential temperature decrease achieved when the proposed mitigation scenarios are applied. The results of the reference scenario indicate that ambient temperature varies between about 32.00°C to about 36.40°C in urban areas when wind speed is taken as 5m/s. The ambient temperature falls within a range of about 32.80°C to about 36.00°C for the wind speed of 1m/s in the reference scenario. The maximum surface temperature of asphalt pavements (parking area) reaches to above 55.00°C and 56.00°C with the wind speed of 5m/s and 1m/s, respectively.

Surface temperature (°C)

NW winds

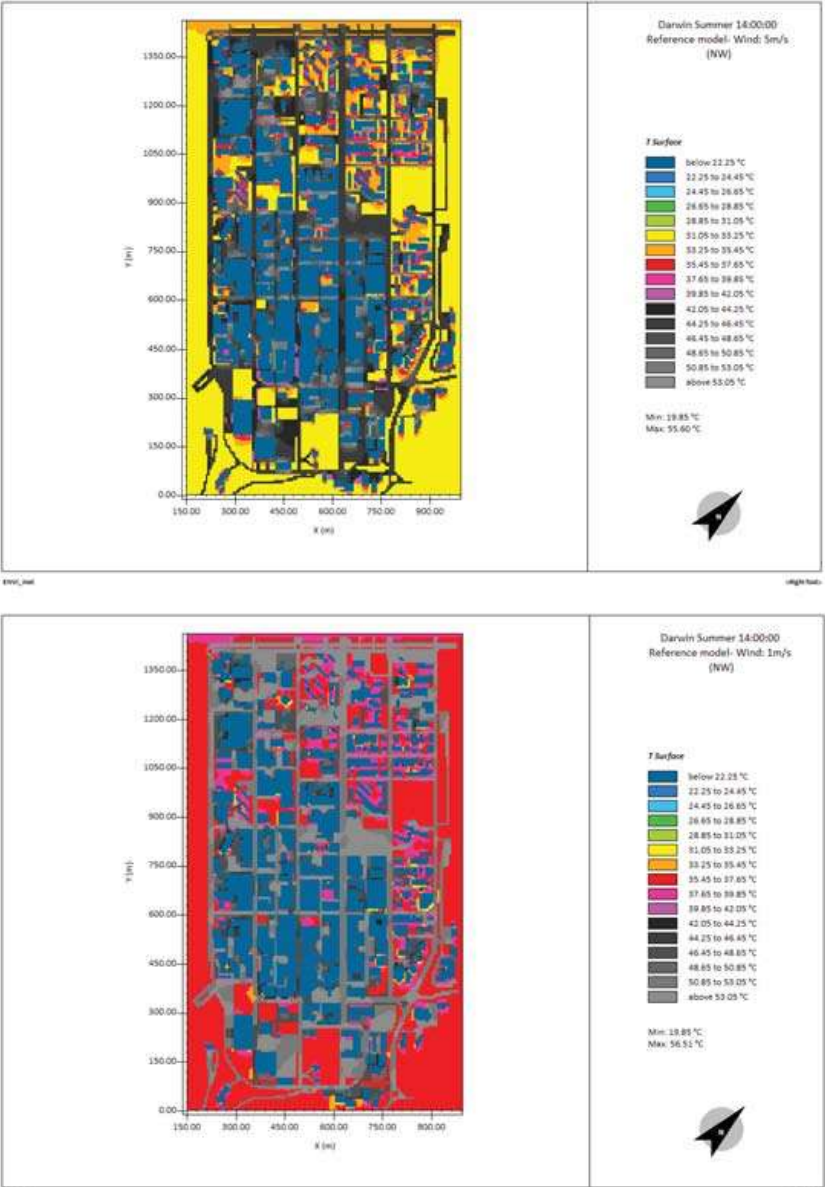


Figure 4. Reference Case: Surface temperature in the selected area: 5m/s-NW (top), 1m/s-NW (bottom).

SE winds

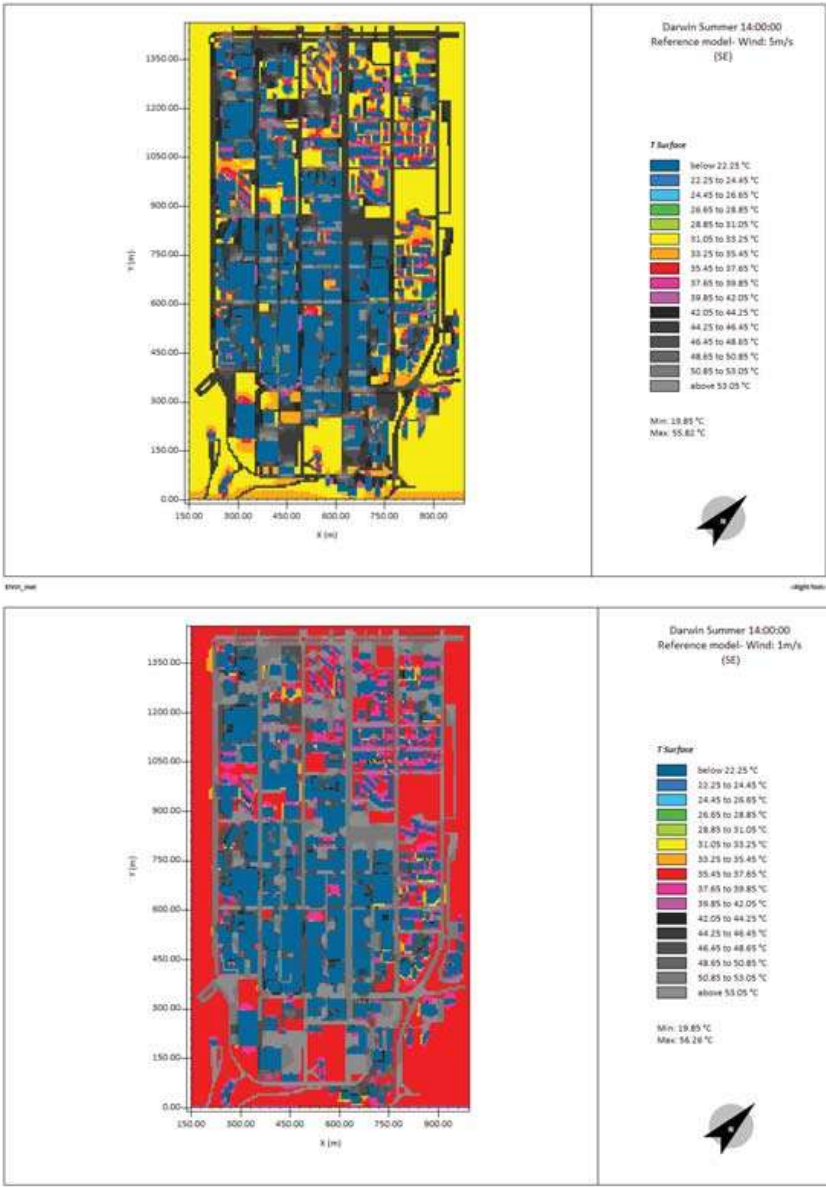


Figure 5. Reference Case: Surface temperature in the selected area: 5m/s-SE (top), 1m/s-SE (bottom).

Simulation results

The simulated distribution of the surface temperature at 14:00:00 in the reference scenario is given in Figure 4 and 5 for North westerly and South easterly winds and for the speed of 1m/s and 5m/s.

It is shown that the surface temperature reaches to 56.5°C in the asphalt car parks and pavements in the reference model when the air speed is 1m/s and wind direction is from North west. Figure 4 and 5 illustrates that the main streets and car parks have highest surface temperature because of a longer period of direct exposure and the asphalt material used. The surface temperature is generally lower in case of the higher wind speed (5 m/s) compared to that when wind speed is 1 m/s in the reference scenario. The maximum and minimum surface temperature ranges from 19.85°C to 55.60°C for the North westerly winds at the speed of 5m/s. The maximum surface temperature for the same wind speed from South east reaches to 55.82°C. The maximum surface temperature when the wind speed is taken as 1m/s is 56.51°C and 56.26°C for North westerly and South easterly winds, respectively.

NW winds

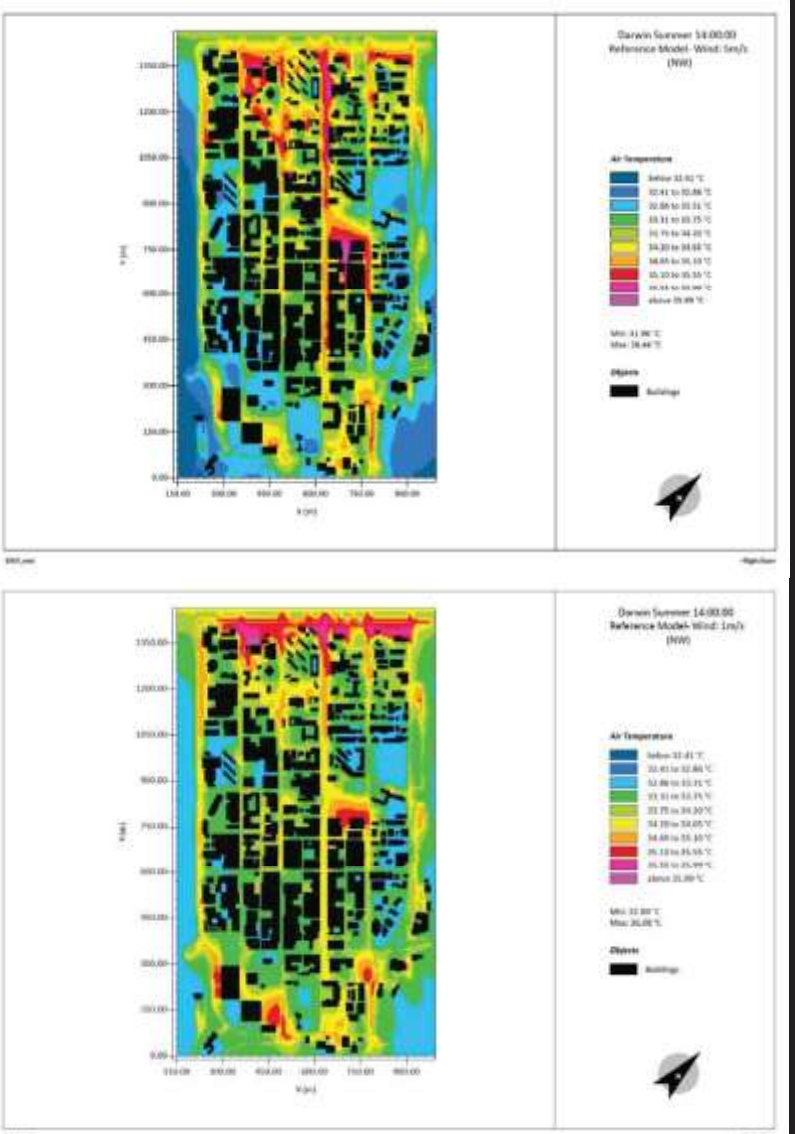


Figure 2. Reference Case: Temperature distribution of the ambient temperature in the selected area: 5m/s-NW (top), 1m/s-NW (bottom).

SE winds

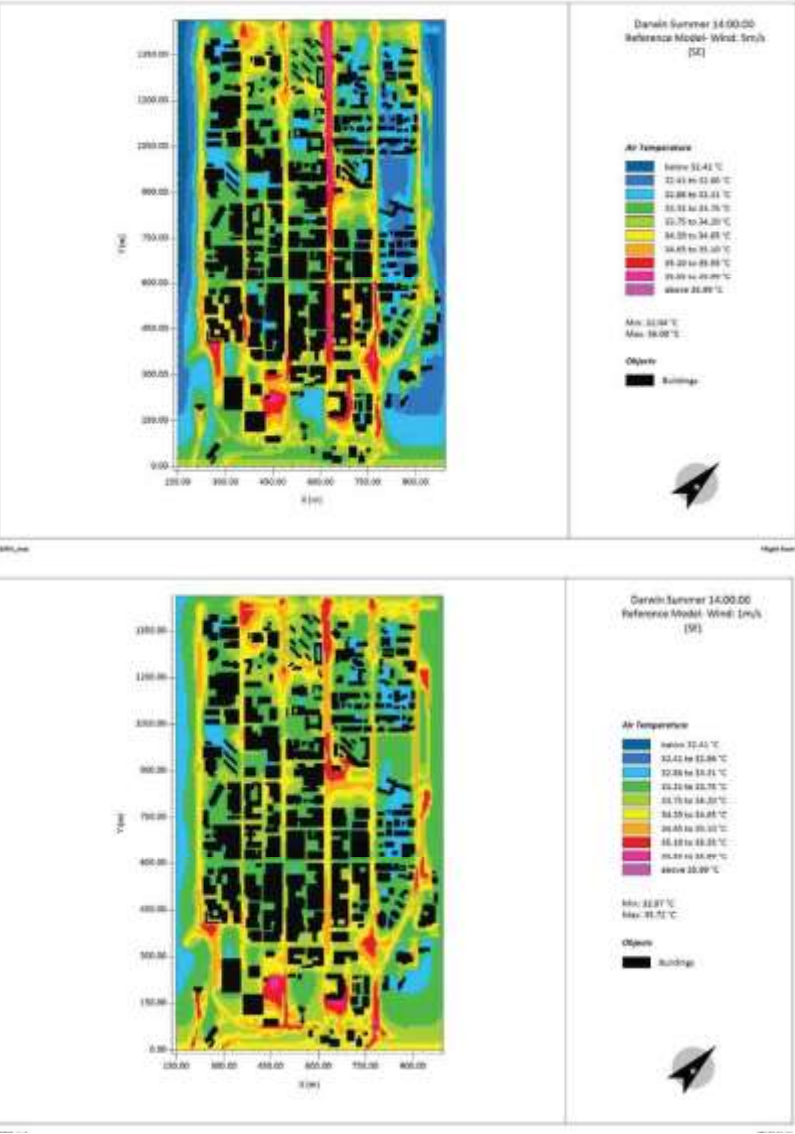


Figure 3. Reference Case: Temperature distribution of the ambient temperature in the selected area: 5m/s-SE (top), 1m/s-SE (bottom).

Simulation results

The model has been made by applying standard values of the urban environment in Darwin. Radiative properties of buildings and pavements include: Albedo roofs = 0.2, Albedo walls = 0.2, Asphalts Albedo=0.05, Concrete pavements Albedo=0.2, Loamy soil Albedo=0.15. Grass is employed for the greenery in the simulation of the base case scenario. The simulated distribution of the ambient temperature in the reference scenario is given in Figure 2 and 3. Thermal maps of the analyzed area are shown, considering the warmest moment of the day (14:00:00 PM). The ambient temperature at the street level of the open spaces (1.46 m above the ground) ranges between 31.9°C to 36.4°C in the reference model. The maximum temperature is obtained with North westerly winds at the speed of 5m/s. Comparison of the 5m/s and 1m/s maps highlights the effects of convection in the study area. Tables 2 and 3 summaries the minimum and maximum temperatures in the reference scenario (whole area) for North westerly and South easterly winds.

Table 2. Statistical summary of the mitigation results – North westerly winds

Scenarios	Maximum ambient temperature (°C)		Minimum ambient temperature (°C)		Reduction of the maximum ambient temperature (K)		Reduction of the minimum ambient temperature (K)		Maximum temperature decrease (K)	
	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s
Reference Model	36.44	36.08	31.96	32.84	-	-	-	-	-	-

Table 3. Statistical summary of the mitigation results – South easterly winds

Scenarios	Maximum ambient temperature (°C)		Minimum ambient temperature (°C)		Reduction of the maximum ambient temperature (K)		Reduction of the minimum ambient temperature (K)		Maximum temperature decrease (K)	
	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s
Reference Model	38.00	35.72	32.04	32.97	-	-	-	-	-	-

Ambient temperature (°C)-NW winds

NW winds

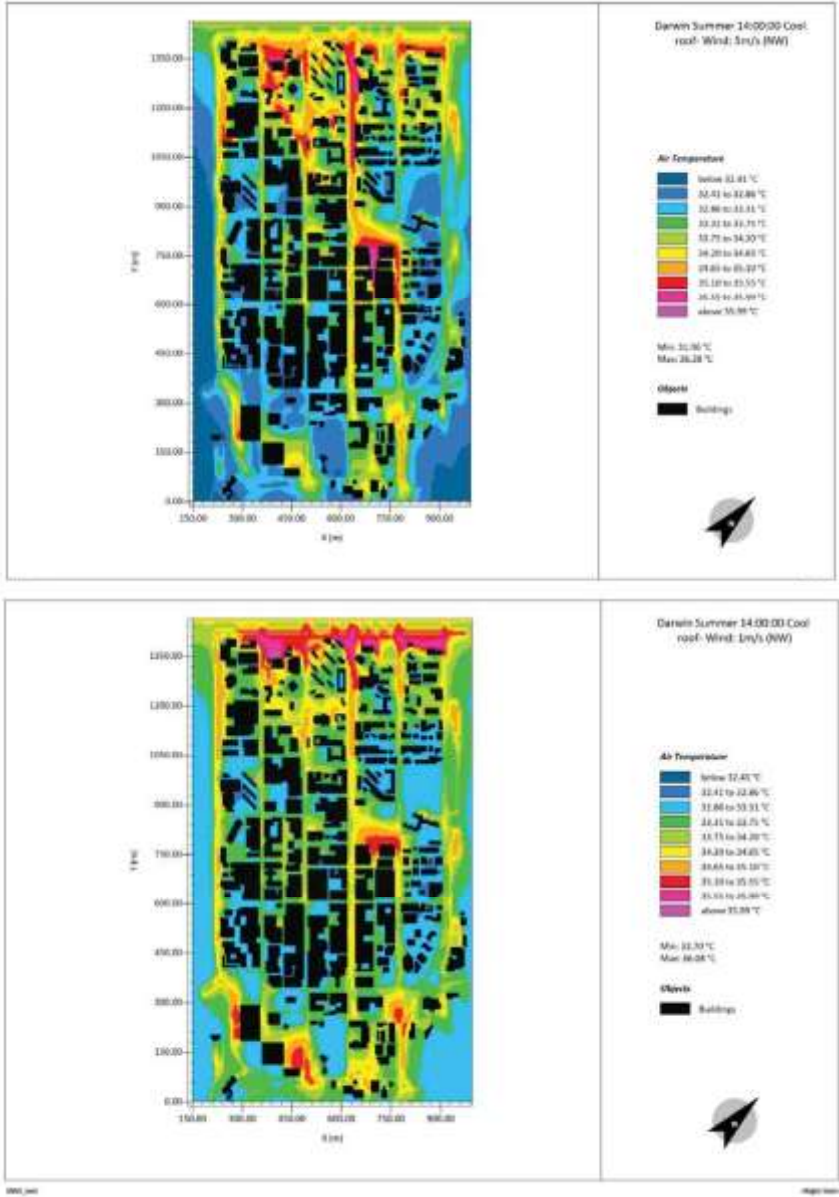


Figure 1. Cool roof: Temperature distribution of the ambient temperature in the selected area: 5m/s-NW (top), 1m/s-NW (bottom)

SE winds

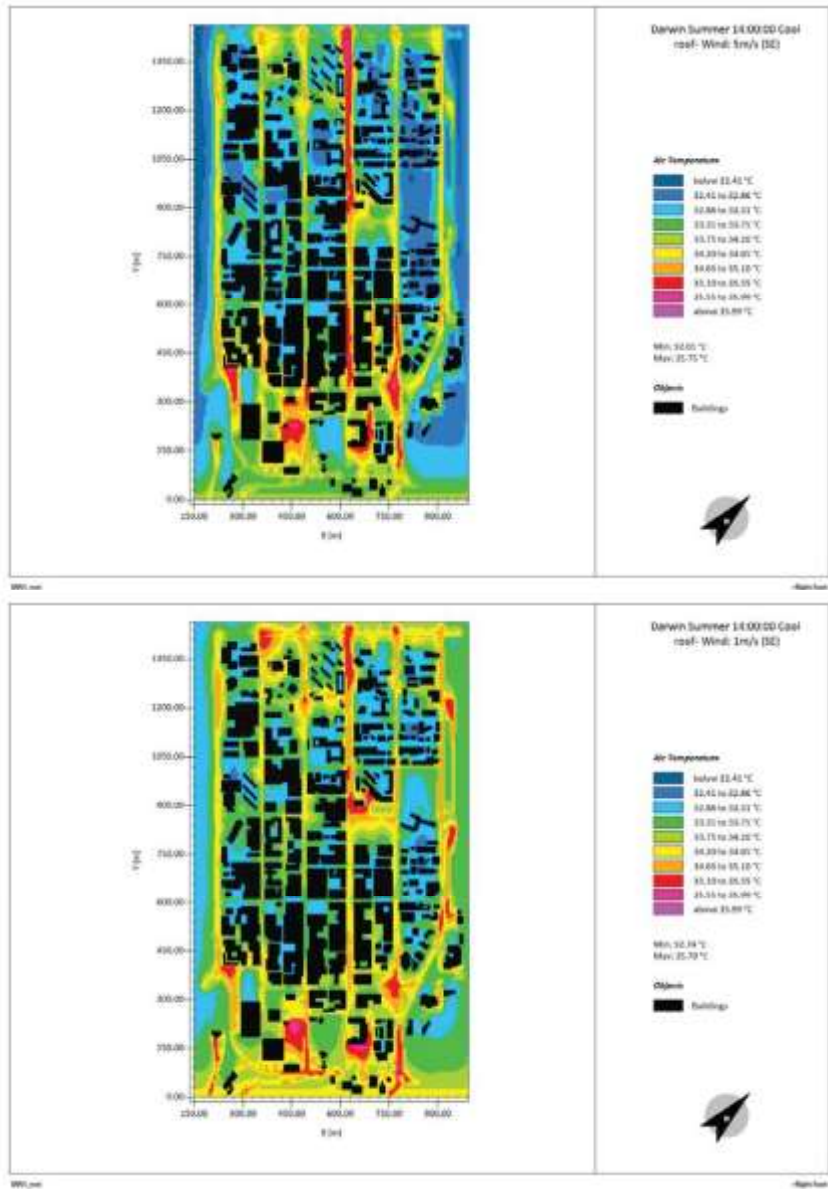


Figure 2. Cool roof: Temperature distribution of the ambient temperature in the selected area: 5m/s-SE (top), 1m/s-SE (bottom).

Simulation results

The model was simulated for the scenario of the cool roof. The Albedo of all building roofs was taken as 0.85. The total roof area in the model is 314272 m².

Figure 1 and 2 show the simulated distribution of the ambient temperature when cool roofs are used in the study area. The results of simulation for wind speeds of 5m/s and 1m/s and North westerly and South easterly directions are presented. It has been shown that the ambient temperature in the study area at 14:00:00 ranges between about 31.96°C to 36.08°C at the street level of the open spaces (1.46 m above the ground level) when cool roof was employed. The minimum and maximum ambient temperatures with the wind speed of 5m/s are lower and higher than those at the speed of 1m/s. Tables 1 and 2 summaries the minimum and maximum temperatures, reduction of the maximum and minimum temperatures, and the local maximum temperature drop achieved in this scenario.

Table 1: Statistical summary of the mitigation results – North westerly winds

Scenarios	Maximum ambient temperature (°C)		Minimum ambient temperature (°C)		Reduction of the maximum ambient temperature (K)		Reduction of the minimum ambient temperature (K)		Maximum temperature decrease (K)	
	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s
Reference Model	36.44	36.08	31.96	32.84	-	-	-	-	-	-
Cool roof	36.28	36.08	31.96	32.70	0.16	0.00	0.00	0.14	0.67	0.49

Note: ^a Maximum temperature decrease achieved based on the scenarios compared to the reference model

Table 2: Statistical summary of the mitigation results – South easterly winds

Scenarios	Maximum ambient temperature (°C)		Minimum ambient temperature (°C)		Reduction of the maximum ambient temperature (K)		Reduction of the minimum ambient temperature (K)		Maximum temperature decrease (K)	
	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s	5m/s	1m/s
Reference Model	36.00	35.72	32.04	32.97	-	-	-	-	-	-
Cool roof	35.75	35.7	32.01	32.74	0.25	0.02	0.03	0.23	0.70	0.59

Note: ^a Maximum temperature decrease achieved based on the scenarios compared to the reference model

Surface temperature (°C)

NW winds

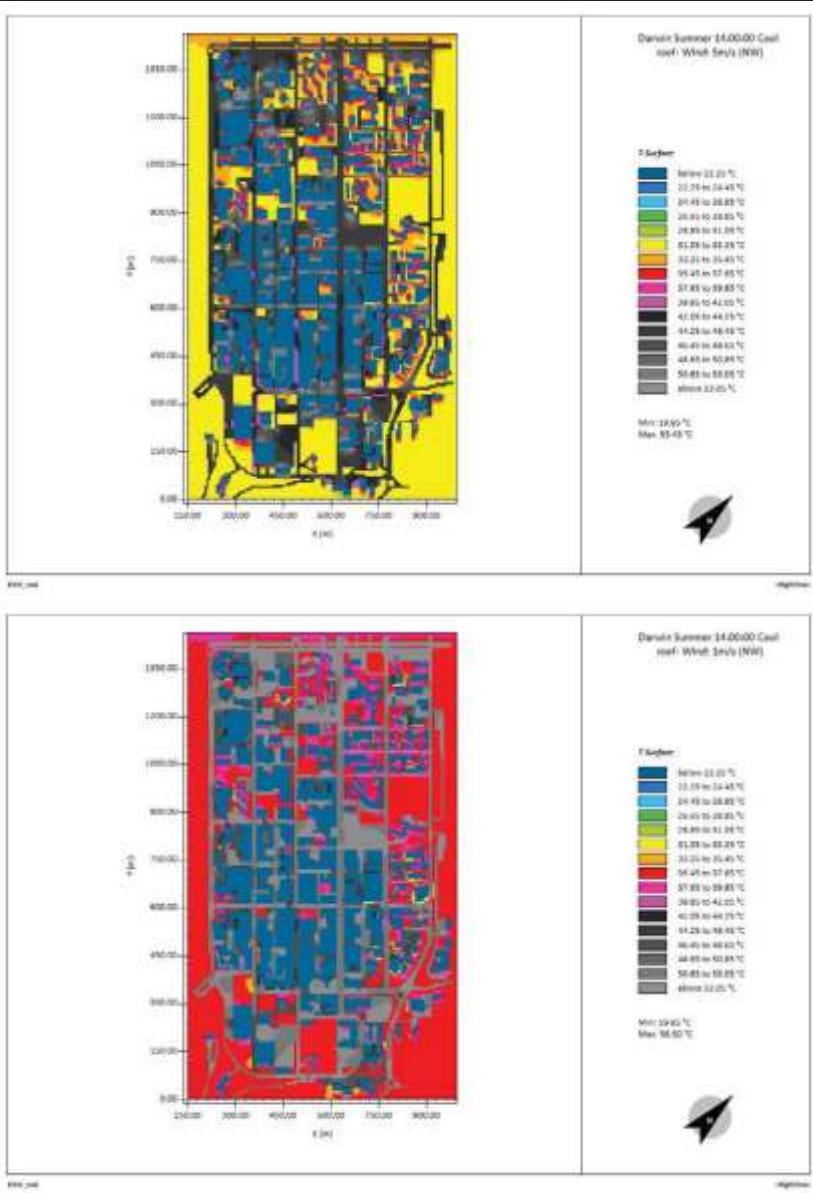


Figure 5. Cool roof: Surface temperature in the selected area:5m/s-NW (top), 1m/s-NW (bottom).

SE winds

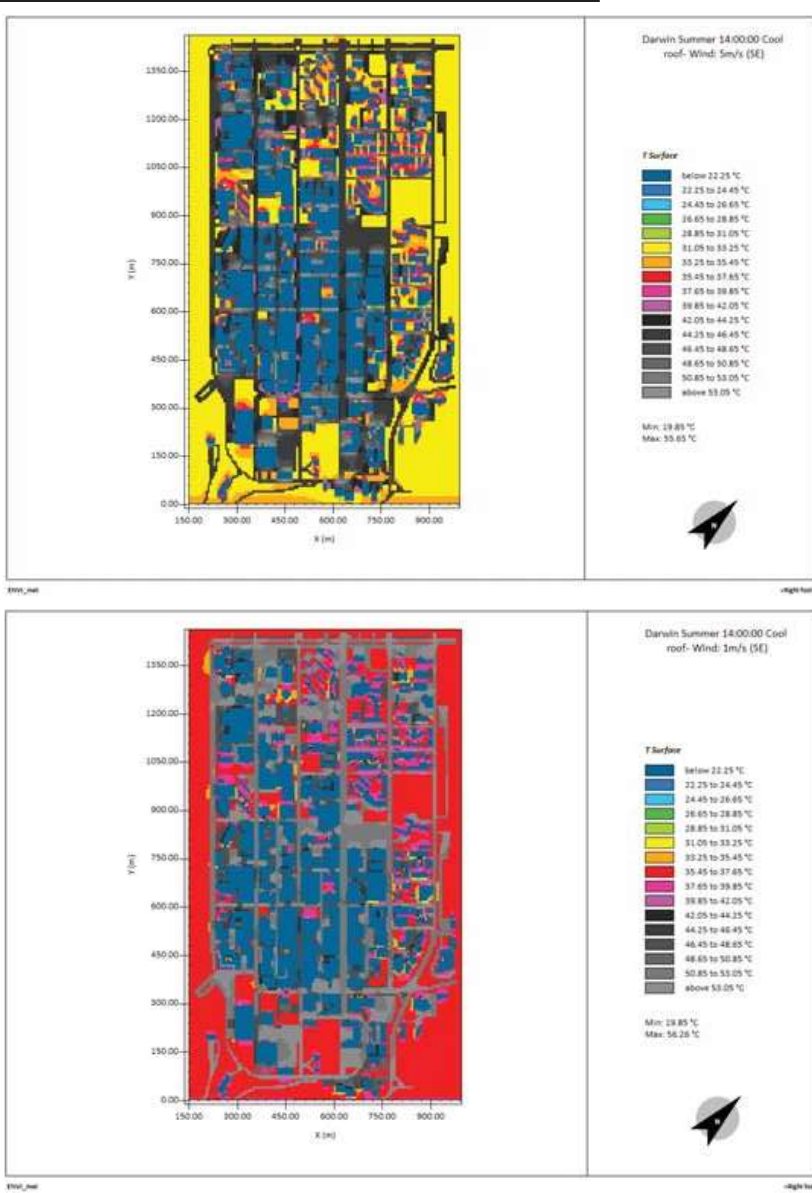


Figure 6. Cool roof: Surface temperature in the selected area:5m/s-SE (top), 1m/s-SE (bottom).

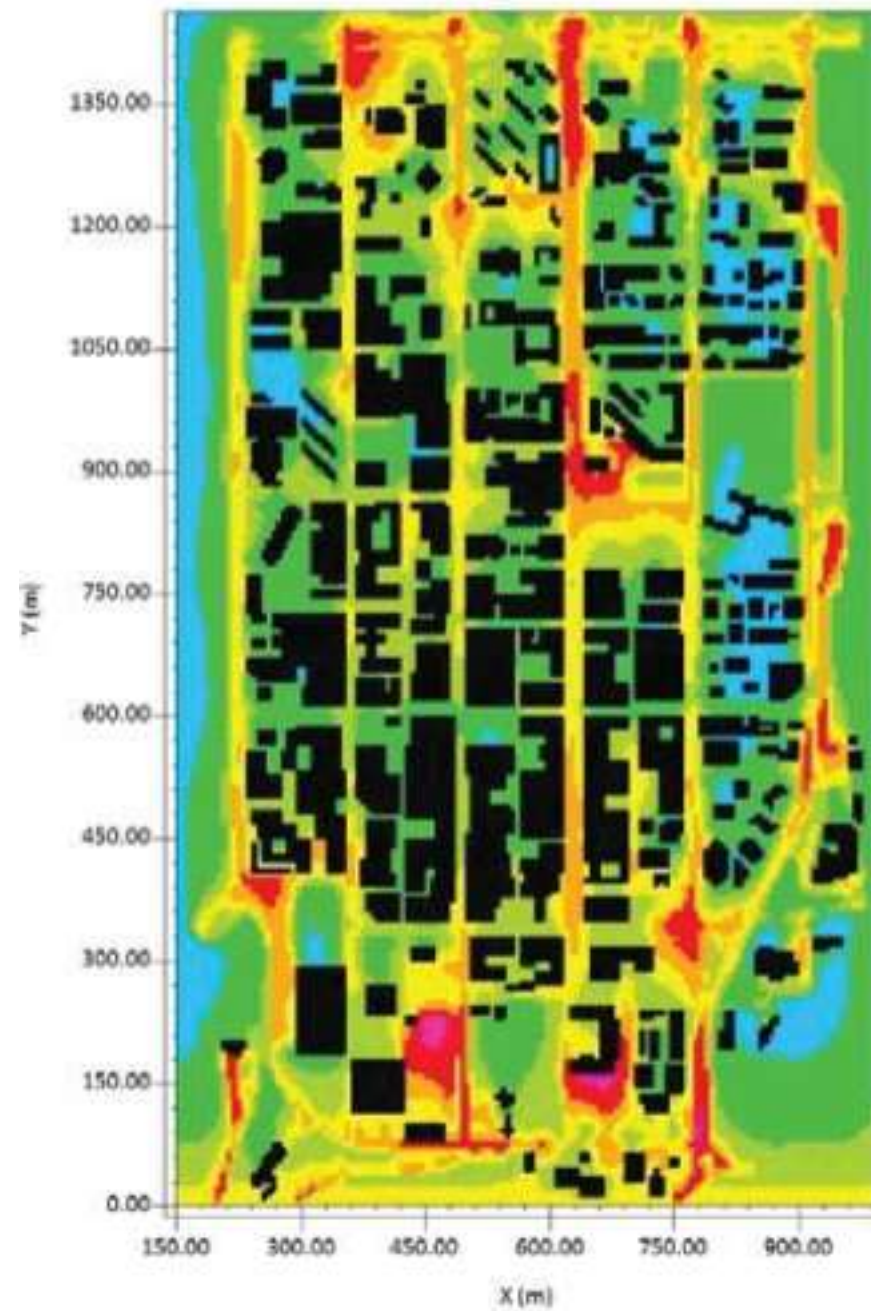
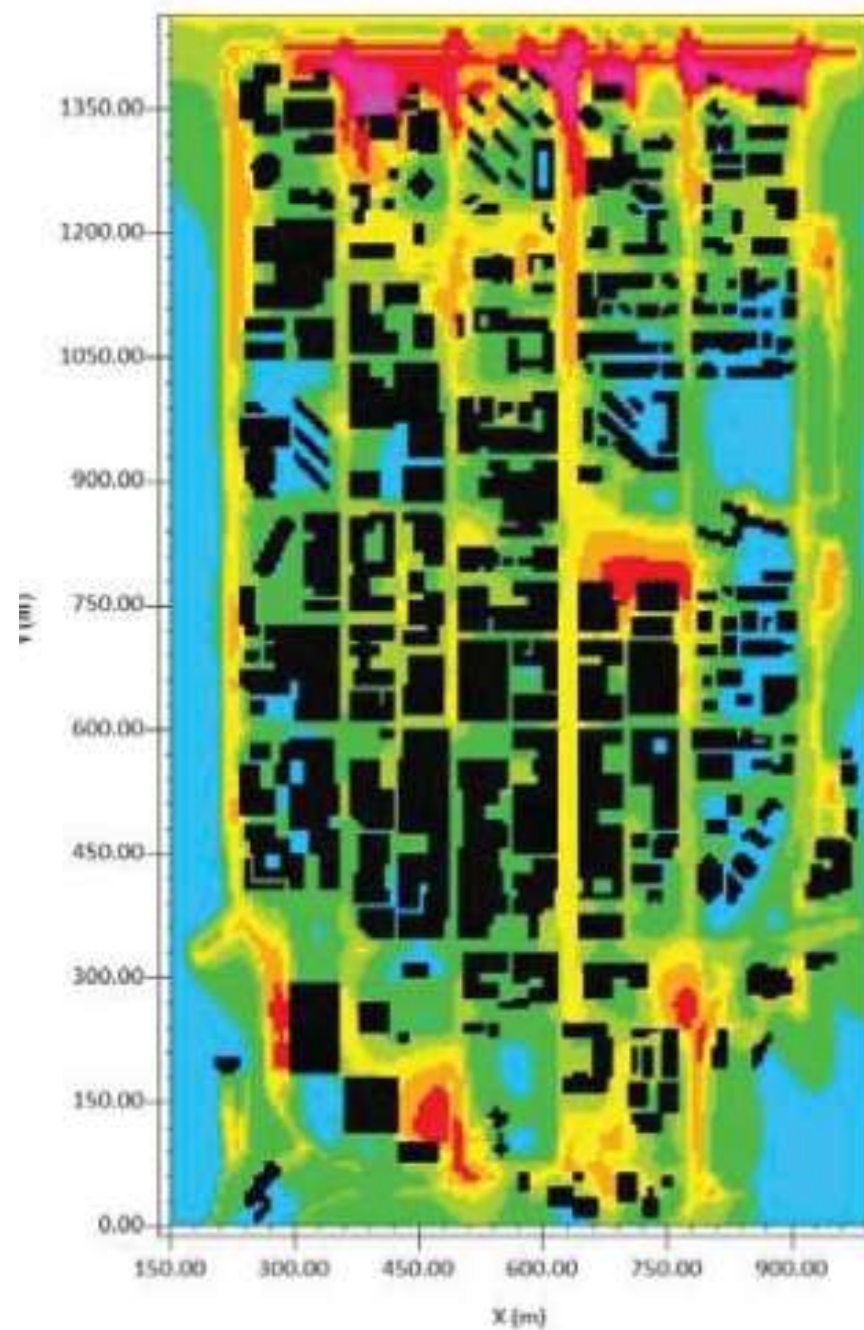
Simulation results

The simulated distribution of the surface temperature in this scenario is given in Figures 5 and 6.

The maximum surface temperatures are 55.43°C and 55.65°C with the wind speed of 5m/s from North west and South west, respectively. These temperatures at the surface level are just slightly lower than those observed in the reference model for both wind direction at the speed of 5m/s. When wind speed is taken as 1m/s, the surface temperature seems very similar to the reference scenario.



Ambient Temperature
Humidity
Surface Temperature
Wind



**LIVEABILITY
PRODUCTIVITY
UNIQUENESS**



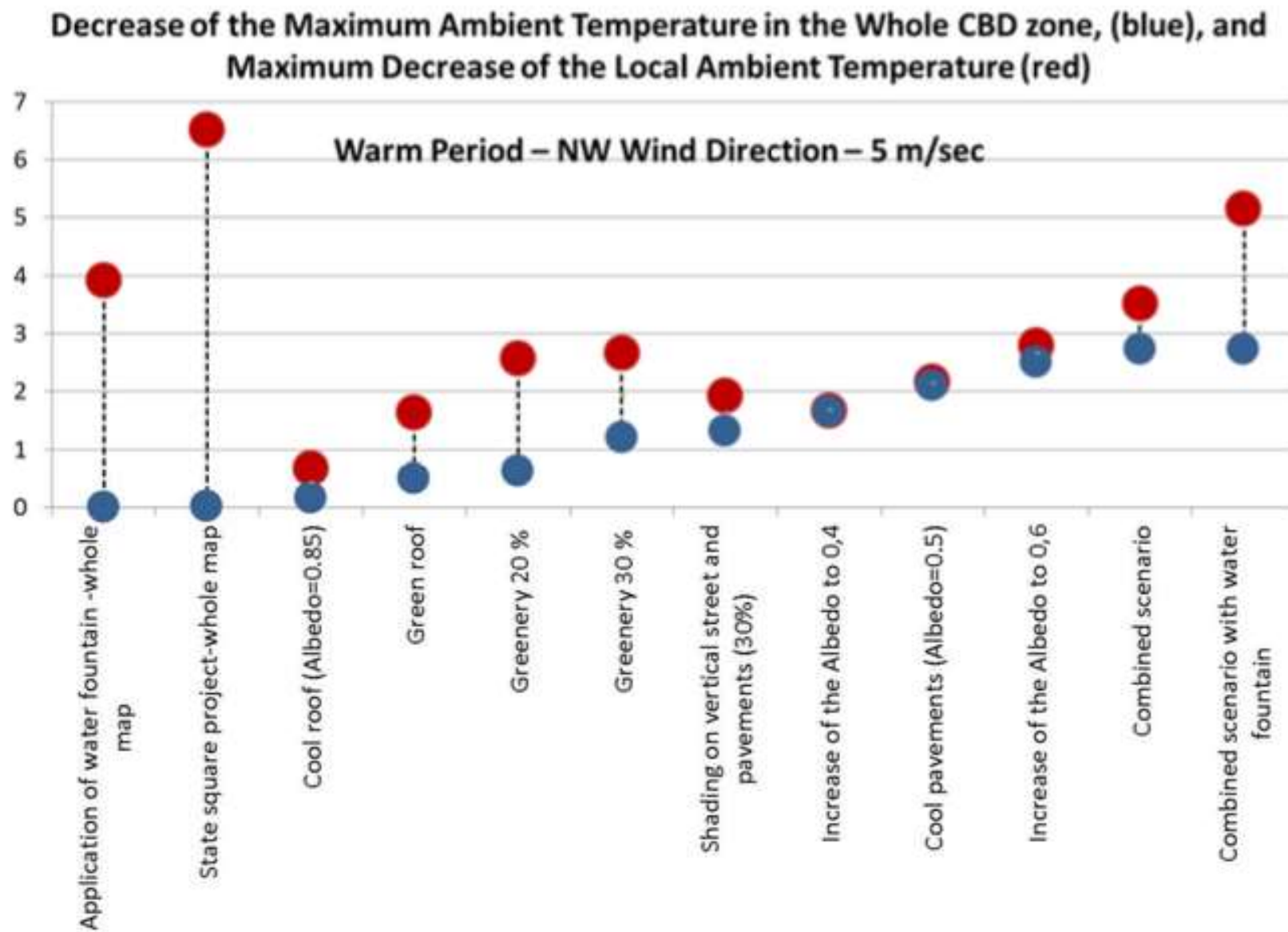


Figure 15. Decreased of the maximum temperature in the whole CBD area, (blue), and the corresponding maximum decrease of the local temperatures.

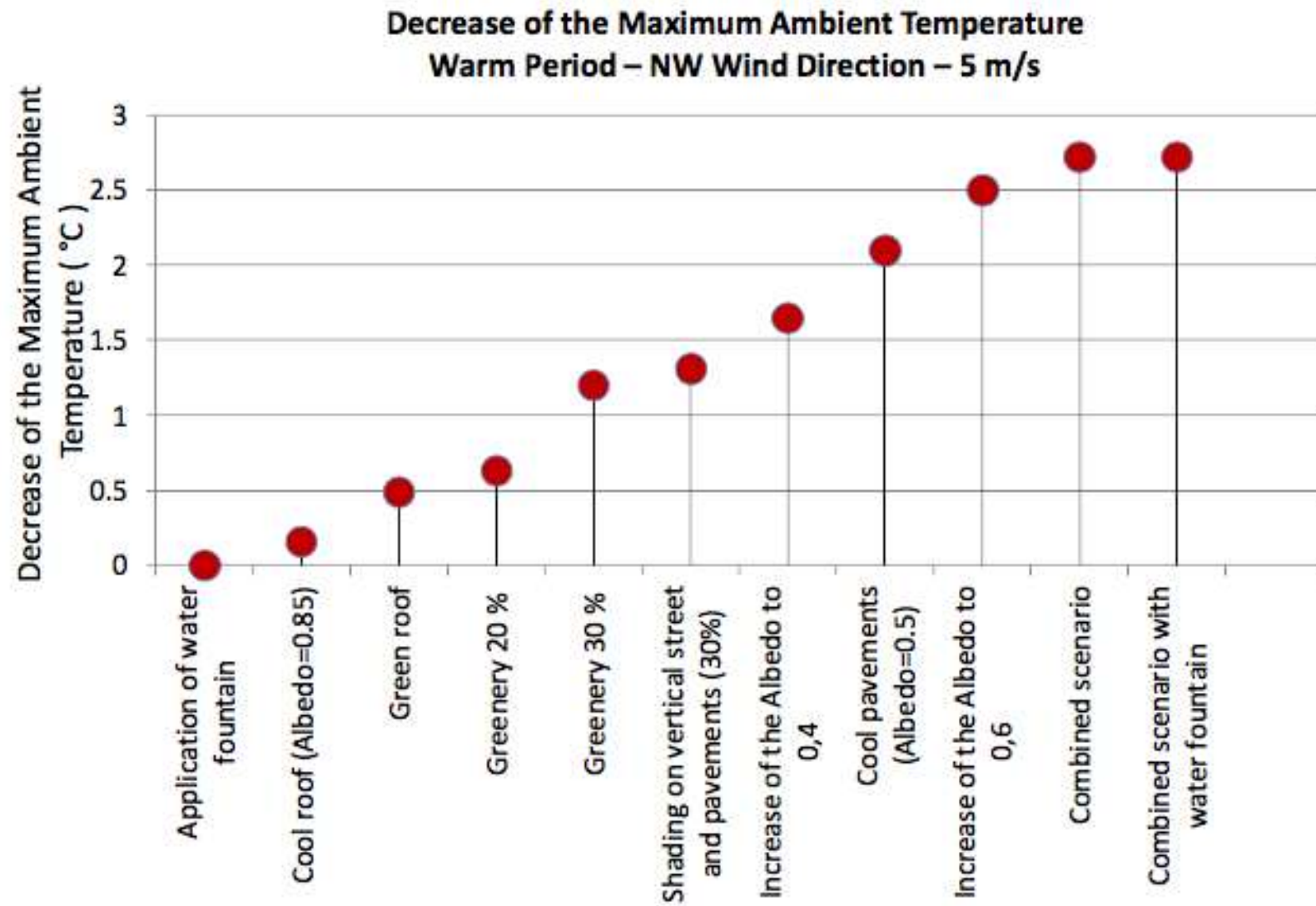
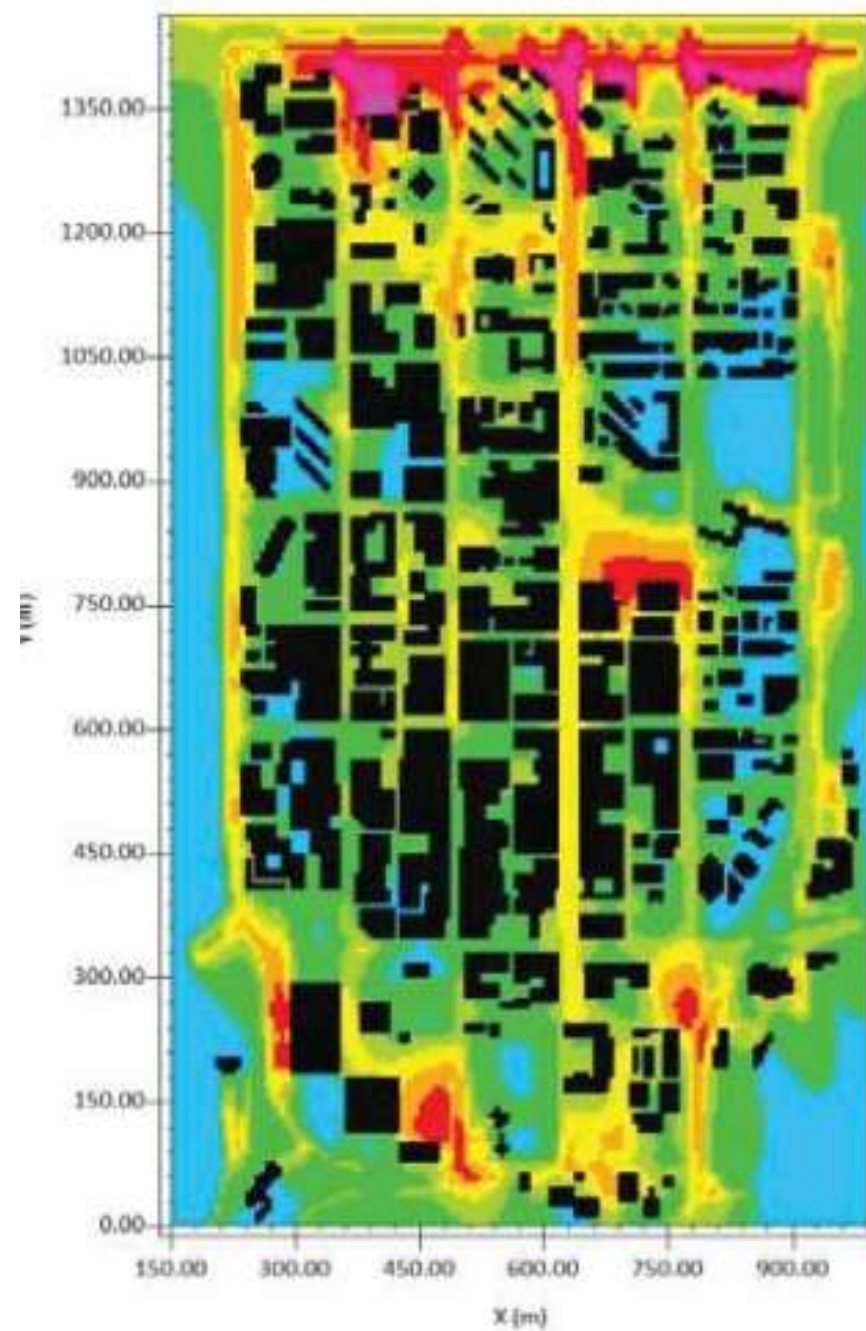


Figure 11. Decrease of the maximum ambient temperature achieved by the various considered mitigation scenarios.









**LIVEABILITY
PRODUCTIVITY
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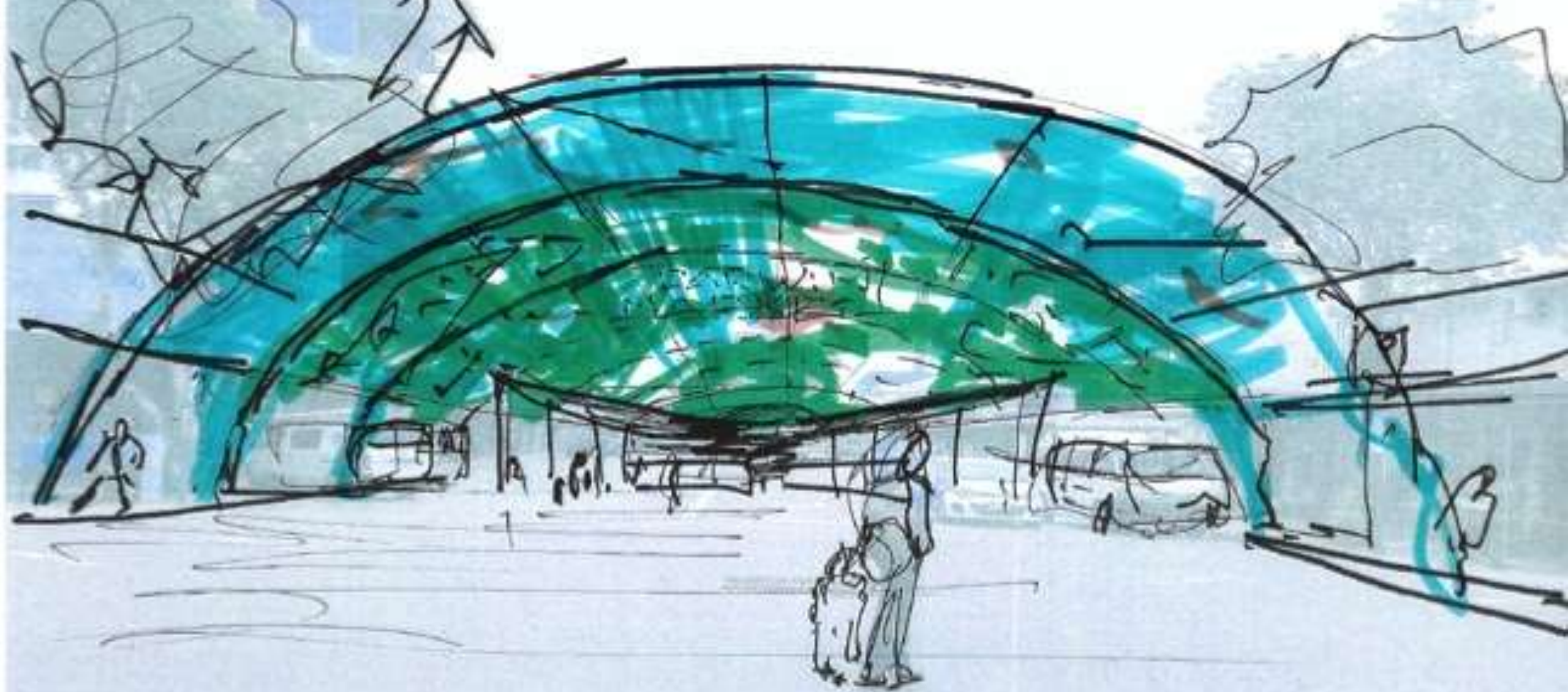
TYPES OF GREENERY













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Scale 1:15000

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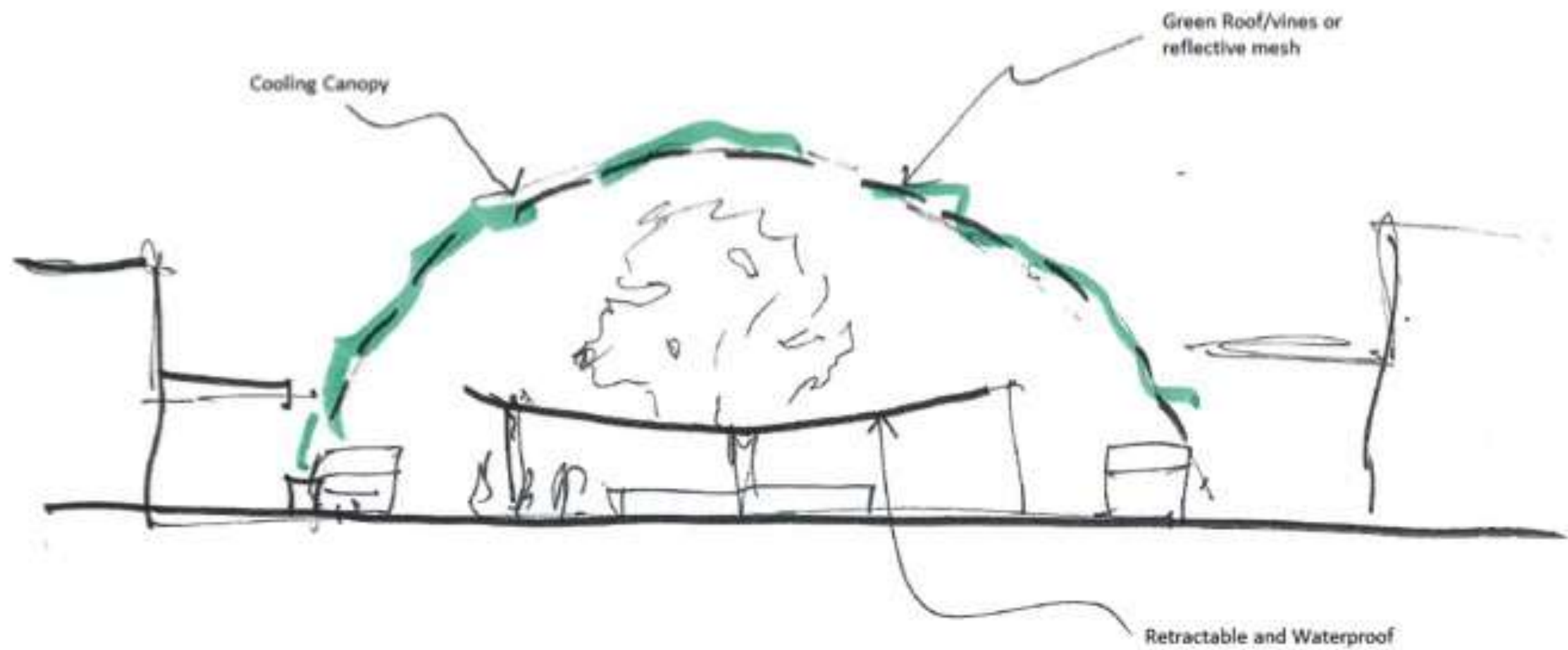
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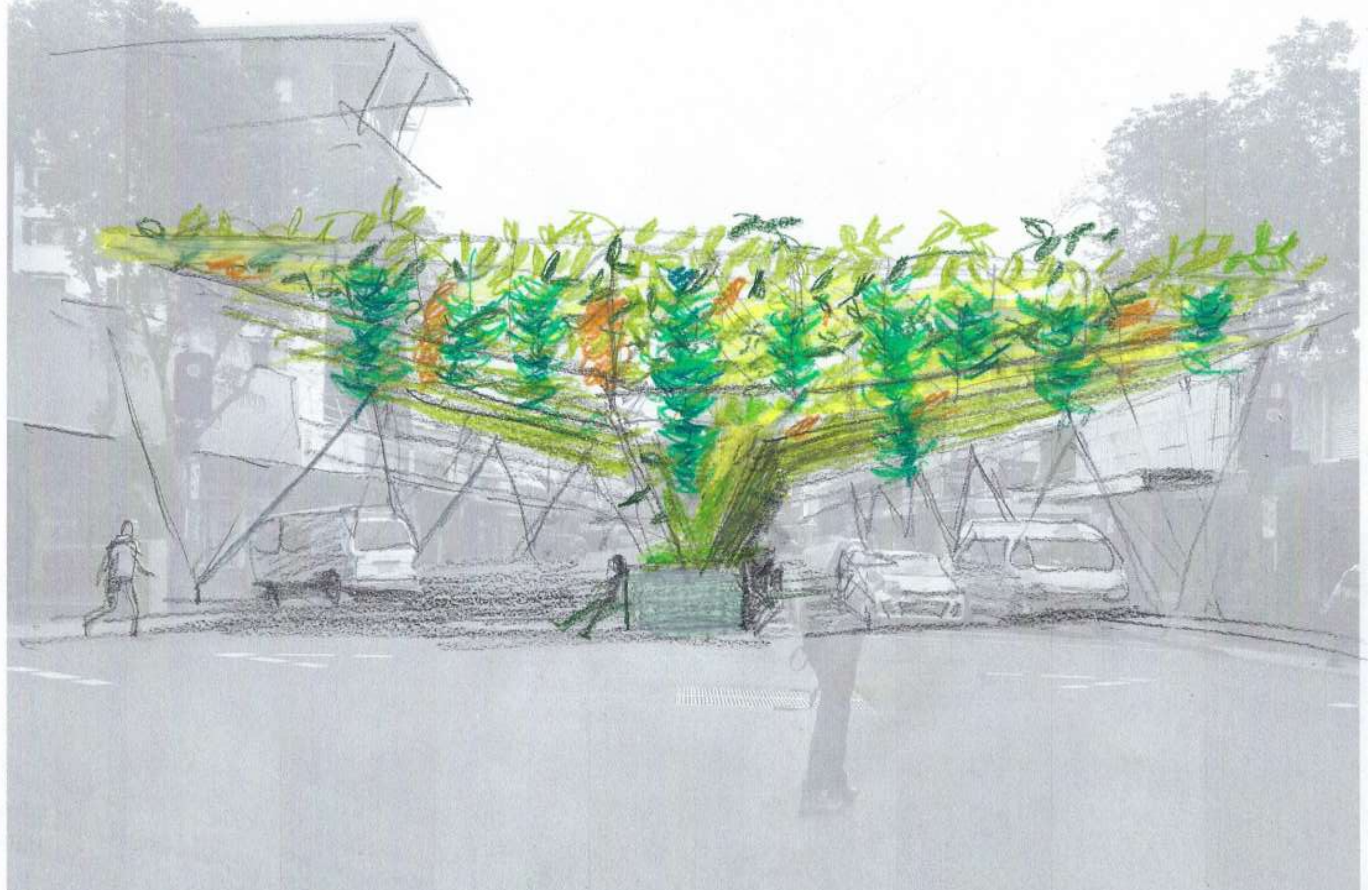
**LIVEABILITY
PRODUCTIVITY
UNIQUENESS**

28
THE
MALL

REVENUE









Fraser Island Creeper
Tecomanthe hillii



- Consider heat
- Thank you