Getting the Water Out: Addressing High Heat Index

A case provided by C. Kelly

HNPW
Humanitarian Networks & Partnerships Weeks

2–12 MARCH 2026

UNIVERSITY OF TWENTE.

The Team

Stijn Servaas
Mechanical Engineering
stijnservaas11@gmail.com

Oskar Thörl
Creative Technology
oskar@thoerl.net

Susanne Fuentes Bongenaar
Creative Technology
s.fuentes.bongenaar@gmail.com

Nienke Dik
Creative Technology
dik.nienke@gmail.com

Problem Statement

Extreme Heat index (High Heat, High Humidity) at in enclosed shelters at IDP sites

→ Frugal methods to cool down

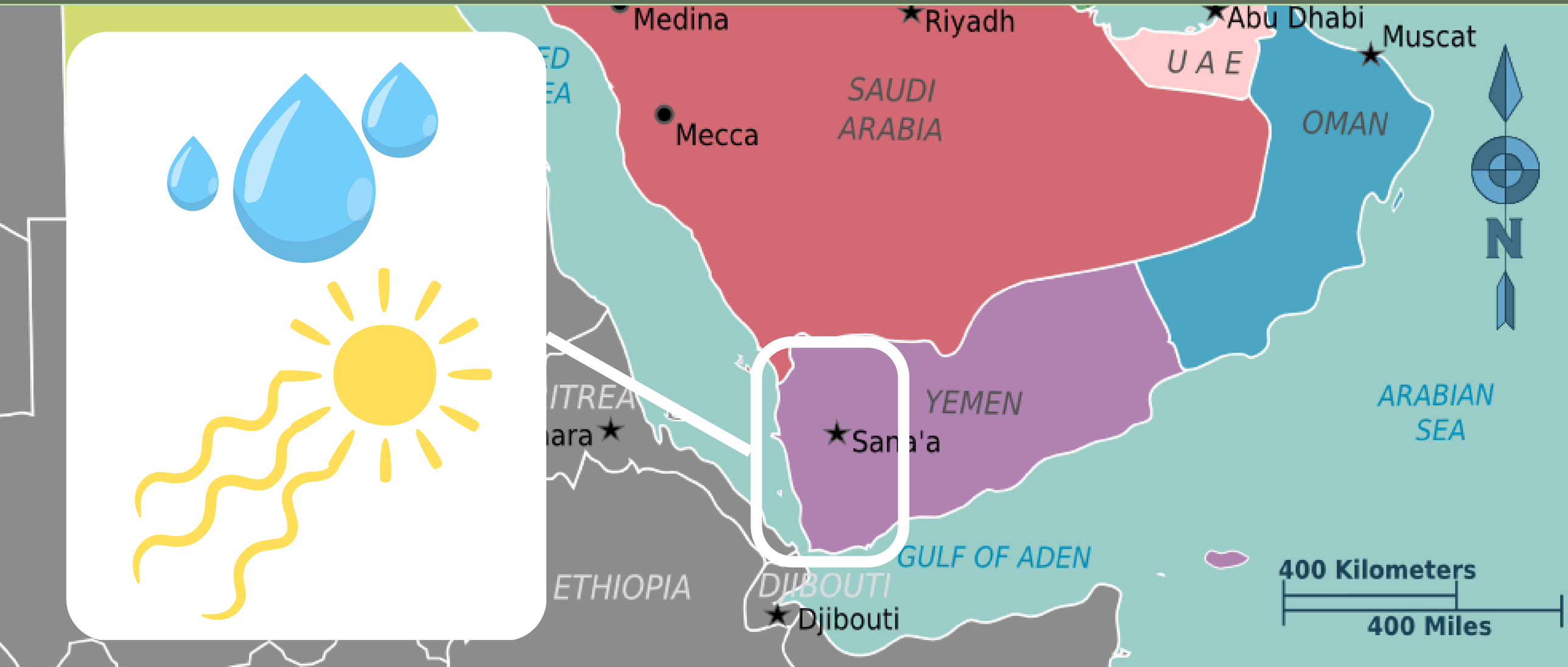
Traditional evaporative cooling

Problem Statement

Extreme Heat index (High Heat, High Humidity) at in enclosed shelters at IDP sites

→ Frugal methods to cool down

IDP Sites (Scope)



Background

Humidity and Heat

- Heat is the amount of energy in the air
- Humidity holds energy, so increasing the humidity increases heat (Heat Index)

Moisture capacity

- The amount of moisture the air can hold at a temperature
- Increases with temperature
- If saturated air (100%) is cooled down, moisture leaves by condensing or fog

HEAT INDEX °F (°C)

The heat index is an accurate measure of how hot it really feels when the affects of humidity are added to high temperature.

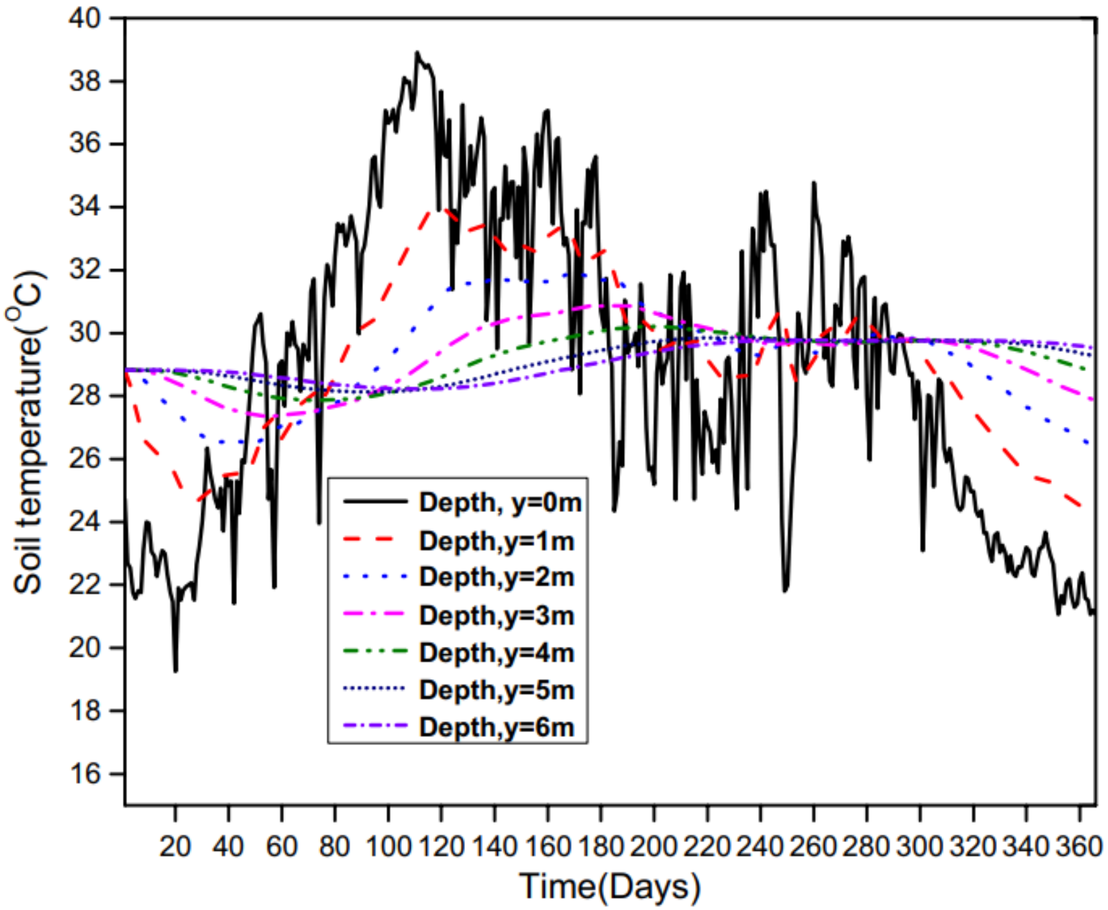
	RELATIVE HUMIDITY (%)												
Temp.	40	45	50	55	60	65	70	75	80	85	90	95	100
110 (47)	136 (58)												
108 (43)	130 (54)	137 (58)											
106 (41)	124 (51)	130 (54)	137 (58)							nbsp;			
104 (40)	119 (48)	124 (51)	131 (55)	137 (58)									
102 (39)	114 (46)	119 (48)	124 (51)	130 (54)	137 (58)								
100 (38)	109 (43)	114 (46)	118 (48)	124 (51)	129 (54)	136 (58)							
98 (37)	105 (41)	109 (43)	113 (45)	117 (47)	123 (51)	128 (53)	134 (57)						
96 (36)	101 (38)	104 (40)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	132 (56)					
94 (34)	97 (36)	100 (38)	103 (39)	106 (41)	110 (43)	114 (46)	119 (48)	124 (51)	129 (54)	135 (57)			
92 (33)	94 (34)	96 (36)	99 (37)	101 (38)	105 (41)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	131 (55)		
90 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	103 (39)	106 (41)	109 (43)	113 (45)	117 (47)	122 (50)	127 (53)	132 (56)
88 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	98 (37)	100 (38)	103 (39)	106 (41)	110 (43)	113 (45)	117 (47)	121 (49)
86 (30)	85 (29)	87 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	102 (39)	105 (41)	108 (42)	112 (44)
84 (29)	83 (28)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	92 (33)	94 (34)	96 (36)	98 (37)	100 (38)	103 (39)
82 (28)	81 (27)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	91 (33)	93 (34)	95 (35)
80 (27)	80 (27)	80 (27)	81 (27)	81 (27)	82 (28)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	86 (30)	87 (31)

Ground temperature

- Temperatures stay relatively constant througout the year
- deeper is more constant up to 4m
- equal to the mean annual temperature

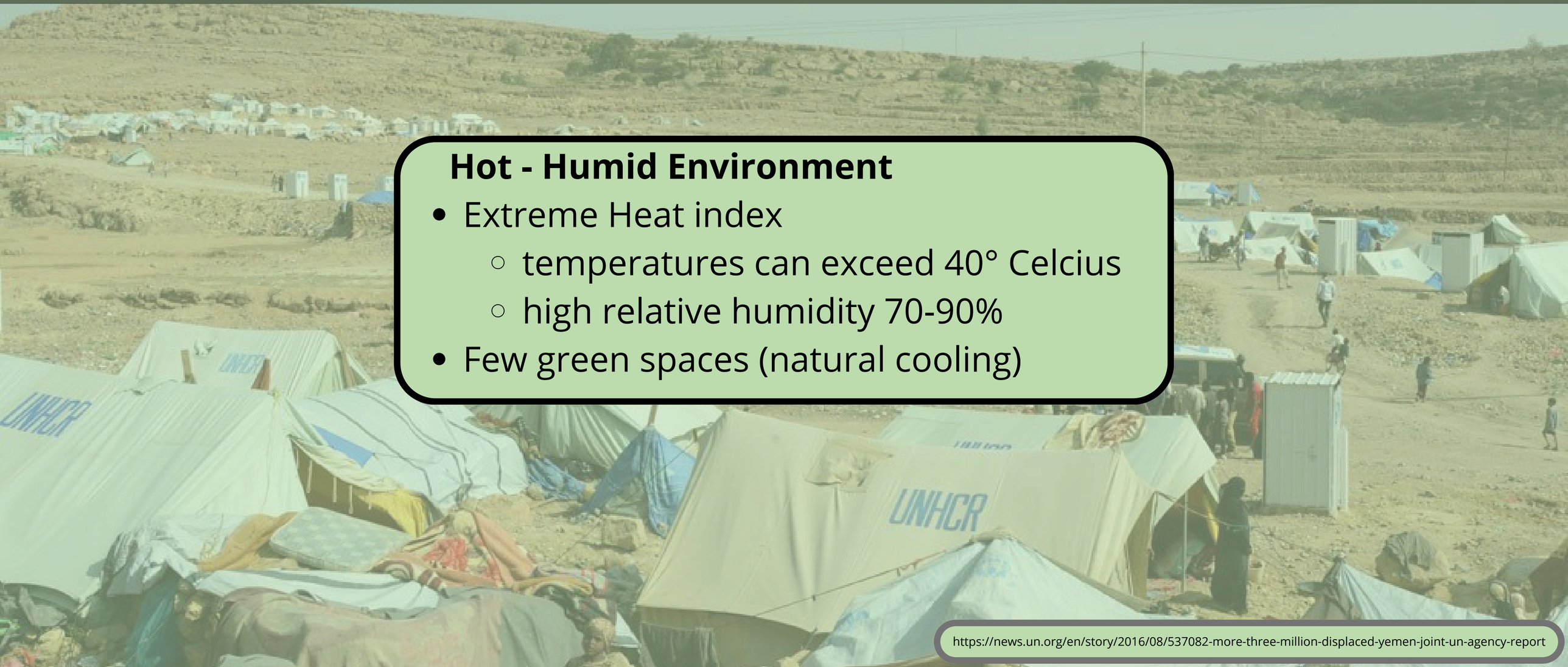
Specific heat

- Energy to increase temp. of a substance by 1K
- Soil needs ≈1000x more energy than air



(Raviranjan Kumar Singh and Ram Vinoy Sharma)

Environmental conditions

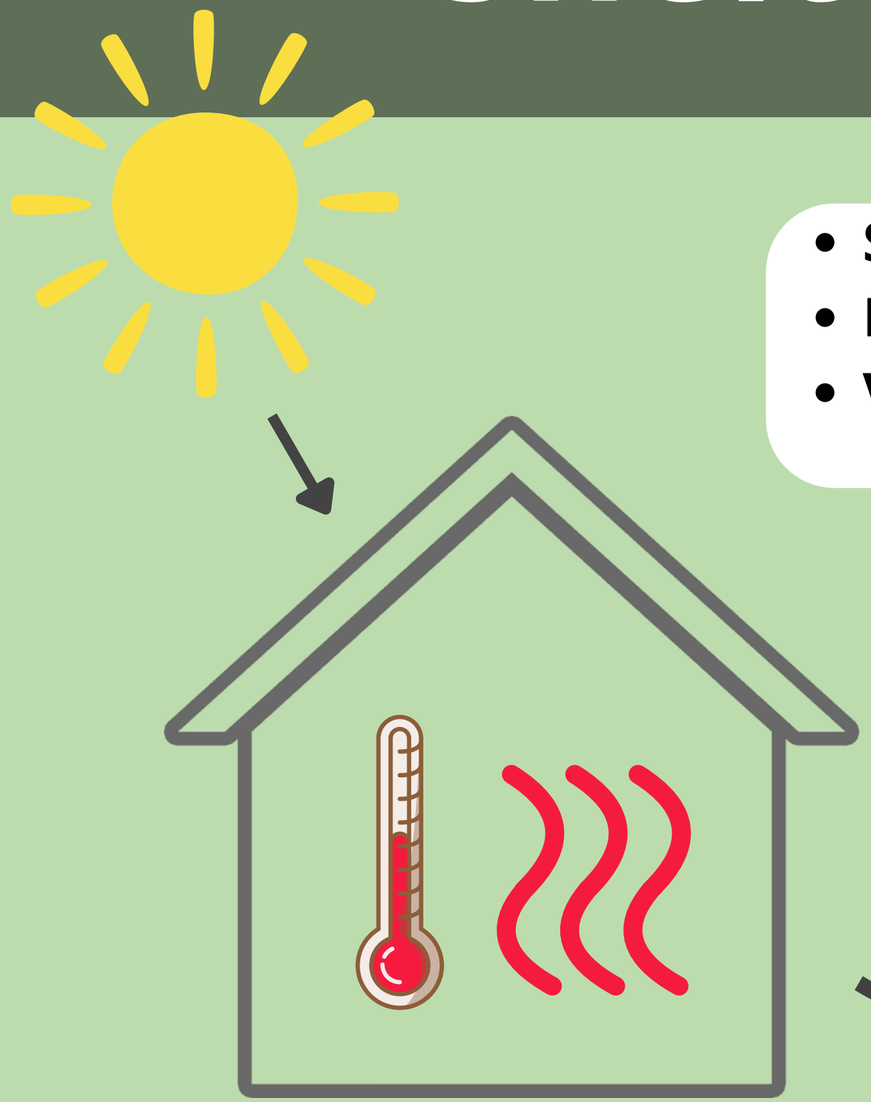


Hot - Humid Environment

- Extreme Heat index
  - temperatures can exceed 40° Celcius
  - high relative humidity 70-90%
- Few green spaces (natural cooling)

https://news.un.org/en/story/2016/08/537082-more-three-million-displaced-yemen-joint-un-agency-report

Shelter dimensions



- **Standard tent:** 4 x 4 m for 4 people (≈ 4 m²/person)
- **Material:** single-layer plastic sheeting → low insulation
- **Ventilation:** often kept closed → heat + humidity trapped

Temperatures up to 62°C!

tent surface temperature (tests)* [2]

[2] K. Cao, M. Lan, H. Wang, Y. Li, and X. Liu, "The thermal environment and thermal comfort of disaster relief tents in high-temperature composite environment," Case Studies in Thermal Engineering, vol. 50, p. 103 453, Oct. 1, 2023, ISSN: 2214-157X. DOI: 10 . 1016 / j . csite . 2023 . 103453. Accessed: Jan. 19, 2026. [On-line]. Available: https://www.sciencedirect.com/science/article/pii/S2214157X23007591.

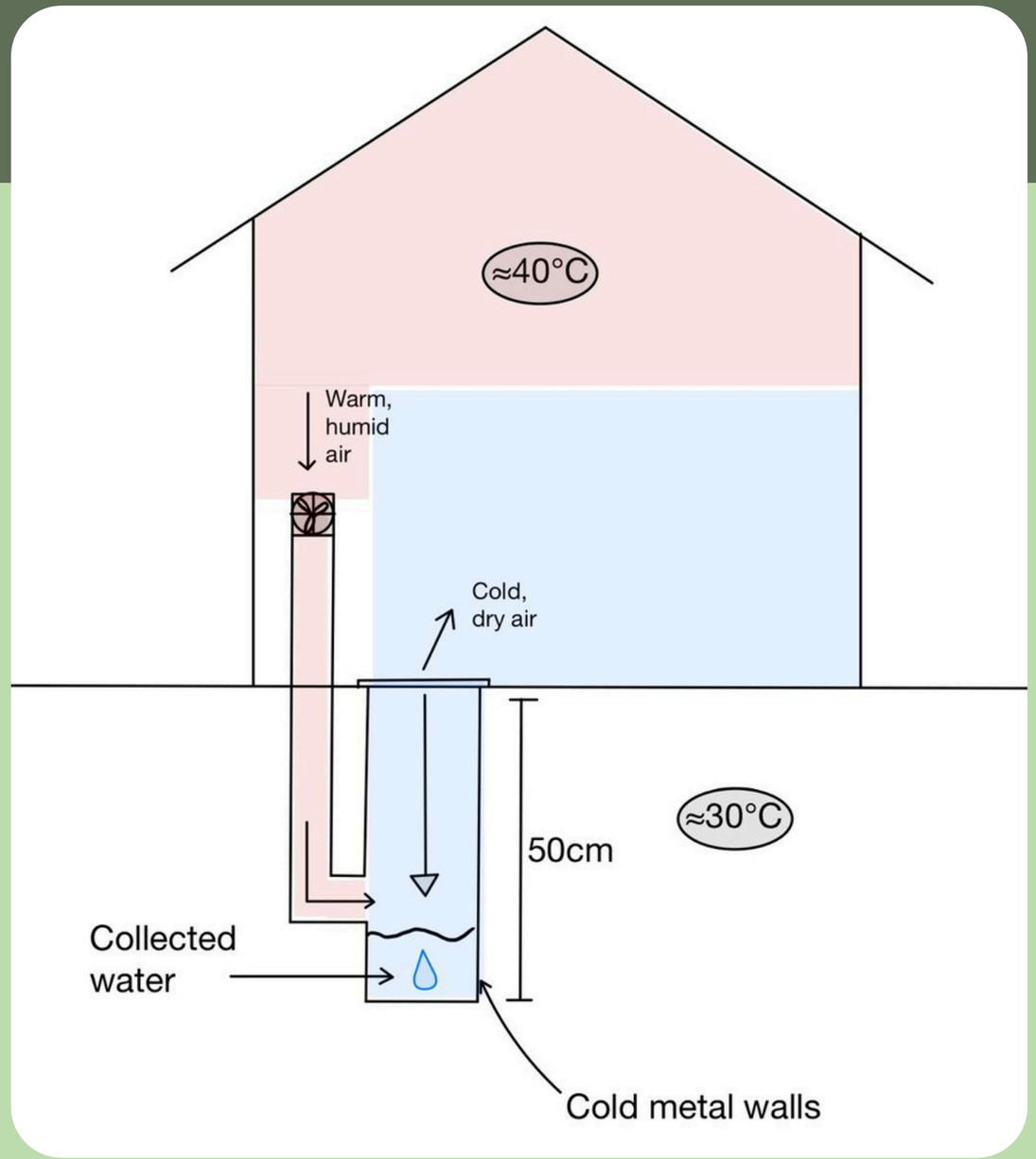
Concepts

Airwell - indoor

Removing moisture using temperature difference underground

Max Ground Temperature Aden City, Yemen (19/01/2026) [1]	
Surface	41c
6cm	36c
10cm	34c
18cm	31c
54cm	29c

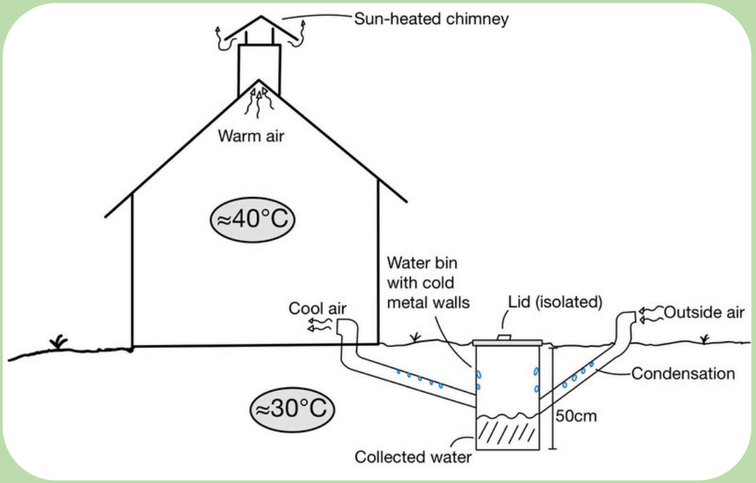
[1]: https://soiltemperature.app/

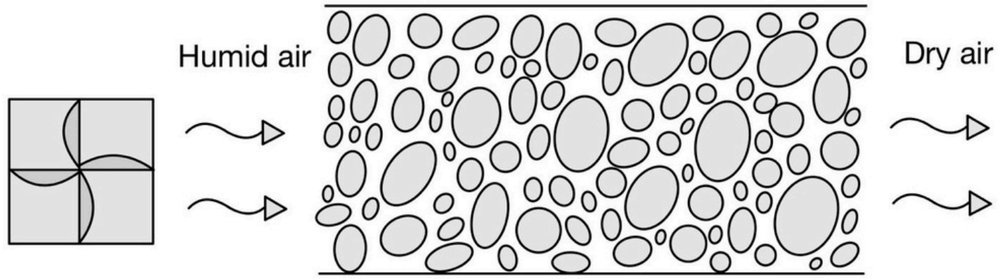


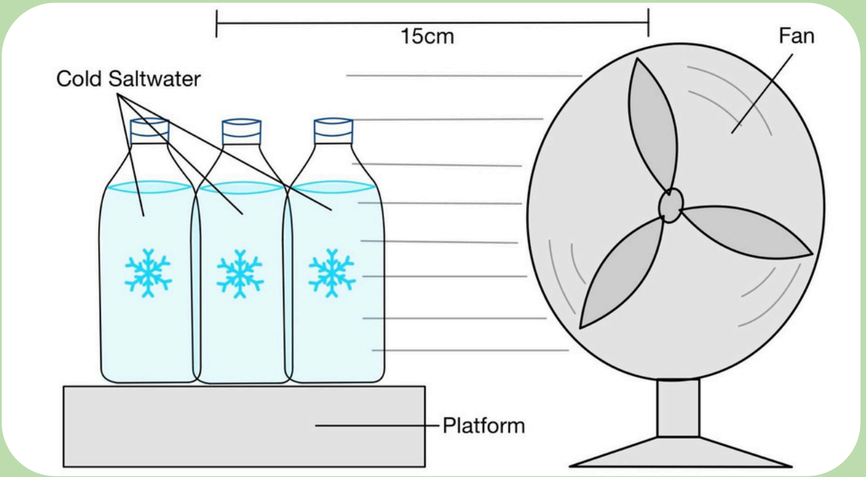
Comparative analysis

Analysed concepts

- Desiccants
- (partially) Outdoor Airwell
- Frozen bottles

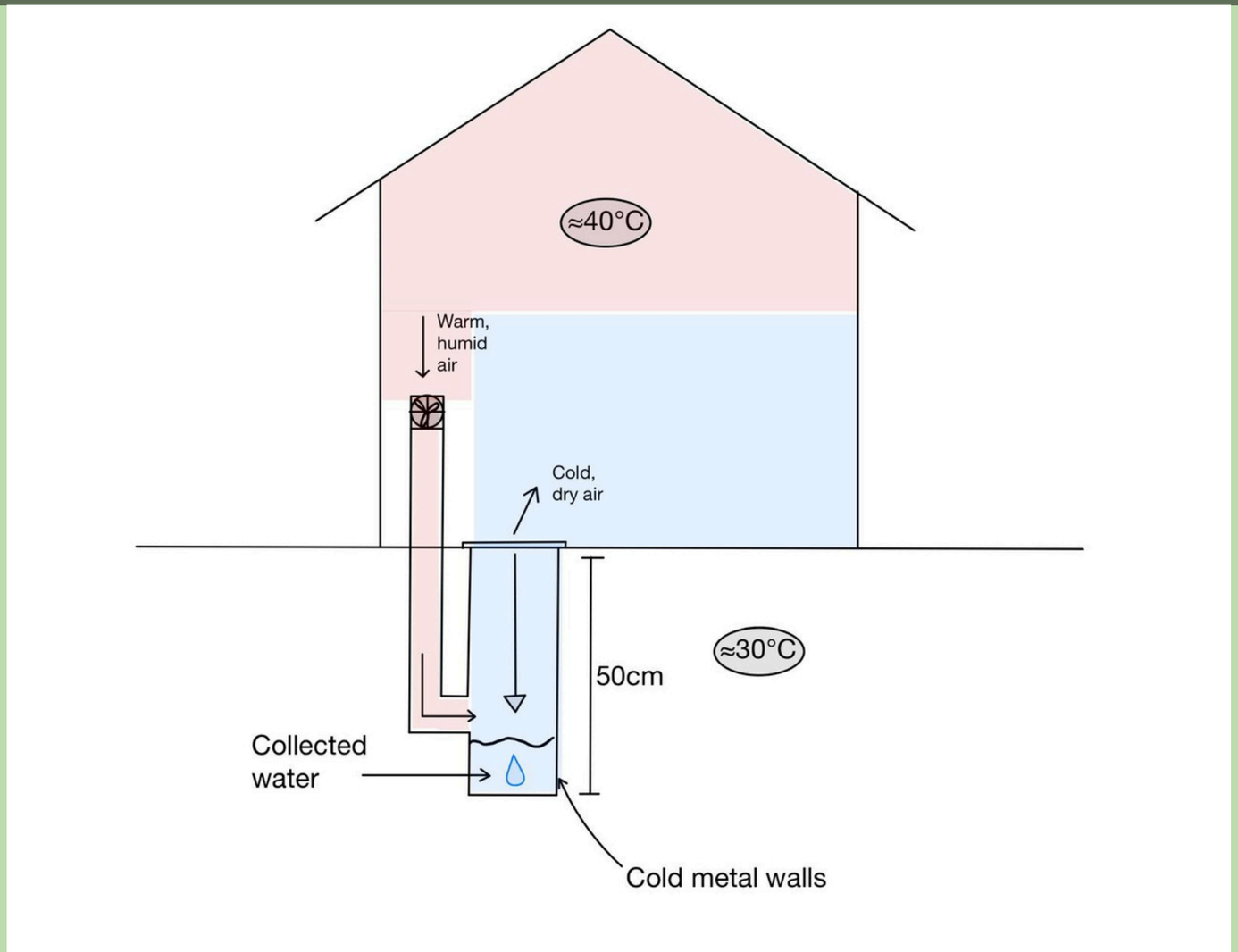




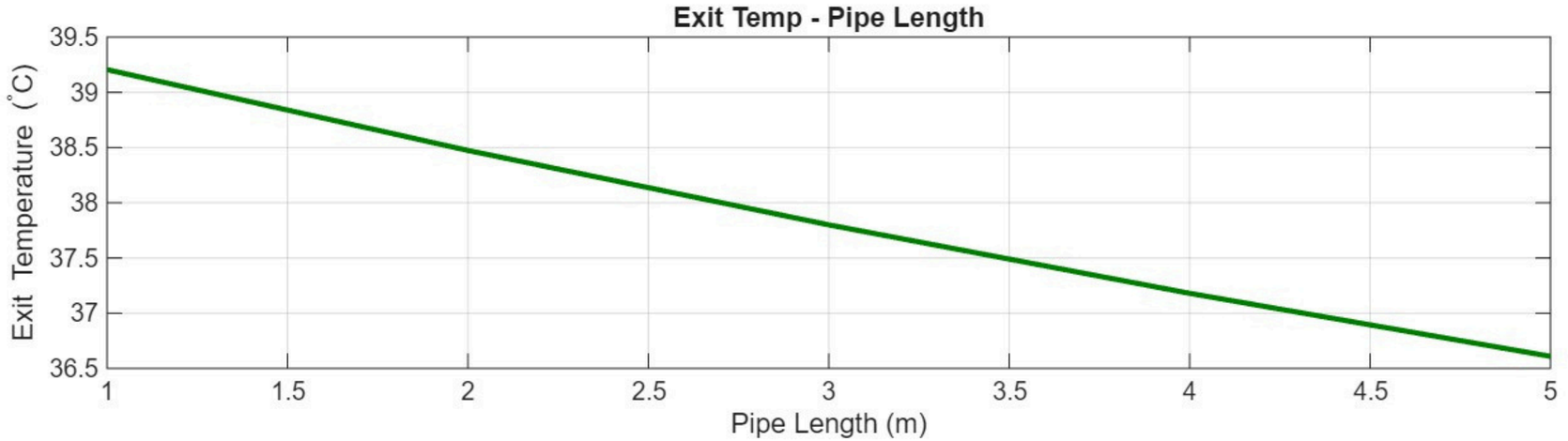


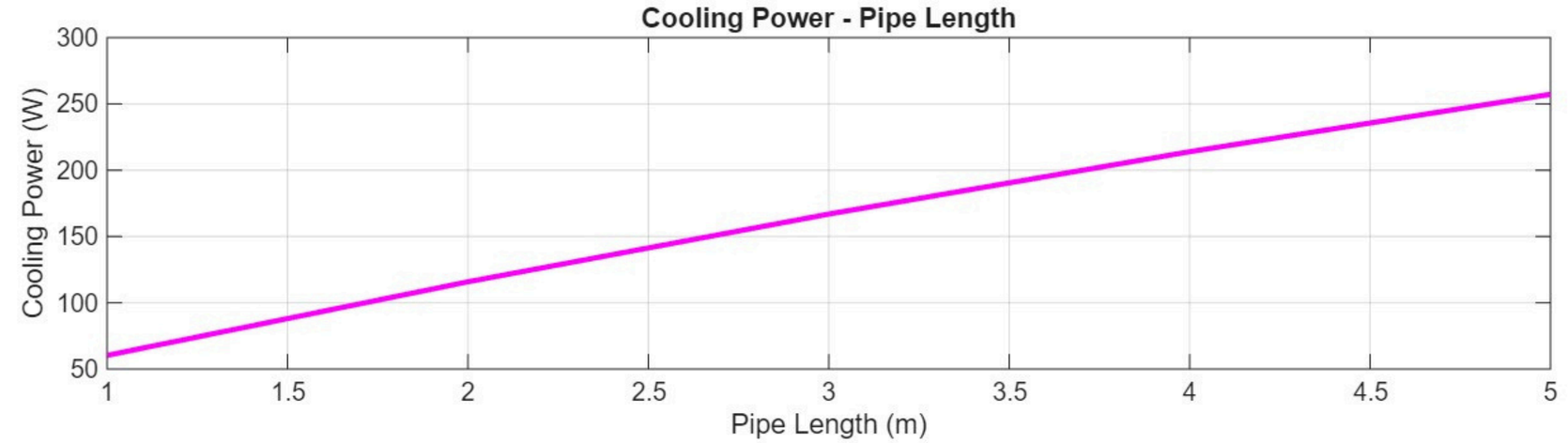
Specification of final concept

Starting point

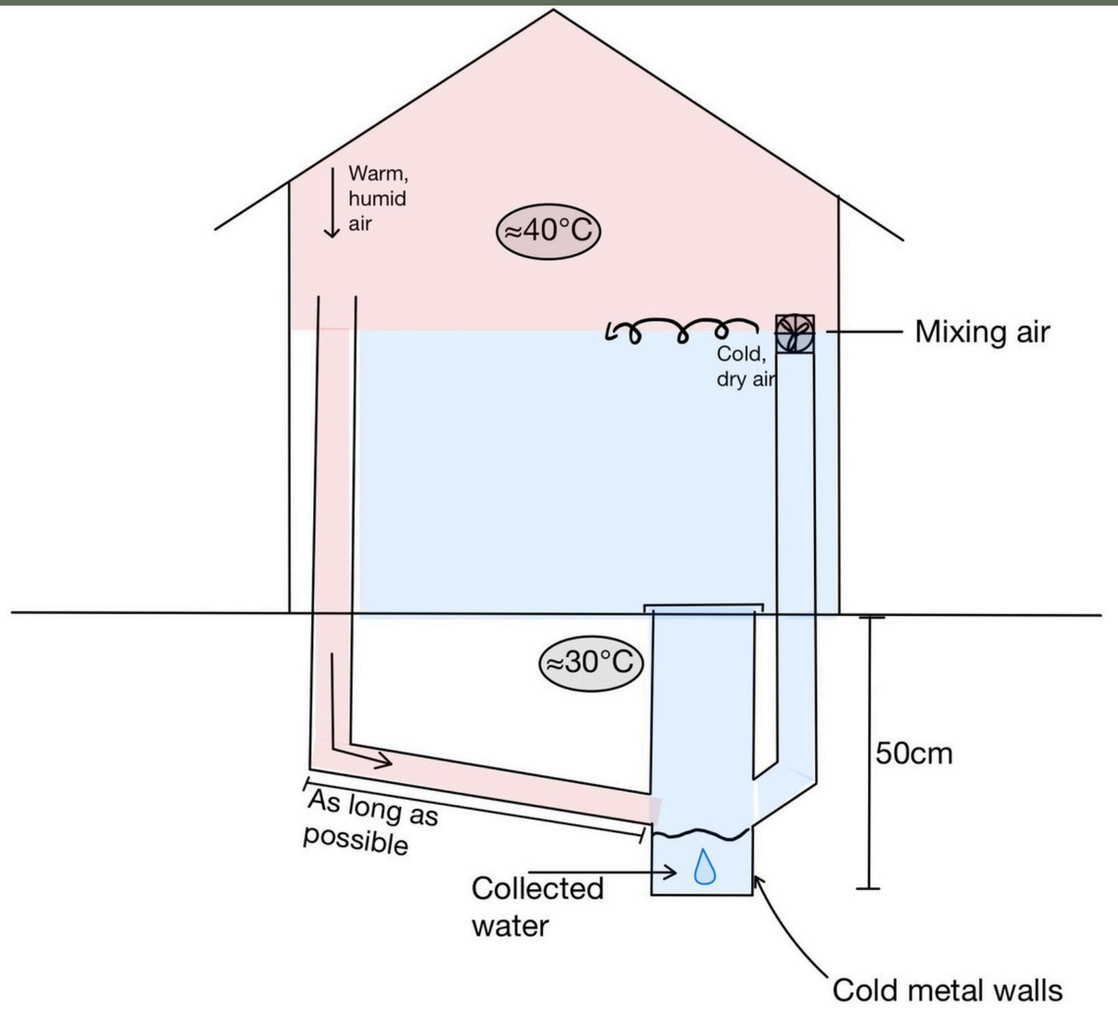


Pipe length

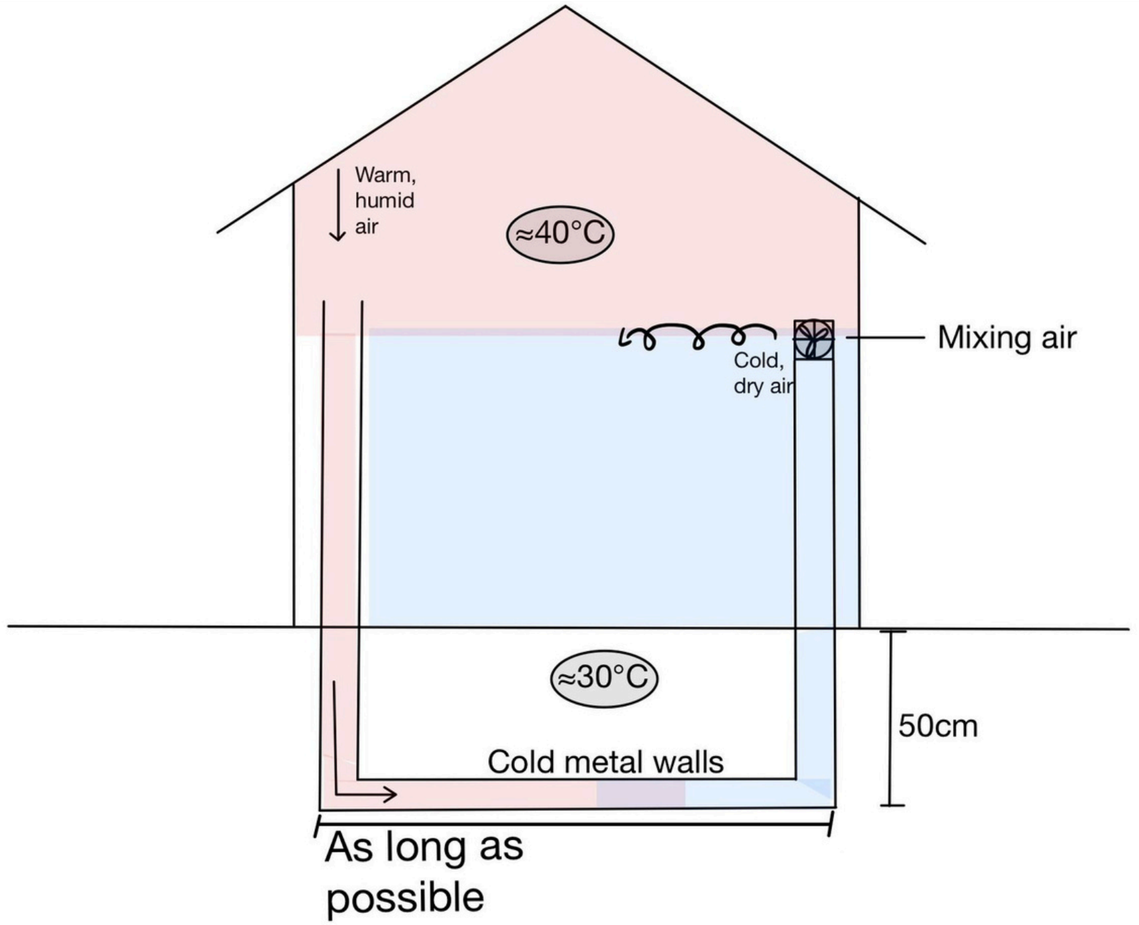

Exit Temp - Pipe Length
Exit Temperature (˚C)
39.5
39
38.5
38
37.5
37
36.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Pipe Length (m)


Cooling Power - Pipe Length
Cooling Power (W)
300
250
200
150
100
50
1
1.5
2
2.5
3
3.5
4
4.5
5
Pipe Length (m)

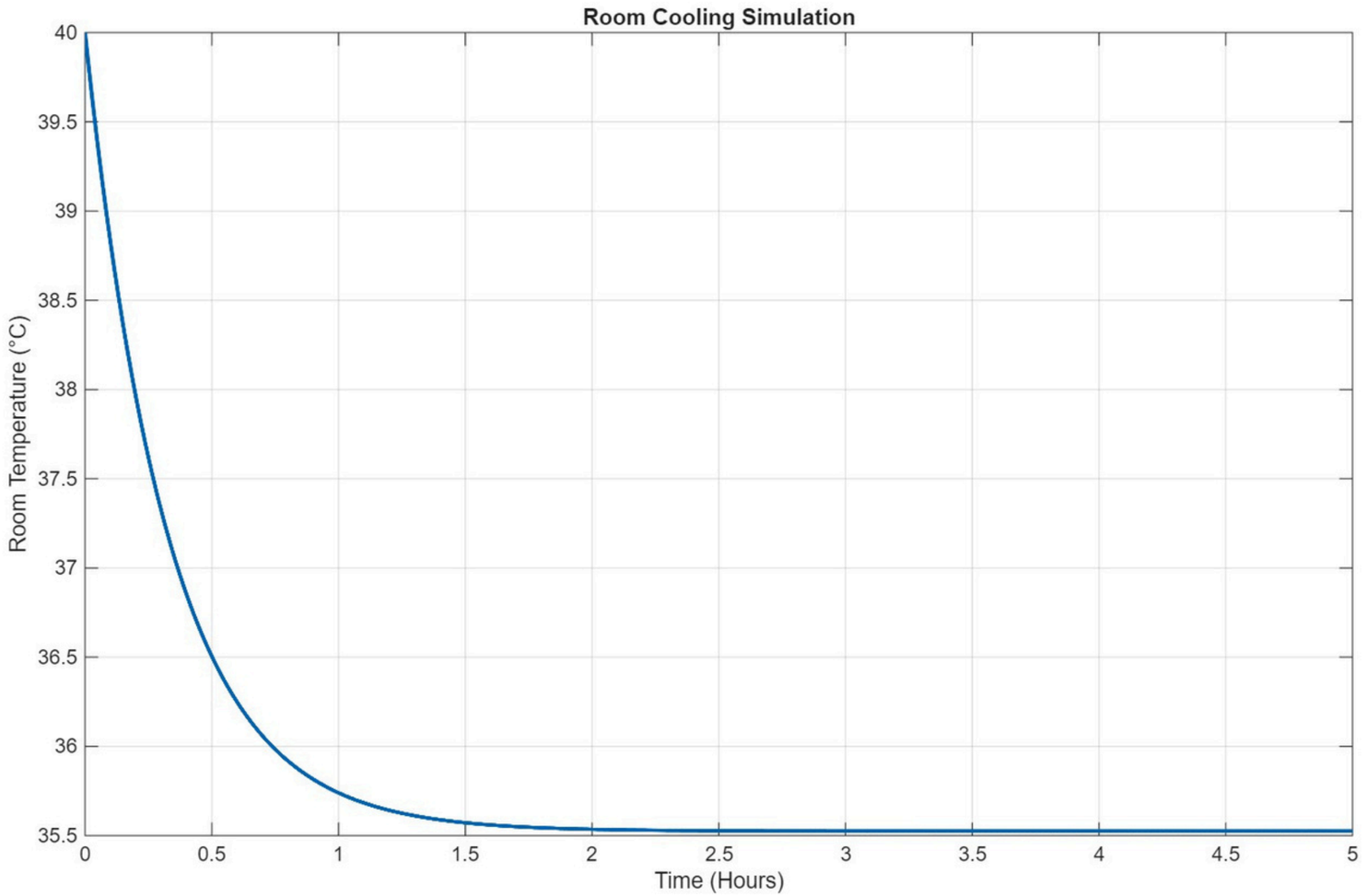
Pipe length


Warm,
humid
air
≈40°C
Mixing air
Cold,
dry air
≈30°C
50cm
As long as
possible
Collected
water
Cold metal walls

Water collection



Simulation



- Outside temperature = 45 °C
- Pipe length = 5 m
- Air velocity = 2 m/s
- assumptions on physical properties

Likely needed materials

Fan

Plastic Sheeting

Nails

Welding Machine

Galvanized Steel Roofing

Pipe (PVC / Metal)

Digging equipment

HEAT INDEX °F (°C)

The heat index is an accurate measure of how hot it really feels when the affects of humidity are added to high temperature.

Temp.	RELATIVE HUMIDITY (%) 40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
(47)	(58)												
108	130	137											
(43)	(54)	(58)											
106	124	130	137										
(41)	(51)	(54)	(58)										
104	119	124	131	137									
(40)	(48)	(51)	(55)	(58)									
102	114	119	124	130	137								
(39)	(46)	(48)	(51)	(54)	(58)								
100	109	114	118	124	129	136							
(38)	(43)	(46)	(48)	(51)	(54)	(58)							
98	105	109	113	117	123	128	134						
(37)	(41)	(43)	(45)	(47)	(51)	(53)	(57)						
96	101	104	108	112	116	121	126	132					
(36)	(38)	(40)	(42)	(44)	(47)	(49)	(52)	(56)					
94	97	100	103	106	110	114	119	124	129	135			
(34)	(36)	(38)	(39)	(41)	(43)	(46)	(48)	(51)	(54)	(57)			
92	94	96	99	101	105	108	112	116	121	126	131		
(33)	(34)	(36)	(37)	(38)	(41)	(42)	(44)	(47)	(49)	(52)	(55)		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
(32)	(33)	(34)	(35)	(36)	(38)	(39)	(41)	(43)	(45)	(47)	(50)	(53)	(56)
88	88	89	91	93	95	98	100	103	106	110	113	117	121
(31)	(31)	(32)	(33)	(34)	(35)	(37)	(38)	(39)	(41)	(43)	(45)	(47)	(49)
86	85	87	88	89	91	93	95	97	100	102	105	108	112
(30)	(29)	(31)	(31)	(32)	(33)	(34)	(35)	(36)	(38)	(39)	(41)	(42)	(44)
84	83	84	85	86	88	89	90	92	94	96	98	100	103
(29)	(28)	(29)	(29)	(30)	(31)	(32)	(32)	(33)	(34)	(36)	(37)	(38)	(39)
82	81	82	83	84	84	85	86	88	89	90	91	93	95
(28)	(27)	(28)	(28)	(29)	(29)	(29)	(30)	(31)	(32)	(32)	(33)	(34)	(35)
80	80	80	81	81	82	82	83	84	84	85	86	86	87
(27)	(27)	(27)	(27)	(27)	(28)	(28)	(28)	(29)	(29)	(29)	(30)	(30)	(31)

Conclusion

Research question

Can a frugal cooling intervention achieve a significant reduction in indoor heat index in enclosed IDP shelters under extreme heat index conditions?

In 2 hours, in a 40 m2 shelter reduce

- indoor temperature by **4.5°C**
- heatindex around **15°F**

Discussion

Main limitations

- No end-user validation → cultural acceptance, intrusiveness, noise

Contribution

- Indoor airwell is a promosing theoretical frugal cooling concept
- Various design characteristics are ready to be tested systematically

Key Insights

- Potential seasonal effect → may act as a heater in cooler periods
- Potential stronger effect during the night

Recommendations

Remaining open questions

Practical validation

Feasibility

Adoption

Next steps

- Lab validation → quantify cooling accross the day and night
- Design for constraints → materials, installation, maintenance
- Pilot → test adoption on a small scale before scaling up
- Mapping suitable environments

Thank you for your attention.

Full research report will be online shortly

stijnservaas11@gmail.com