

Thematic track 10: Sustainable Cooling Alternatives

Pathways to High Performance Architecture: Contextual design approach

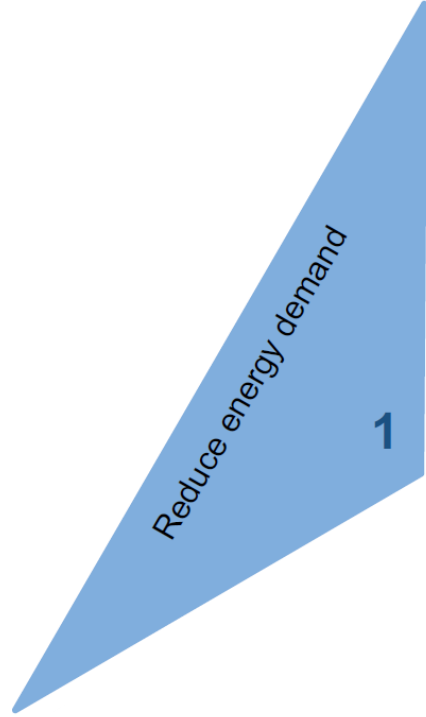


High performance building

The term '**high-performance building**' means a building that integrates and optimizes on a life cycle basis all major high performance attributes, including **energy conservation**, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.

(Energy Independence and Security Act, 2007 <https://www.nibs.org/page/hpbc>)

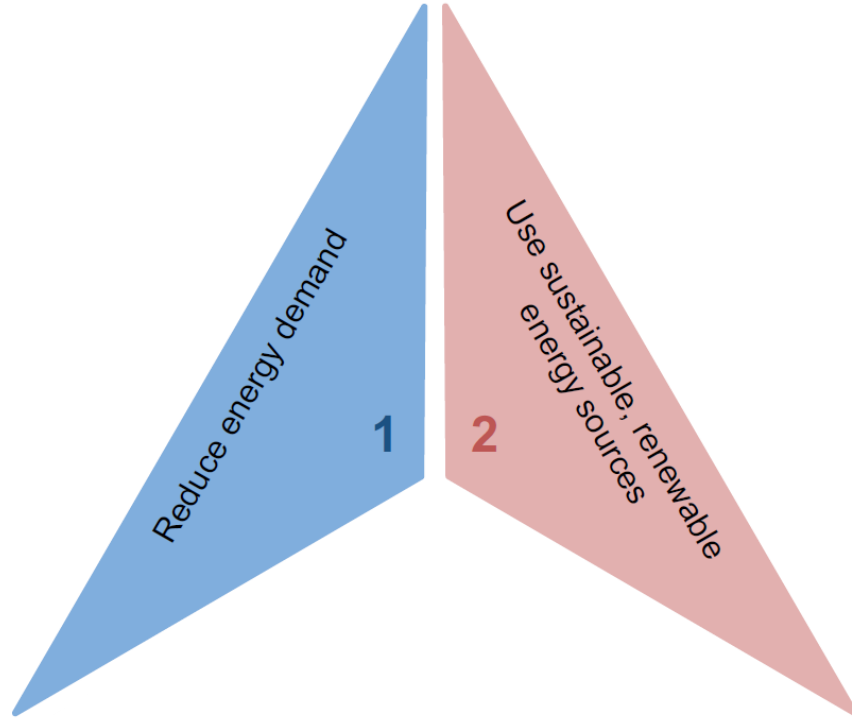
The “Trias Energetica” principle



First, prevent the use of energy (prevention)

(Konstantinou and Prieto, 2018)

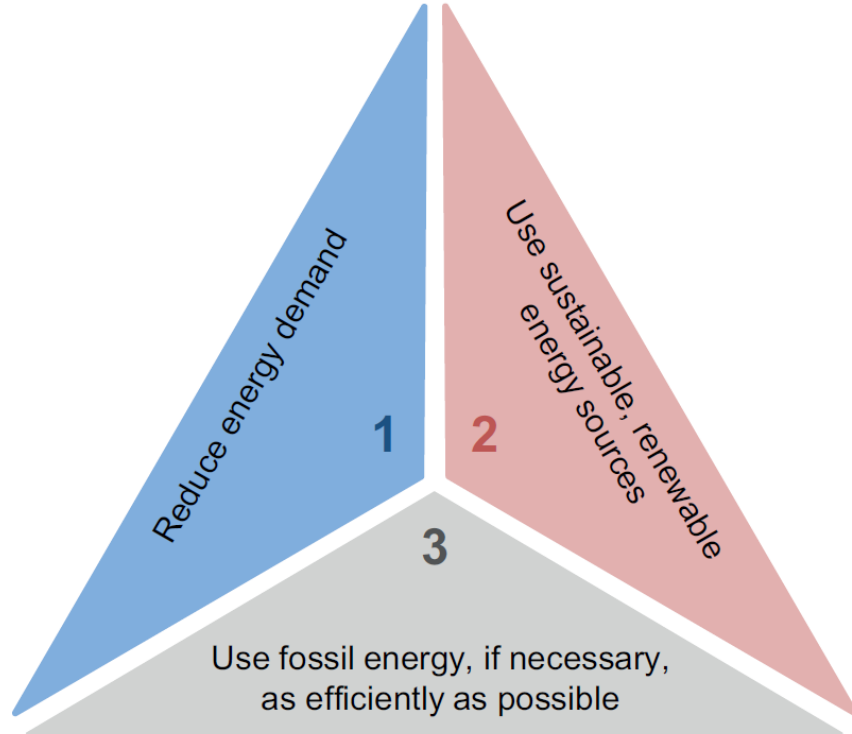
The “Trias Energetica” principle



use renewable energy sources as
extensively as possible
(renewable)

(Konstantinou and Prieto, 2018)

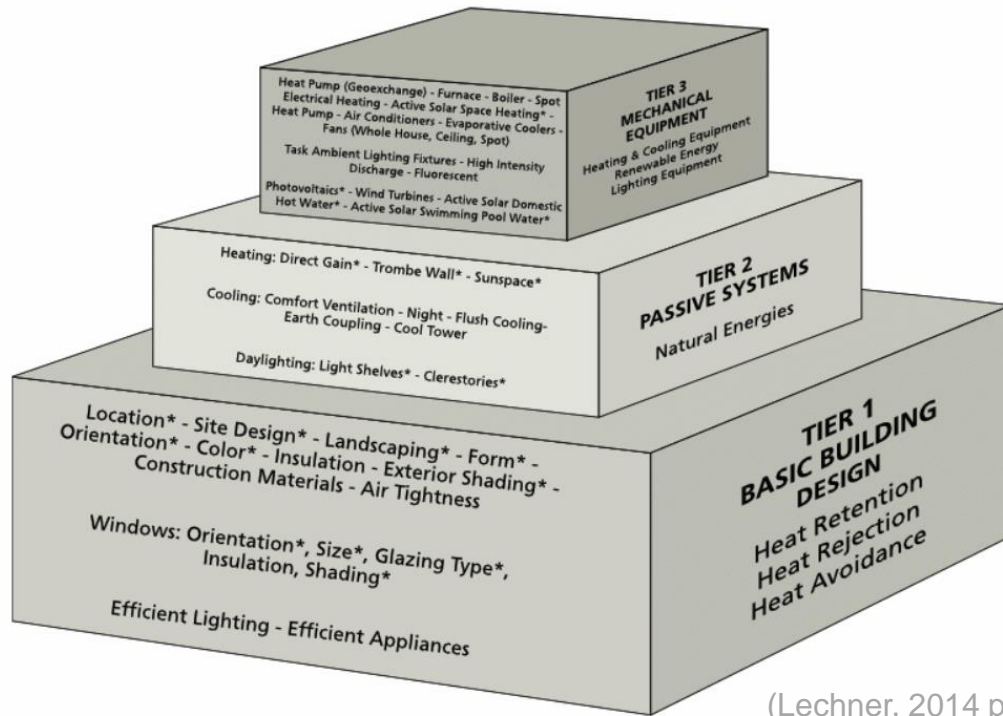
The “Trias Energetica” principle



Finally, if still needed, use fossil fuels as efficiently as possible (efficiency)

(Konstantinou and Prieto, 2018)

An approach to sustainable design



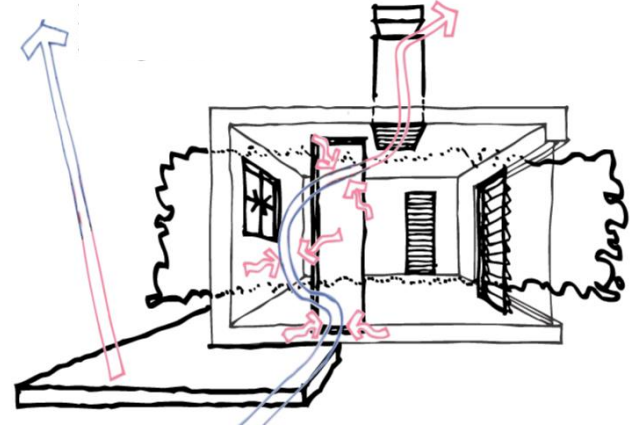
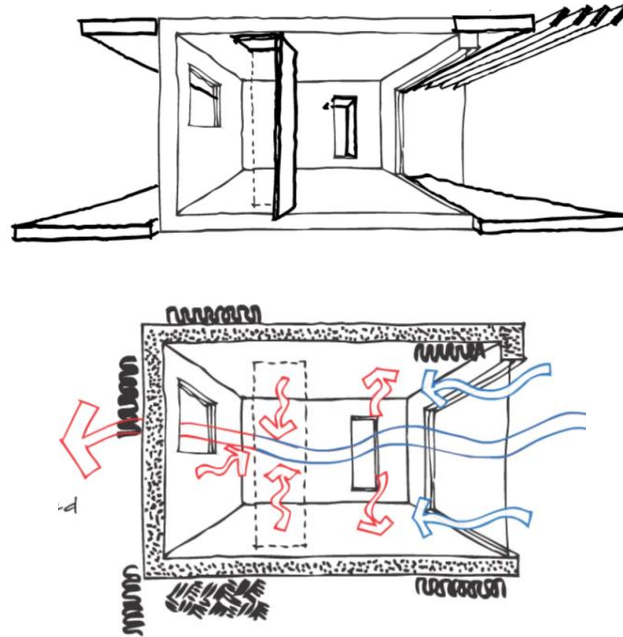
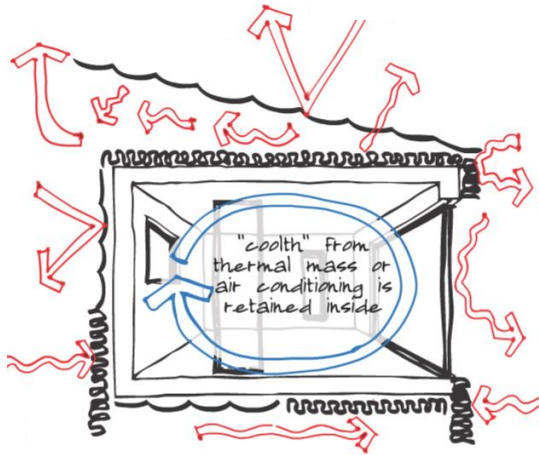
(Lechner, 2014 p.9)

Table 1.4A The Three-Tier Design Approach

	Heating	Cooling
Tier 1	<i>Conservation</i>	<i>Heat avoidance</i>
Basic Building Design	<ol style="list-style-type: none"> 1. Surface-to-volume ratio 2. Insulation 3. Infiltration 	<ol style="list-style-type: none"> 1. Shading 2. Exterior colors 3. Insulation 4. Mass
Tier 2	<i>Passive solar</i>	<i>Passive cooling</i>
Natural Energies and Passive Techniques	<ol style="list-style-type: none"> 1. Direct gain 2. Trombe wall 3. Sunspace 	<ol style="list-style-type: none"> 1. Evaporative cooling 2. Night-flush cooling 3. Comfort ventilation 4. Cool towers
Tier 3	<i>Heating equipment</i>	<i>Cooling equipment</i>
Mechanical and Electrical Equipment	<ol style="list-style-type: none"> 1. Furnace 2. Boiler 3. Ducts/Pipes 4. Fuels 	<ol style="list-style-type: none"> 1. Refrigeration machine 2. Ducts 3. Geo-exchange

Prevent the use of energy - cooling

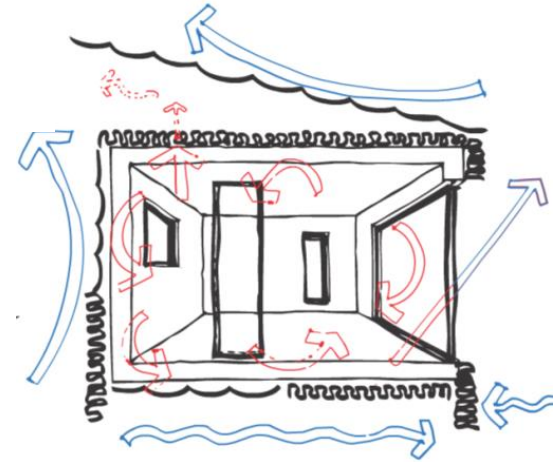
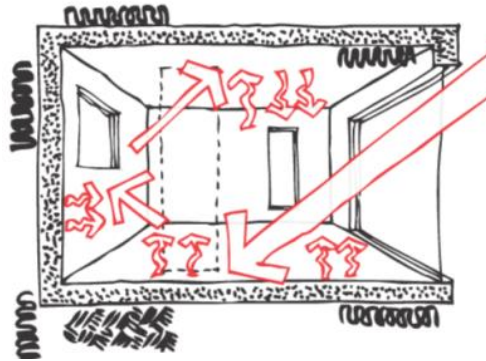
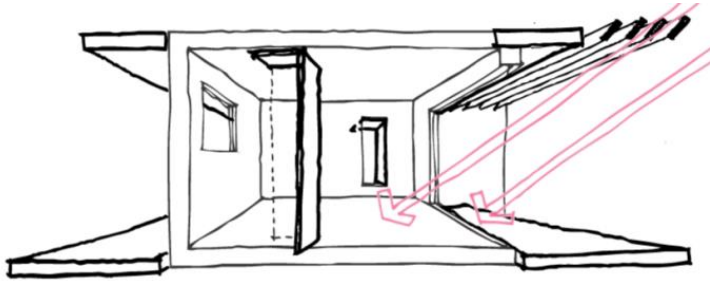
Heat protection/ rejection



(www.designingforclimate.com.au, 2018)

Prevent the use of energy - heating

Heat gain/ retention



(www.designingforclimate.com.au, 2018)

Cooling strategies

Hot and Dry climate



Gaza, Israel, Middle East

(<http://eartharchitecture.org/?tag=domes>)

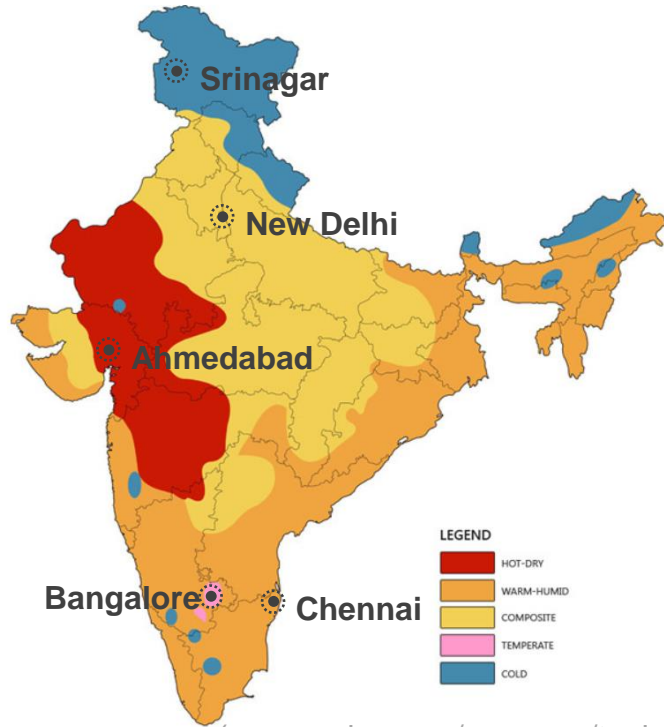
Hot and Humid climate



Malay house, Malaysia

(<http://nalenda14.blogspot.com.au/2010/11/malay-vernacular-architecture.html>)

Indian climate zones



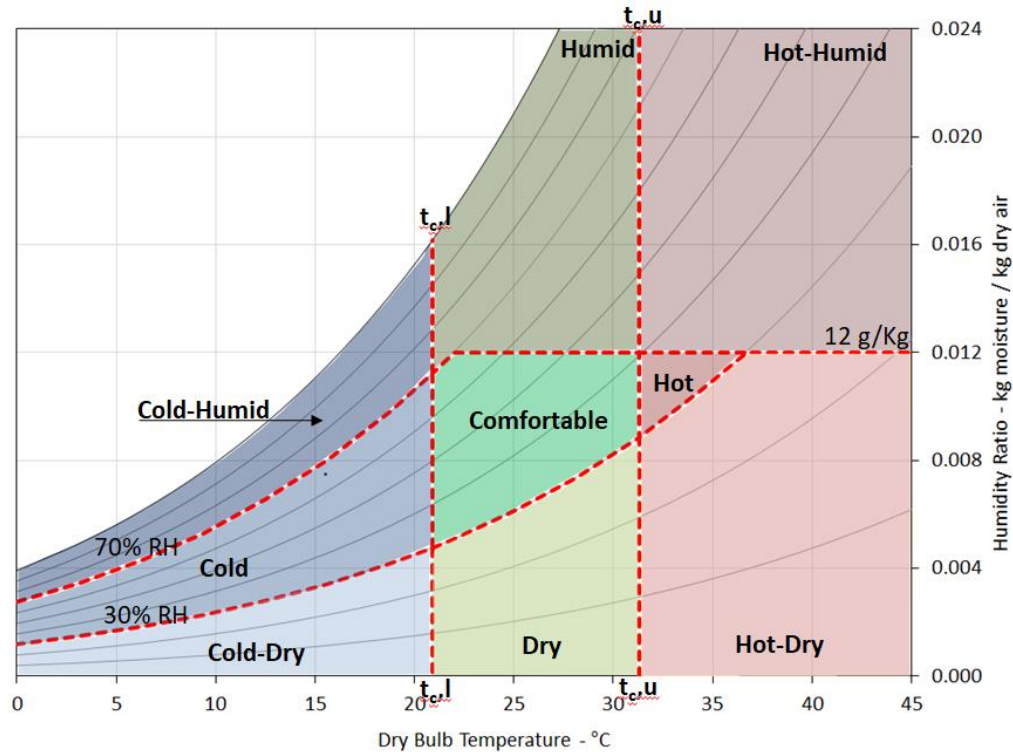
(www.carbse.org/resource/tools/)

Sl No.	Climatic Zone	Mean Monthly Maximum Temperature °C	Mean Monthly Relative Humidity Percent
(1)	(2)	(3)	(4)
i)	Hot-dry	Above 30	Below 55
ii)	Warm-humid	Above 30	Above 55
		Above 25	Above 75
iii)	Temperate	25-30	Below 75
iv)	Cold	Below 25	All values
v)	Composite	<i>see 3.2.2</i>	

3.2.2 Each climatic zone does not have same climate for the whole year; it has a particular season for more than six months and may experience other seasons for the remaining period. A climatic zone that **does not have any season for more than six months** may be called as **composite zone**.

(National Building Code of India, 2016, Vol 2 p.8)

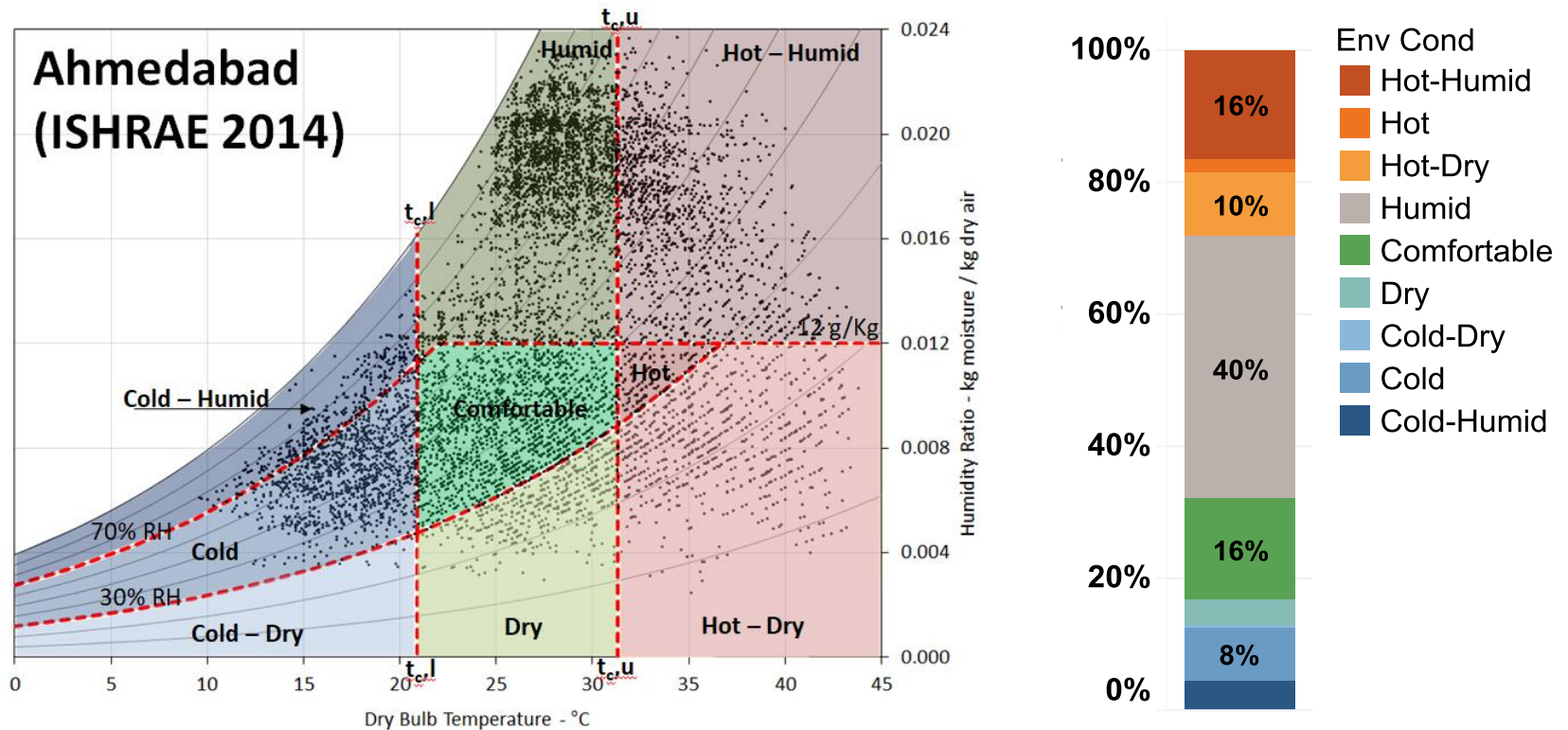
Thermal environmental conditions



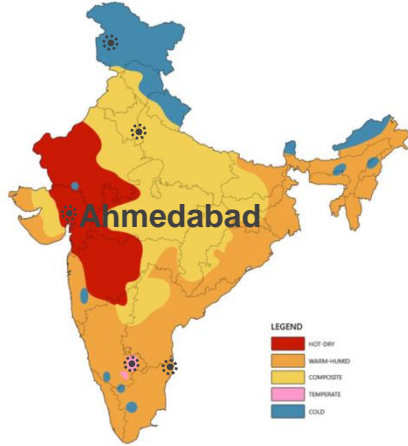
(Upadhyay, 2018)



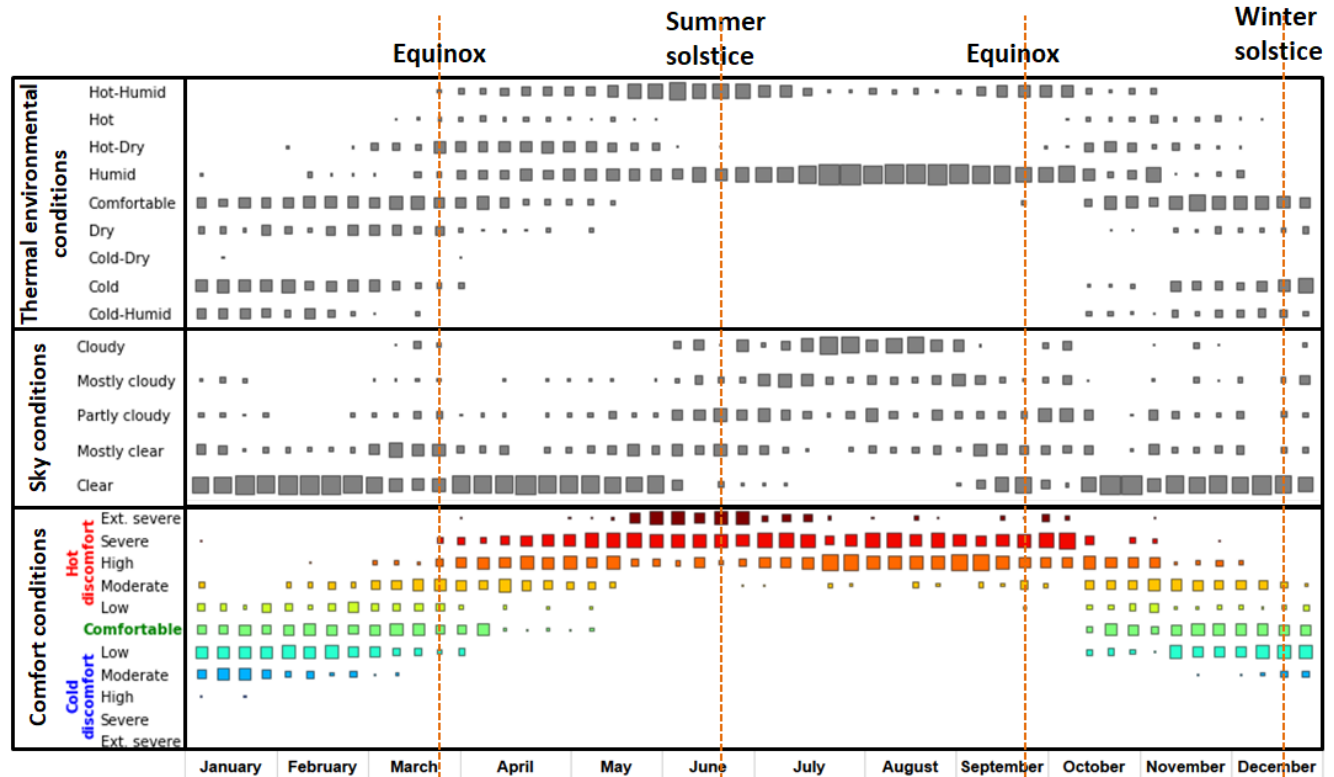
Thermal environmental conditions



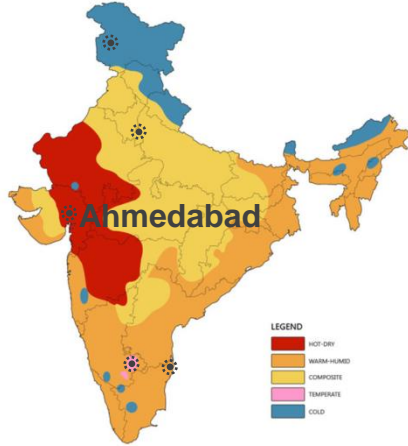
Ahmedabad climate outlook



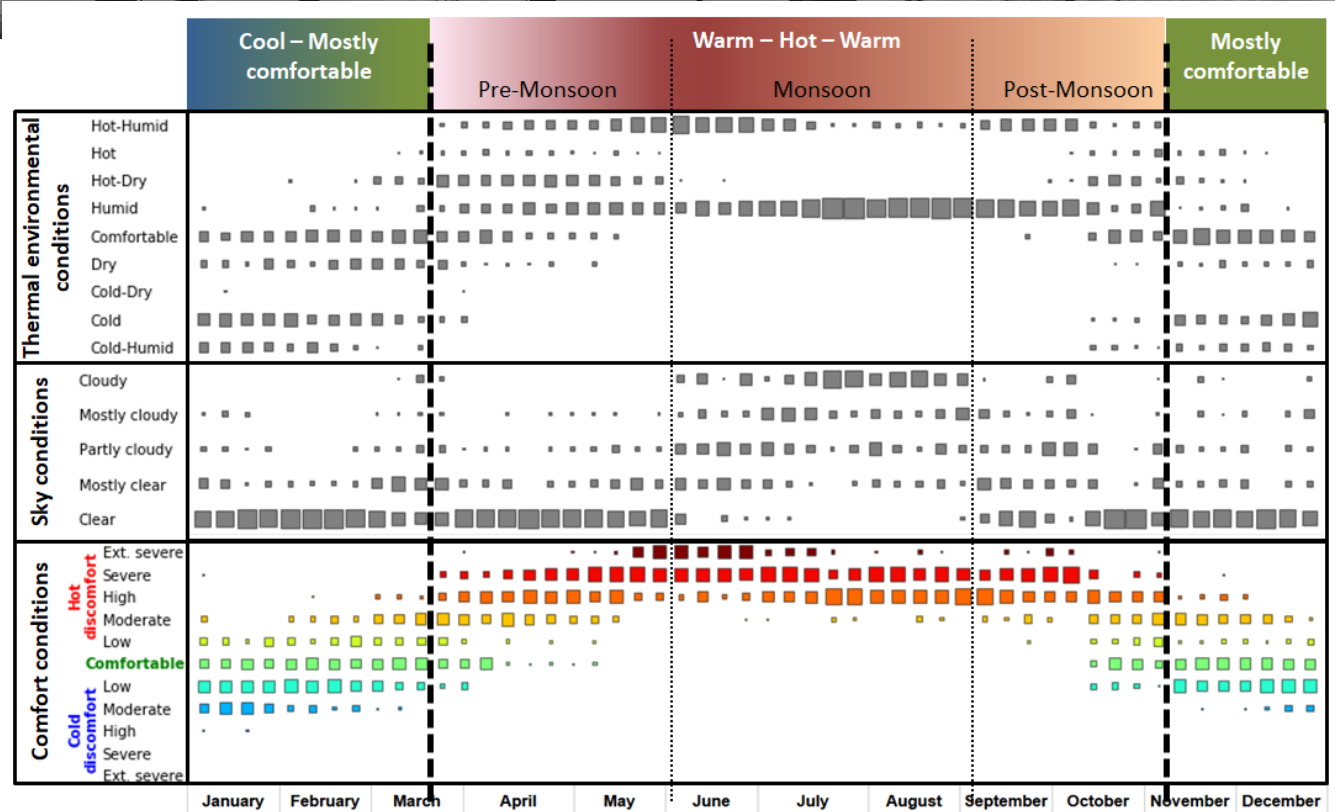
Classified as
hot-dry



Ahmedabad climate outlook



Classified as
hot-dry



Torrent Research centre, Ahmedabad



https://archnet.org/sites/4454/media_contents/17672

Torrent Research centre, Ahmedabad

LARGE VARIATIONS IN THE CLIMATIC CONDITIONS NECESSITATED A DEEPER UNDERSTANDING OF THE IMPLICATIONS OF EACH SEASON AND THE RANGE OF SUN MOVEMENT, TEMPERATURE, HUMIDITY AND WIND VELOCITY VARIATIONS WITHIN IT, AND EVOLVING APPROPRIATE STRATEGIES FOR EACH SITUATION.



HOT SEASON STRATEGY (MARCH - JUNE)

- Passive evaporative cooling elements provide a down draft of cool air
- Night ventilation
- Ambient temperature 41 to 43°C
- Insulated building mass and roof
- High air change rates achievable (8 - 10)
- Air moves across the laboratory through mass of short circuiting
- Control: Microclimate to be controlled automatically for reference to ambient temperature and relative humidity



MONSOON SEASON STRATEGY (JULY - SEPTEMBER)

- Maximize ventilation rate with repressures switched off
- Ceiling and wall fans to induce air movement in the same direction as natural flow
- Air speed upper limit 1.5 m/s
- Possibly close all exhausts in the afternoon



COOL SEASON STRATEGY (OCTOBER - FEBRUARY)

- Minimize ventilation rates
- Intake closed by shutters
- Exhausts also closed by shutters
- Insulated walls and roof reduces heat losses
- Internal gains raise temperature
- Encourage ventilation during the day (usually responsive) control on hot days
- Close intake and exhausts at night



laboratory space

inlet concourse

inlet concourse doors

upward view of the inlet shaft from concourse

view of the concourse

https://archnet.org/sites/4454/media_contents/17675

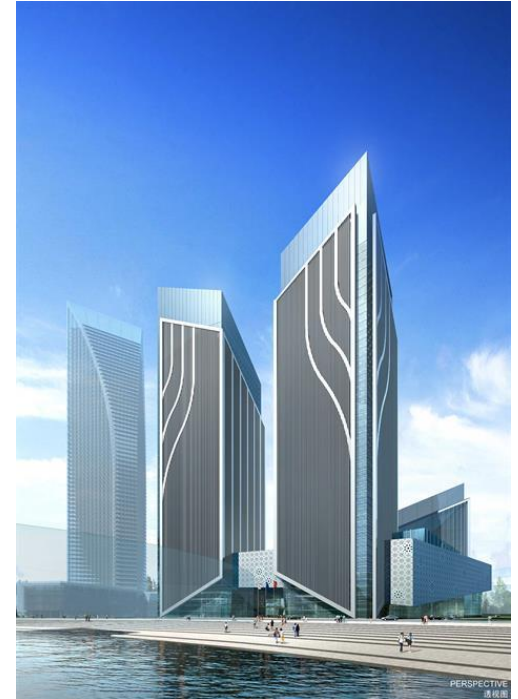
Gift City, near Ahmedabad



<http://www.giftgujarat.in/photo-category#lg=1&slide=7>

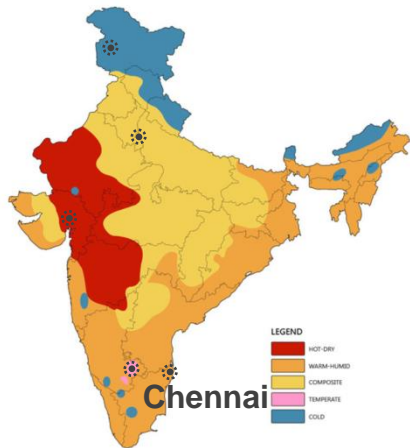


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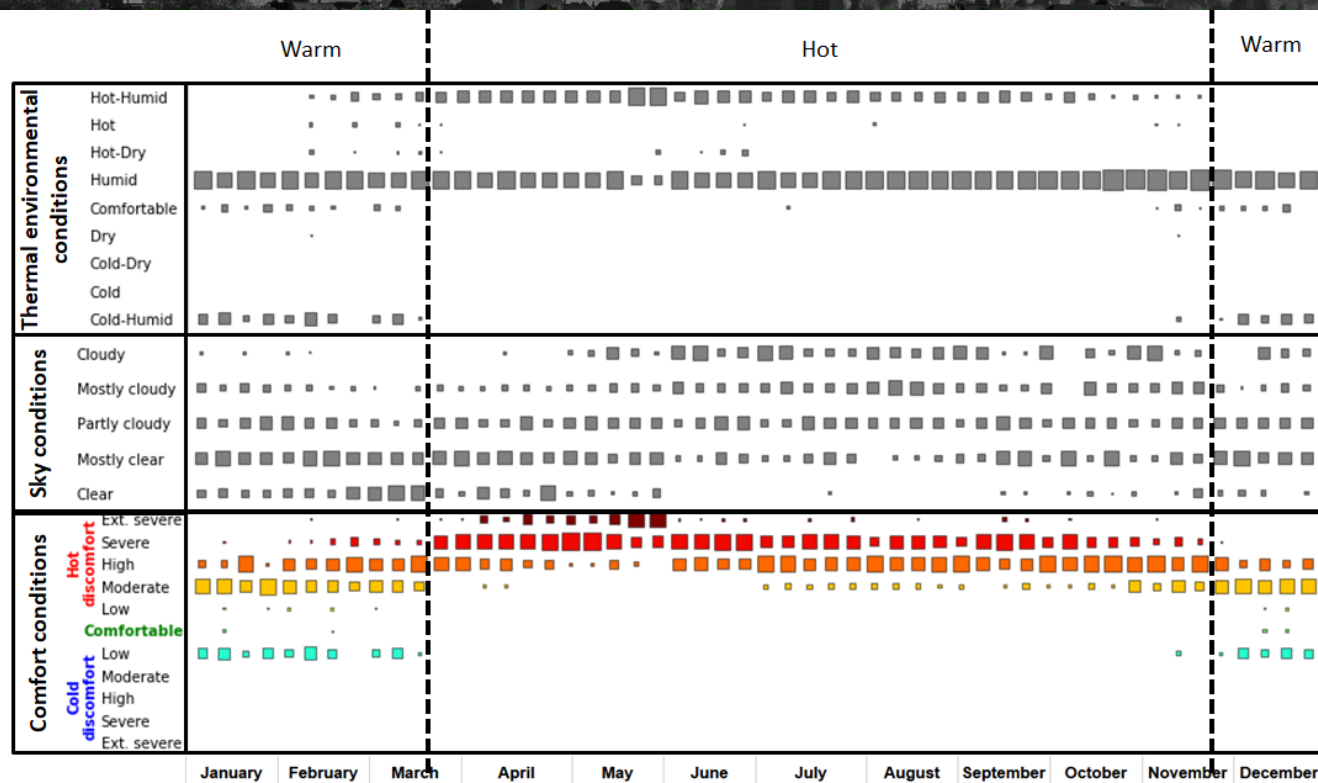


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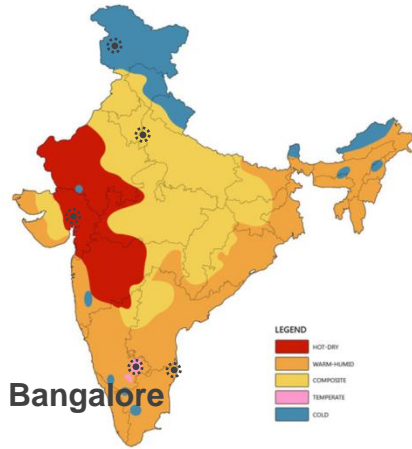
Chennai climate outlook



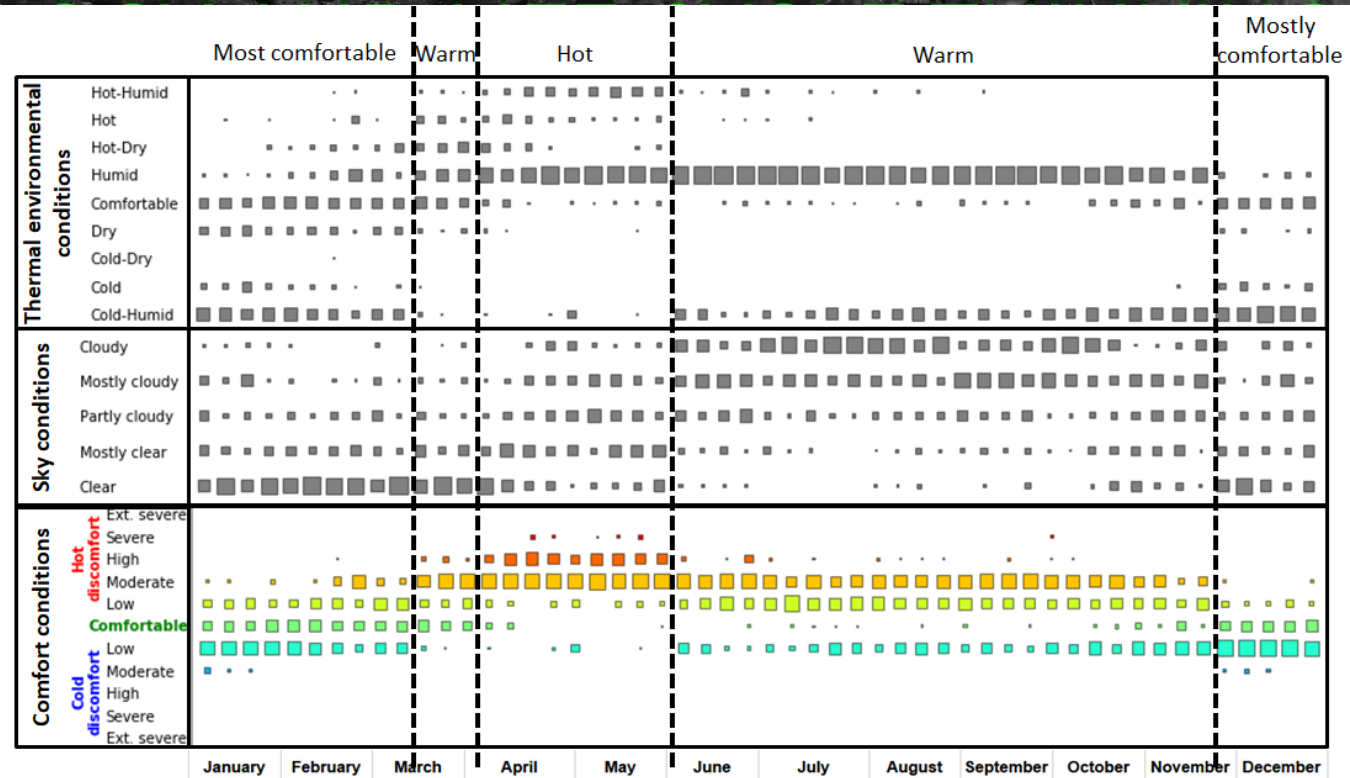
Classified as
warm-humid



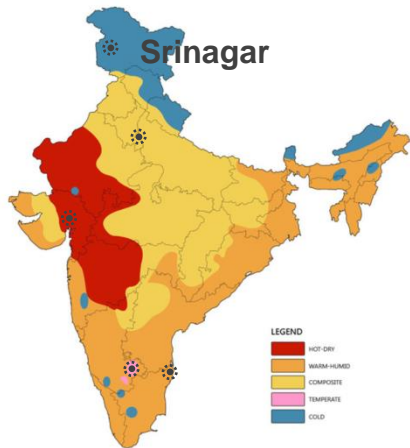
Bangalore climate outlook



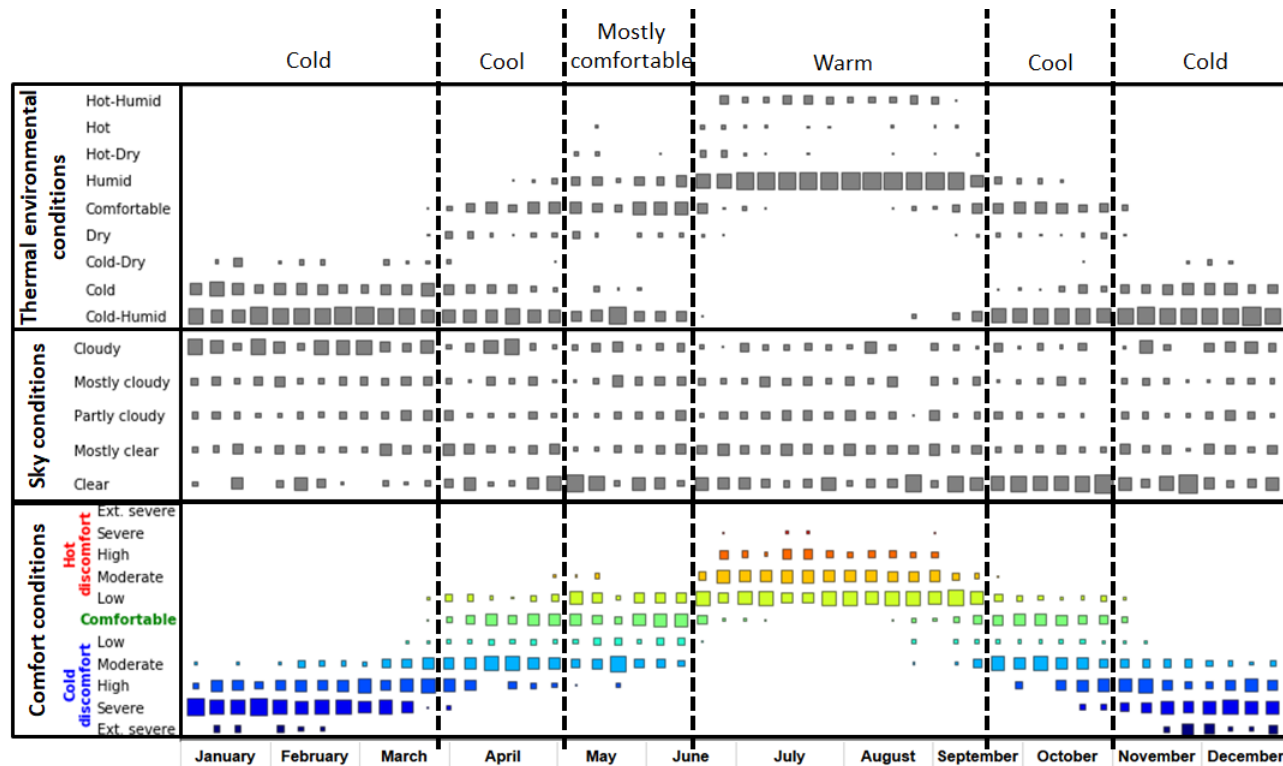
Classified as
warm-humid



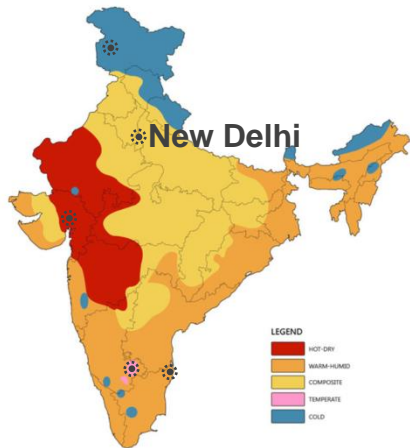
Srinagar climate outlook



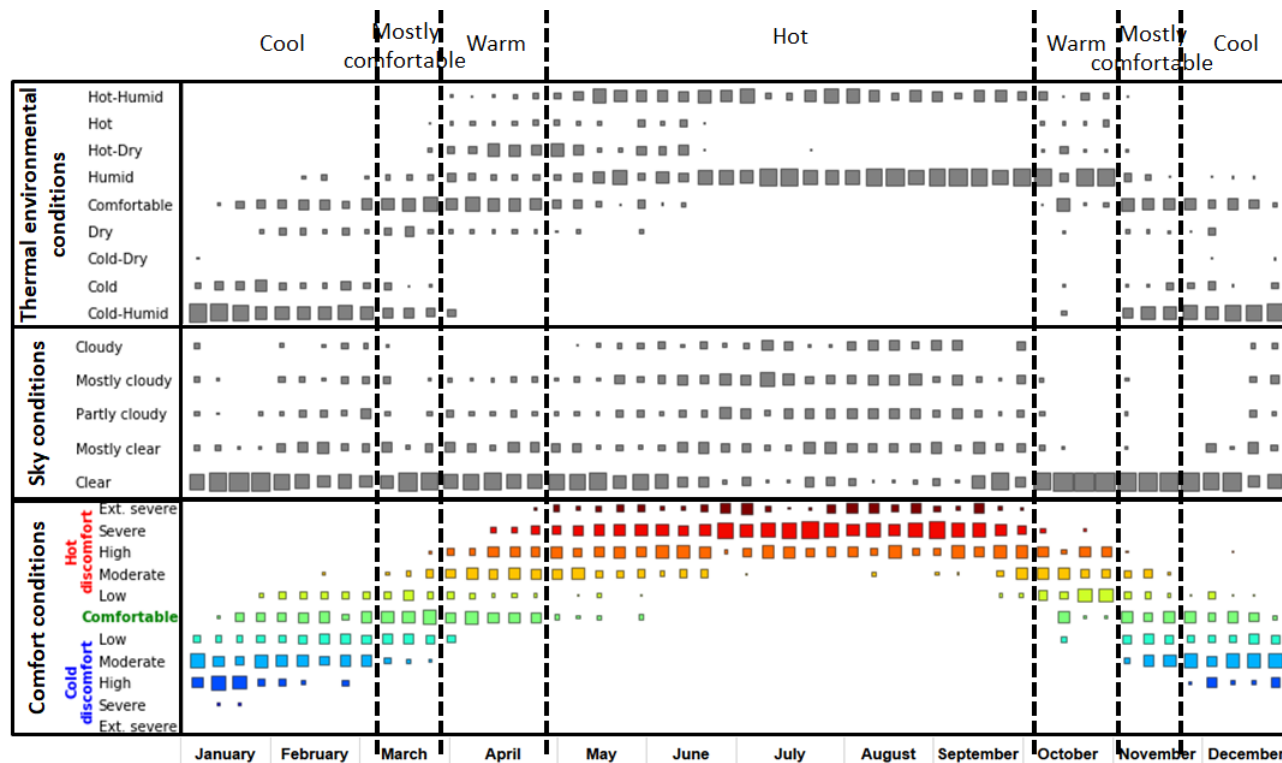
Classified as
cold



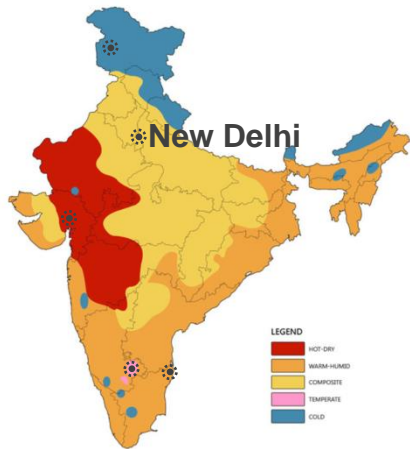
New Delhi climate outlook



Classified as
composite



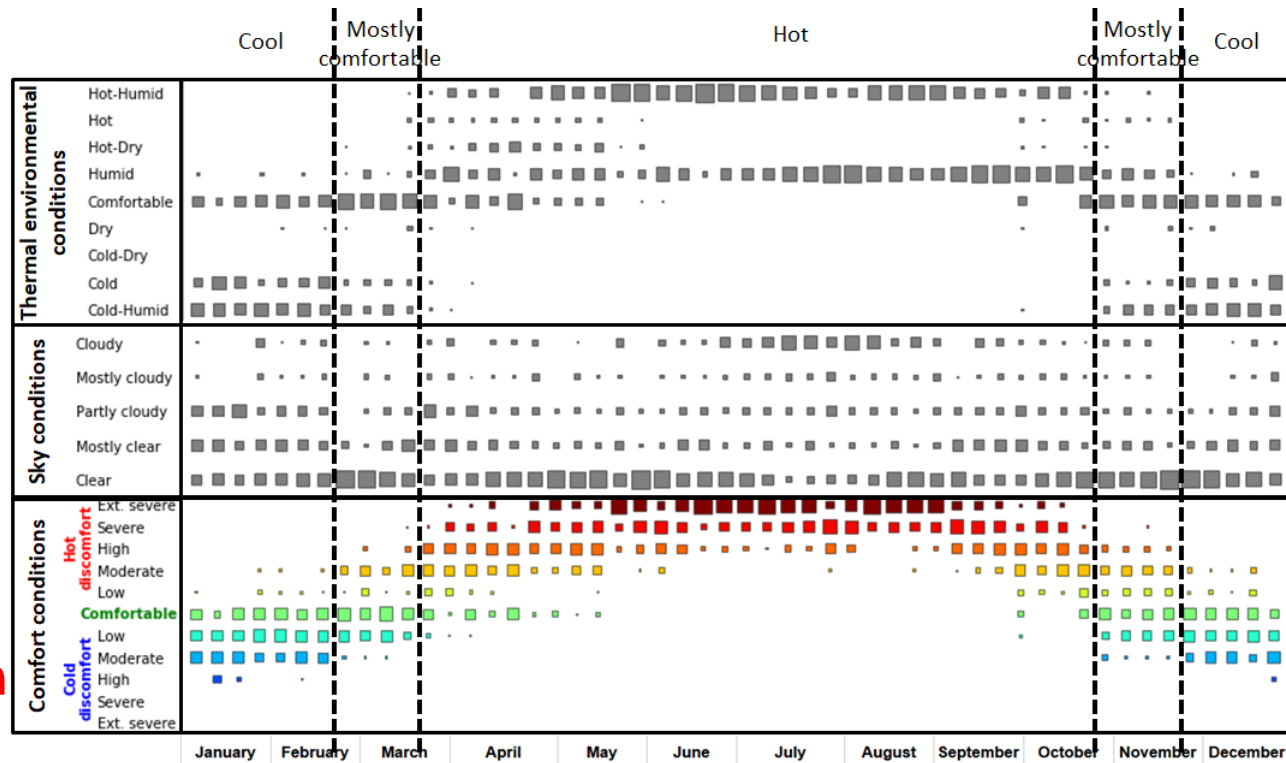
New Delhi climate outlook (2050)



should be Classified as

~~composite~~

predominantly hot with
a brief cool period





Conclusions

- Architectural design can help moderating climate variables to achieve indoor comfort without significant energy input
- Architectural response for hot and humid conditions are not the same
- Current climate classification of India needs to be revisited for high performance buildings, particularly for cooling and heating
- Understanding of the local climate will help developing specific strategies to suite to the local context and also to changing climatic context



Thanks!

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