प्रधान मंत्री आवास योजना-शहरी
Pradhan Mantri Awas Yojana-Urban

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

Azadi Ka Amrit Mahotsav

bmtpc | giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

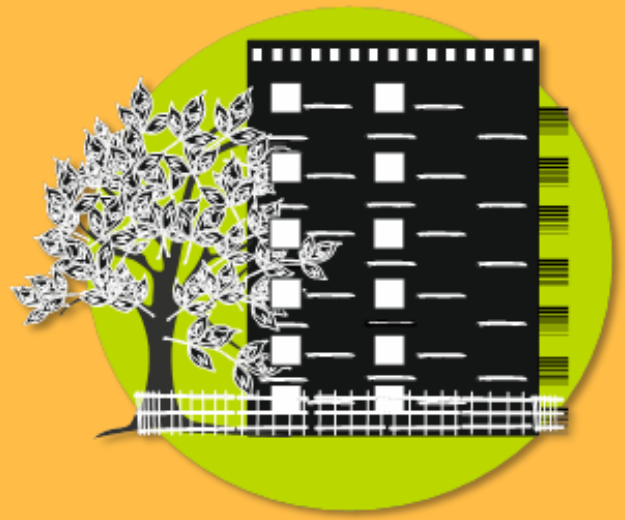
Session 2 – Understanding Indian Climate

MMM dd, yyyy | Place

eds environmental design solutions

Wuppertal Institut

hunnarshālā FOUNDATION



What is Climate?

What is Climate?

Average weather or an integration in time of weather conditions

e.g., tropical climate have heat as a dominant problem with annual average temperature not less than 20°C

30 years average (WMO)

Climate changes very slowly *(scale of tens, hundreds and thousands of years)*

What is Climate?

"We must begin by taking note of the countries and climates in which homes are to be built if our designs for them are to be correct.

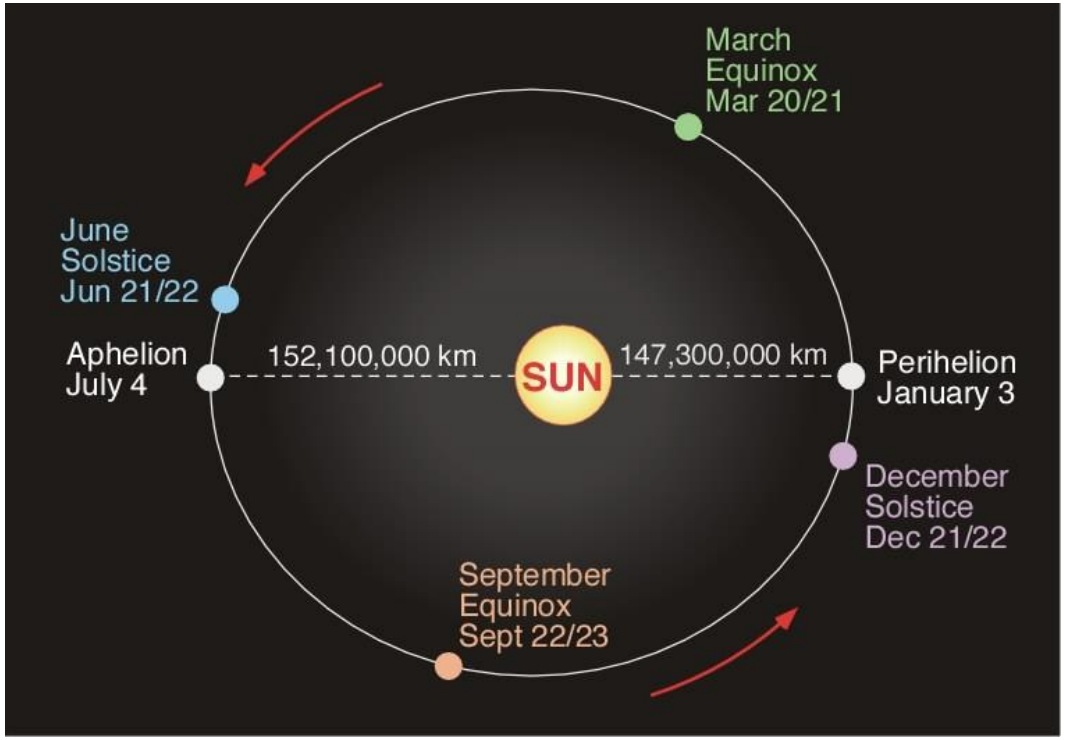
One type of house seems appropriate for Egypt, another for Spain . . . one still different for Rome.

. . . It is obvious that design for homes ought to conform to diversities of climate."

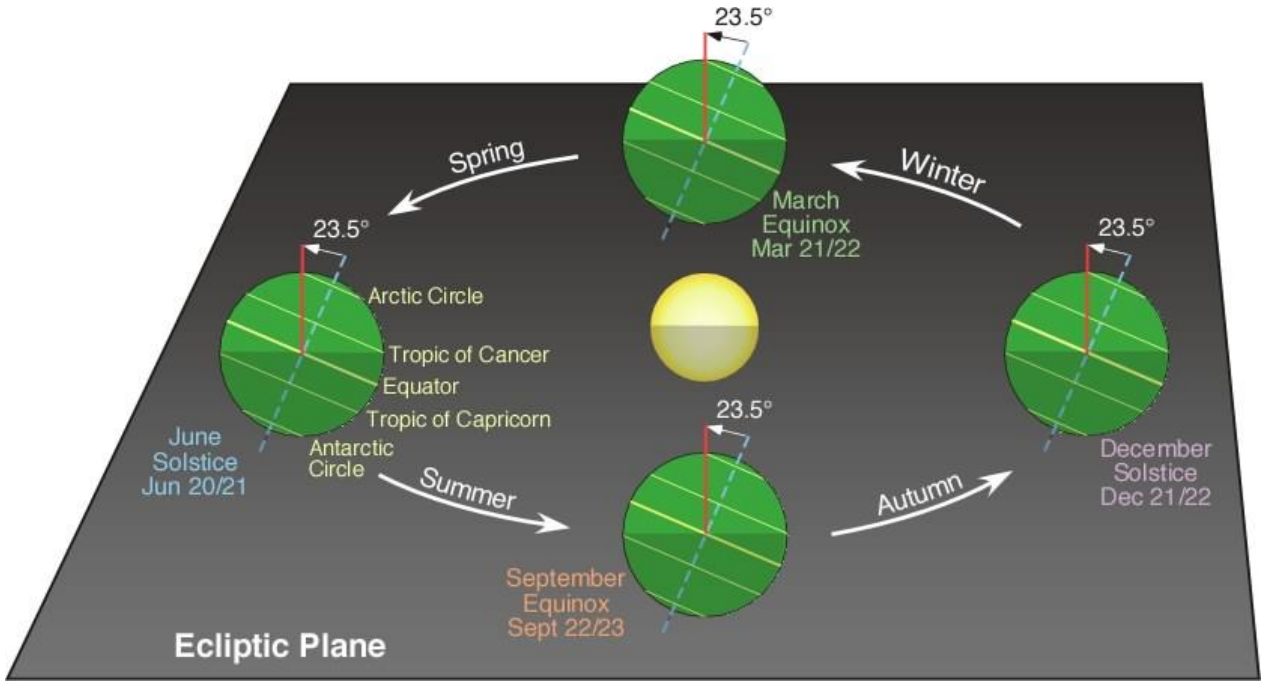
Marcus Vitruvius Pollio, De architectura
(The Ten Books on Architecture) Architect, I century B.C.

Determinants of Climate

Sun-Earth Relationship



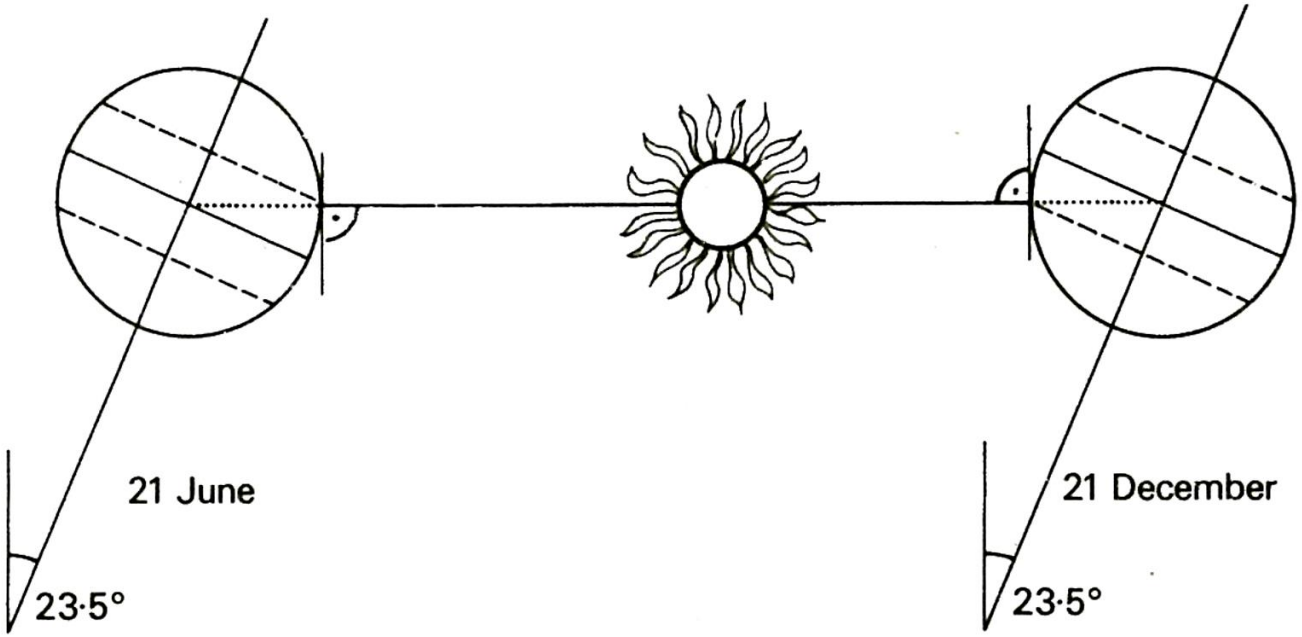
Source:http://www.physicalgeography.net/fundamentals/6h.html

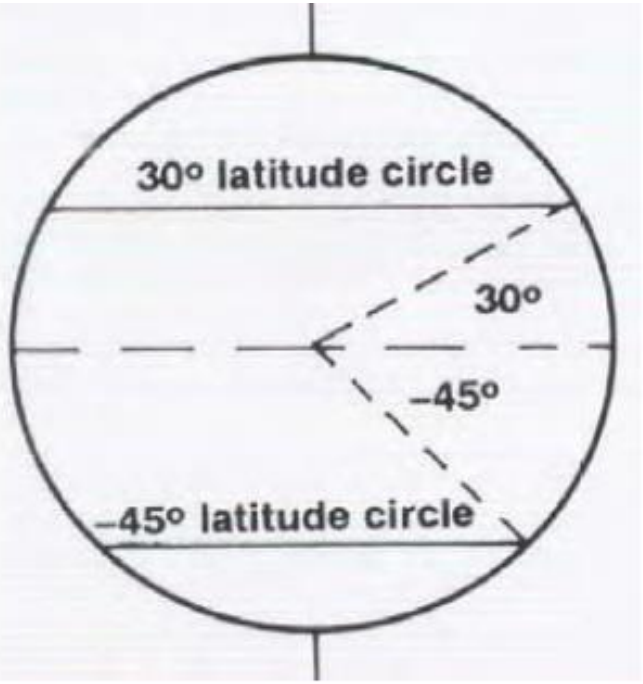


***klima** (Greek) – slope of earth w.r.t. Sun*

Determinants of Climate

Earth's Tilt

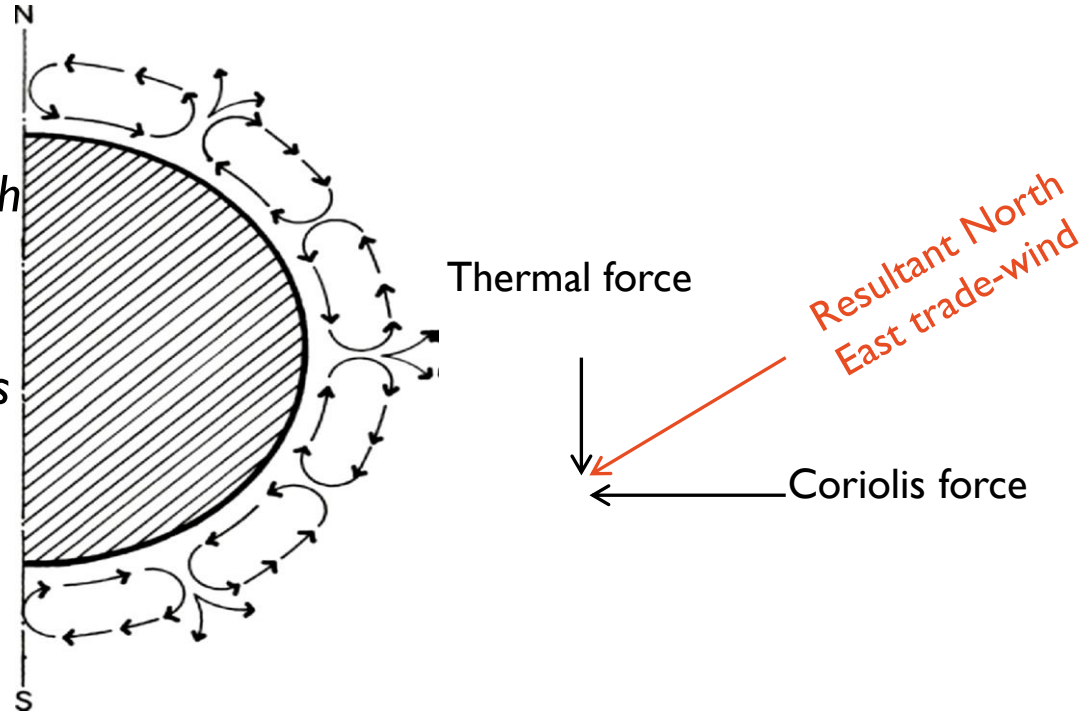




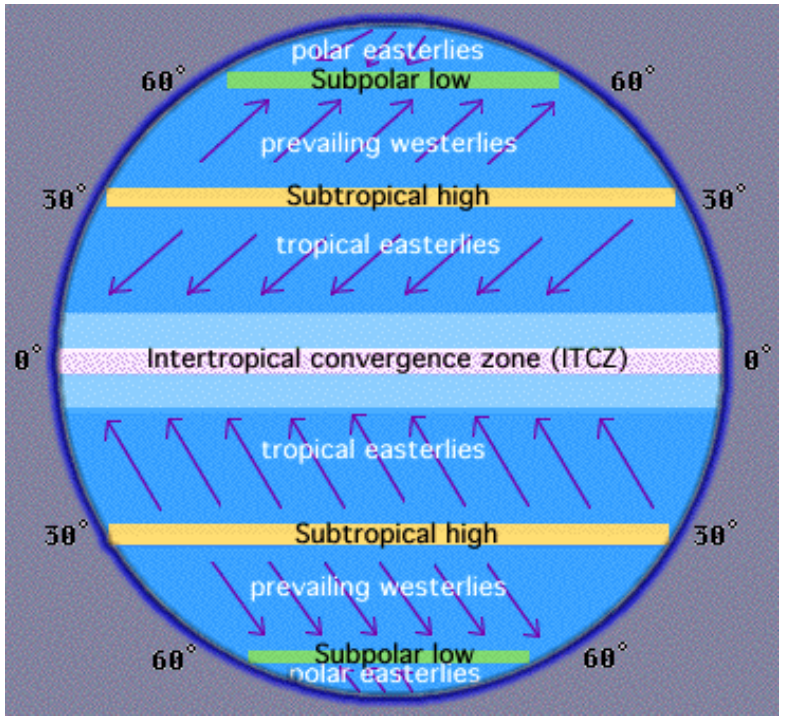
Determinants of Climate

Radiation & Winds

Global North-South flow as earth is heated more at equator than poles



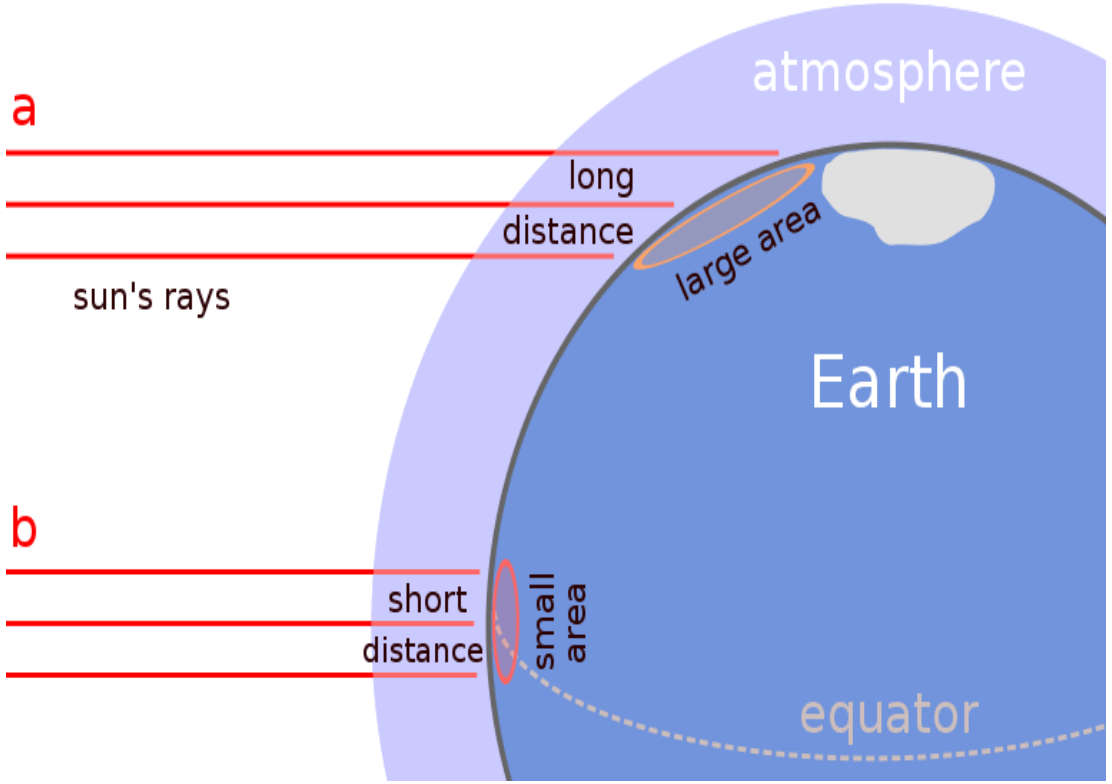
Source: Heating, cooling, lighting: sustainable design methods for architects by Norbert Lechner



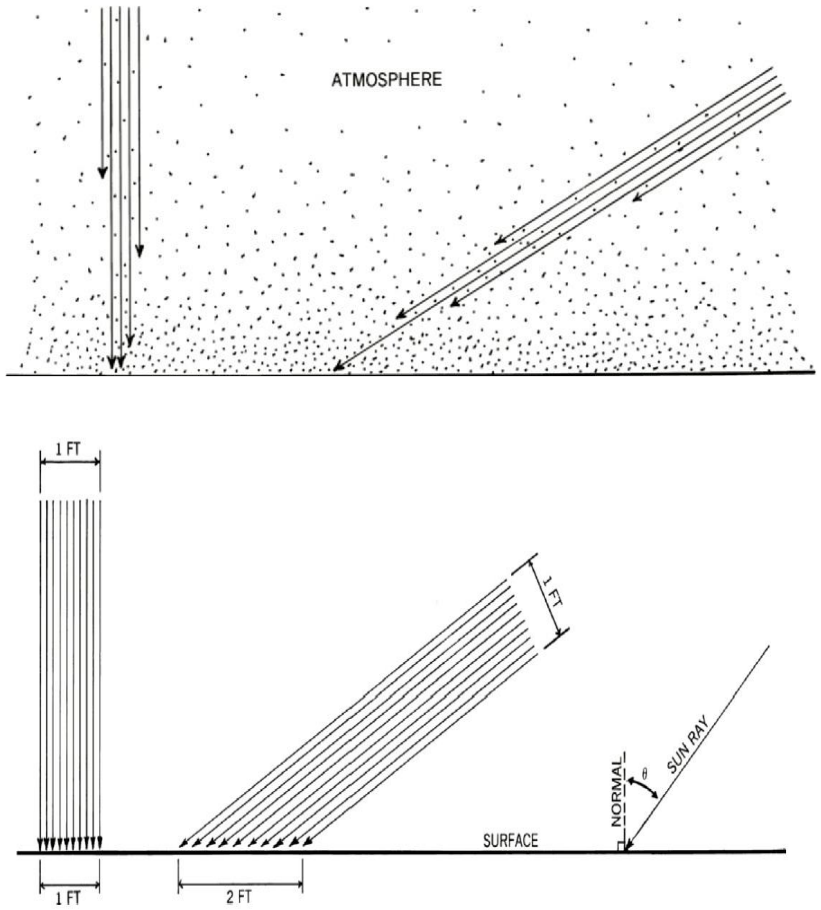
Source:http://ww2010.atmos.uiuc.edu/(Gh)/wwhlpr/hurricane_global winds.rxml

Determinants of Climate

Measure of distance from the equator

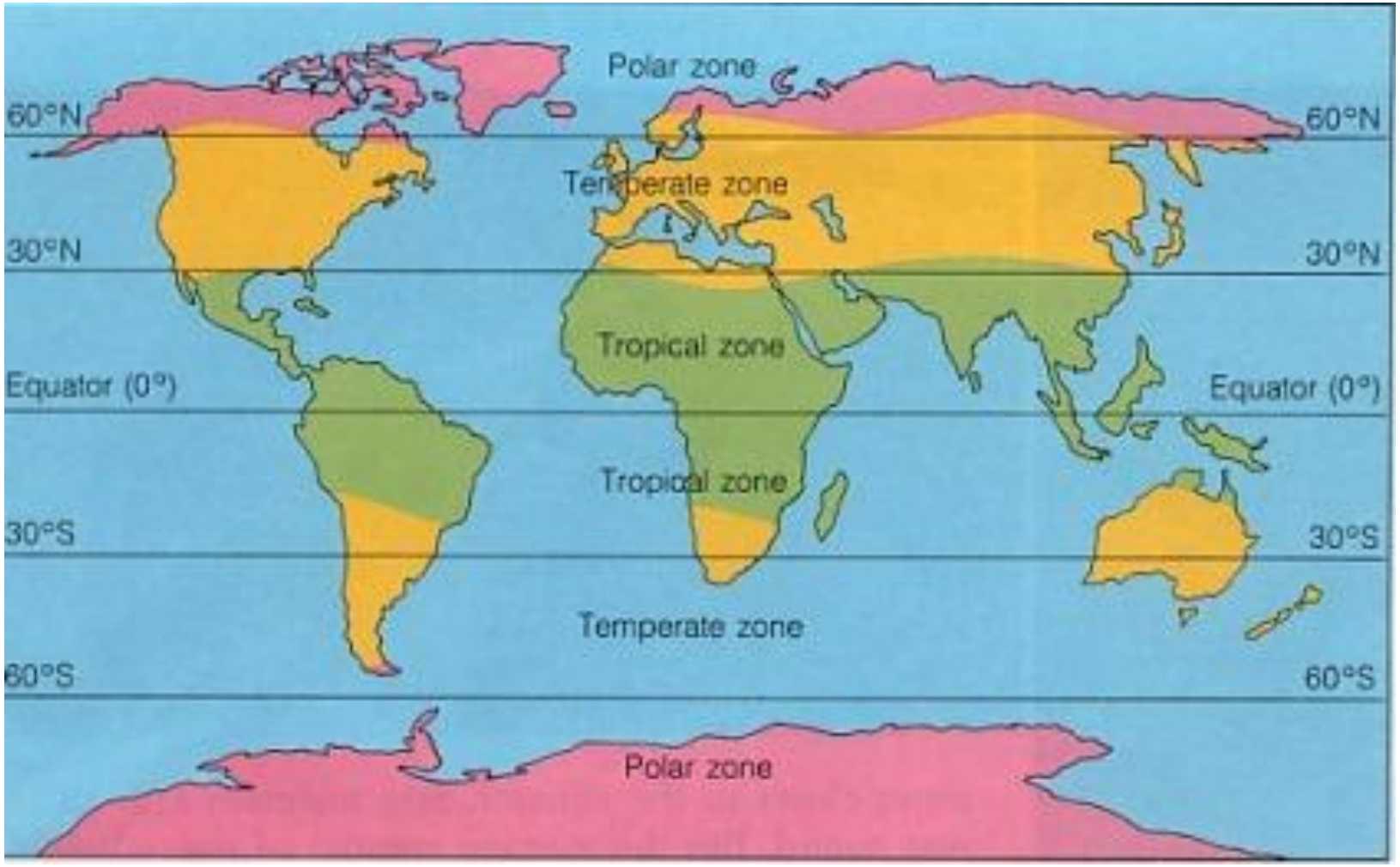


Source:https://en.wikibooks.org/wiki/HKDSE_Geography/M7/Factors_Affecting_Insolation



Source: Heating, cooling, lighting: sustainable design methods for architects by Norbert Lechner

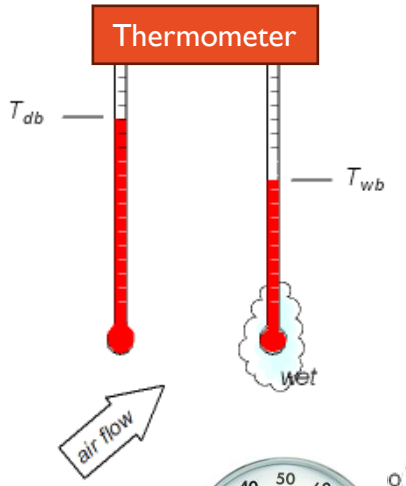
Determinants of Climate



Source: http://climateofberlingermany.weebly.com/temperature-affecting-climate.html

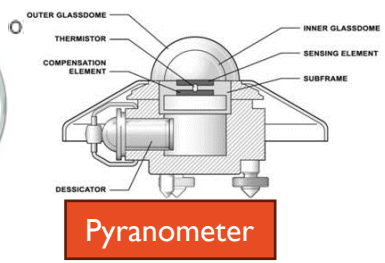
Determinants of Climate

- Temperature
- Humidity
- Radiation
- Precipitation
- Wind
- Sky cover
- Daylight hours

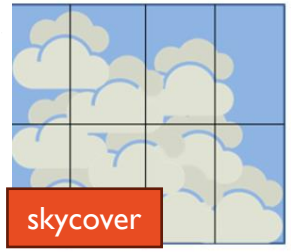



Pyroheliometer


Hygrometer

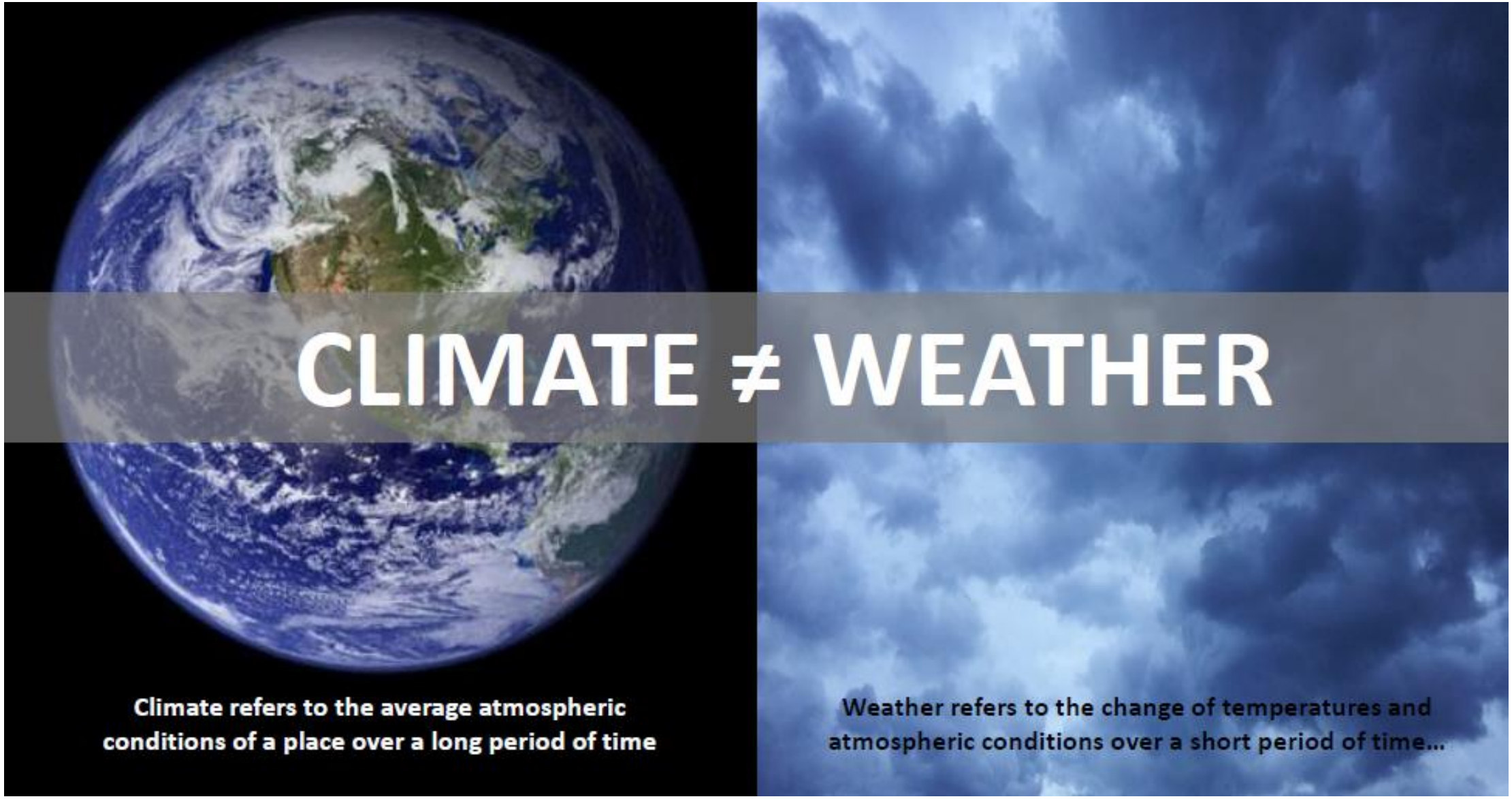


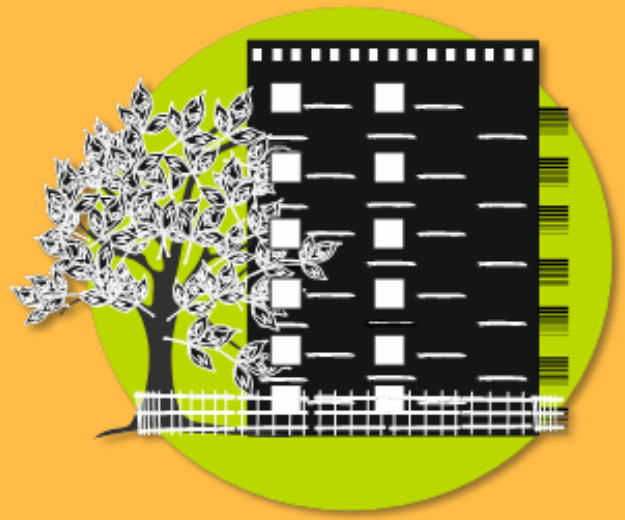
Pyranometer


skycover


Anemometer


Rain gauge meter


CLIMATE ≠ WEATHER
Climate refers to the average atmospheric conditions of a place over a long period of time
Weather refers to the change of temperatures and atmospheric conditions over a short period of time...



Climate of India

Climate of India

Table 2 Classification of Climate

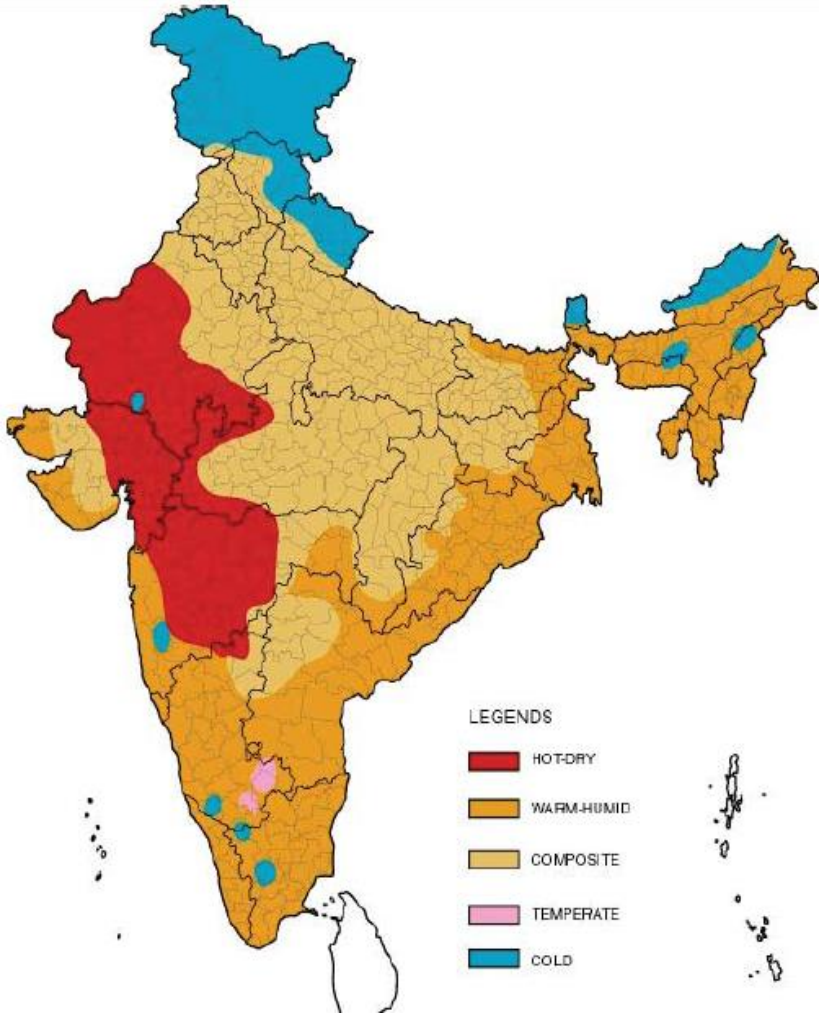
(*Clause* 3.2.1)

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	*see* **3.2.2**	

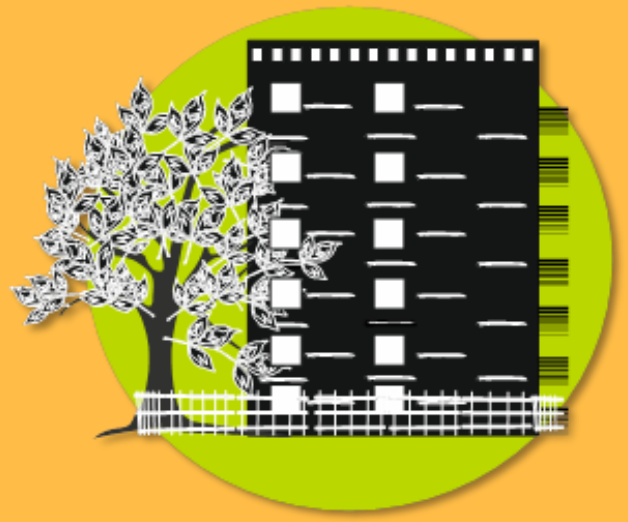
Classification of various climates as per the National Building Code

- Designers must grasp the local climate before building.
- Each climatic zone may have distinct seasons.
- Careful site-specific climate analysis is essential.
- Microclimates within a region also influence design.

Climate of India

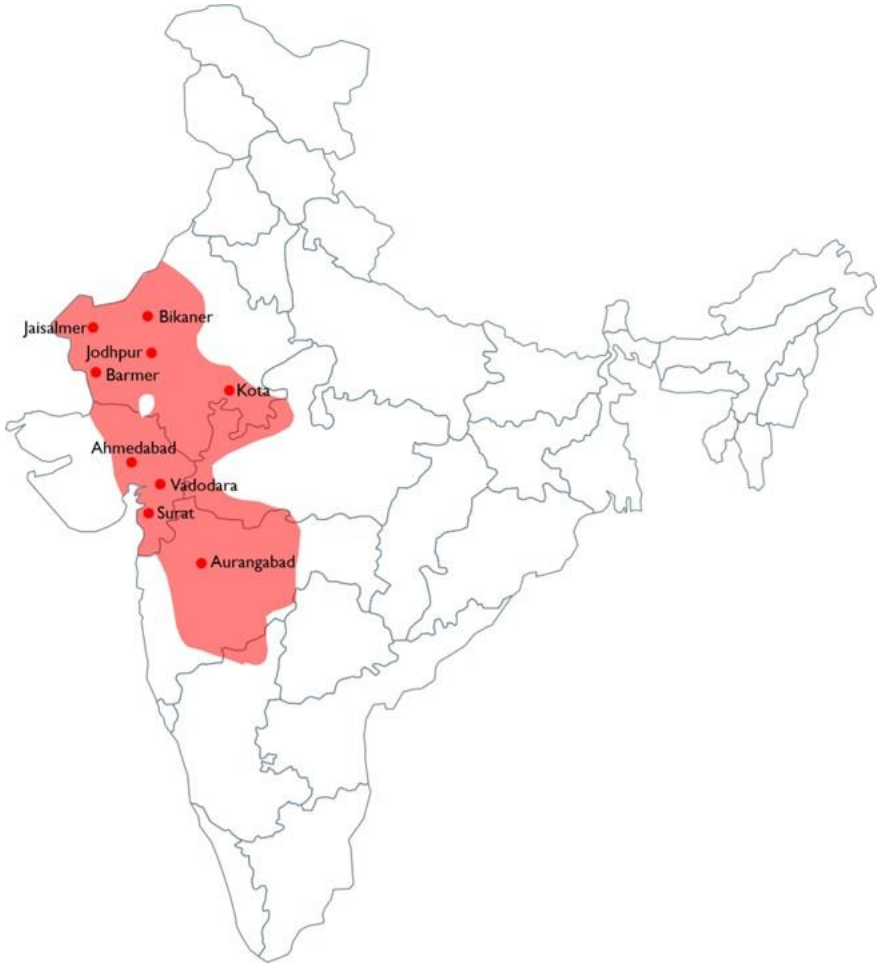


- There are 5 climate zones in India as per NBC
- Each climate zone has its own characteristics
- Building design needs to respond to the climate accordingly



Understanding Hot-Dry Climate

Seasonal Characteristics



39 - 45°C

Day-time mean-max temperature range

27 - 32°C

Day-time mean-max temperature range

10 - 55%

Humidity range

24 - 30°C

Night-time mean-min temperature range

10 - 18°C

Night-time mean min

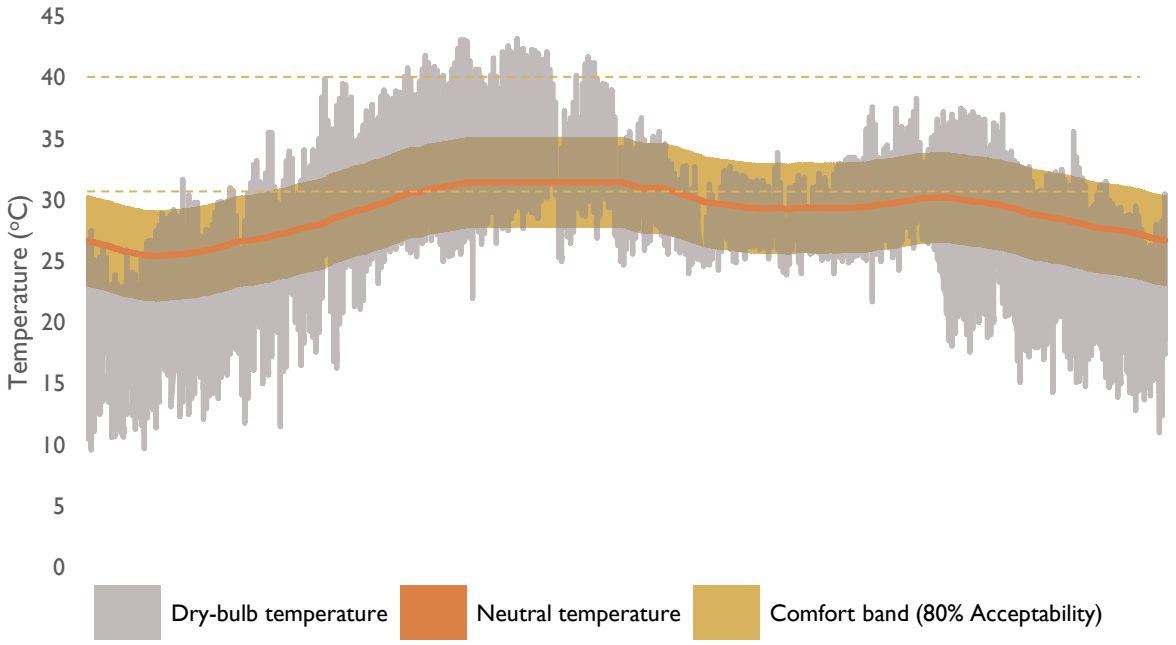
50 -155mm

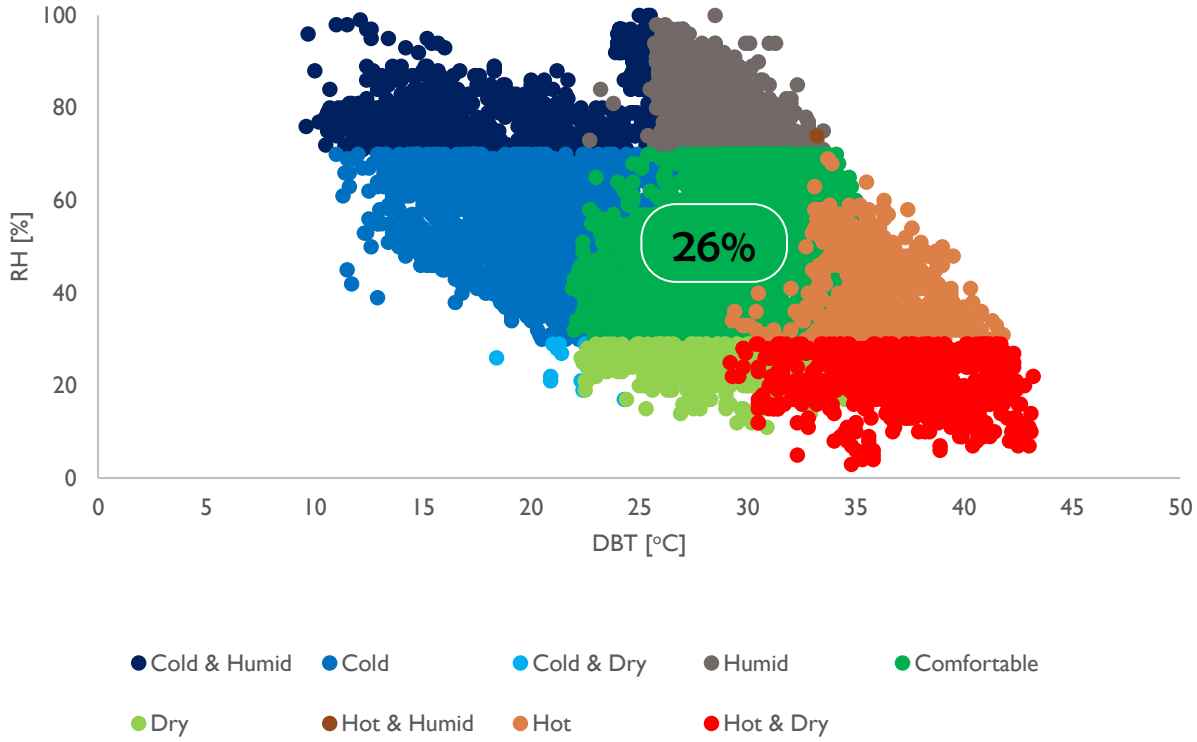
Annual Precipitation

Summer period | **Winter period** | **Precipitation**

Hot-dry climate is characterised by two seasons; hot and dry summers, and somewhat cooler winters. Daily extremes in summers and winters i.e., hot days and cool nights in summers and warm days in winters are a characteristic feature of Hot-dry climate.

Thermal Comfort Potential





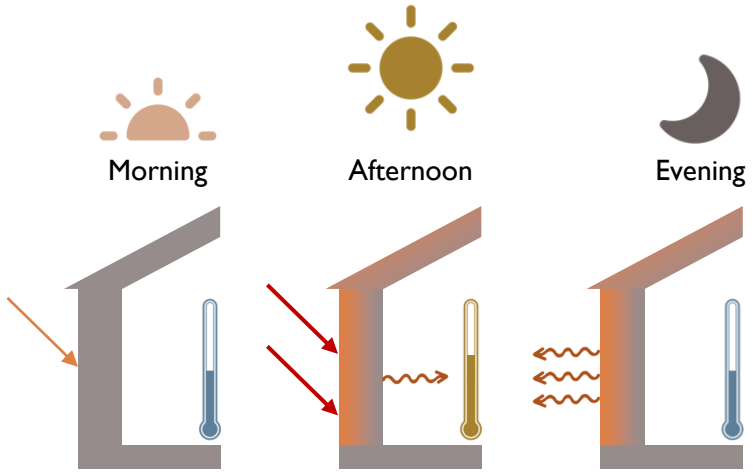
80% acceptability criterion defined by the adaptive comfort model indicates that the comfort band (inclusive of adaptations such as clothing, ceiling fan operation, etc.) lies between 22 and 35oC dry-bulb temperature.

The hot-dry climate can provide comfortable conditions for about 26% hours in a year.

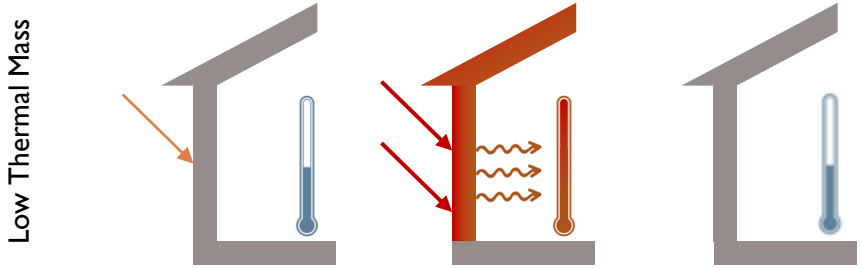
Climatic opportunities

Thermal mass

1



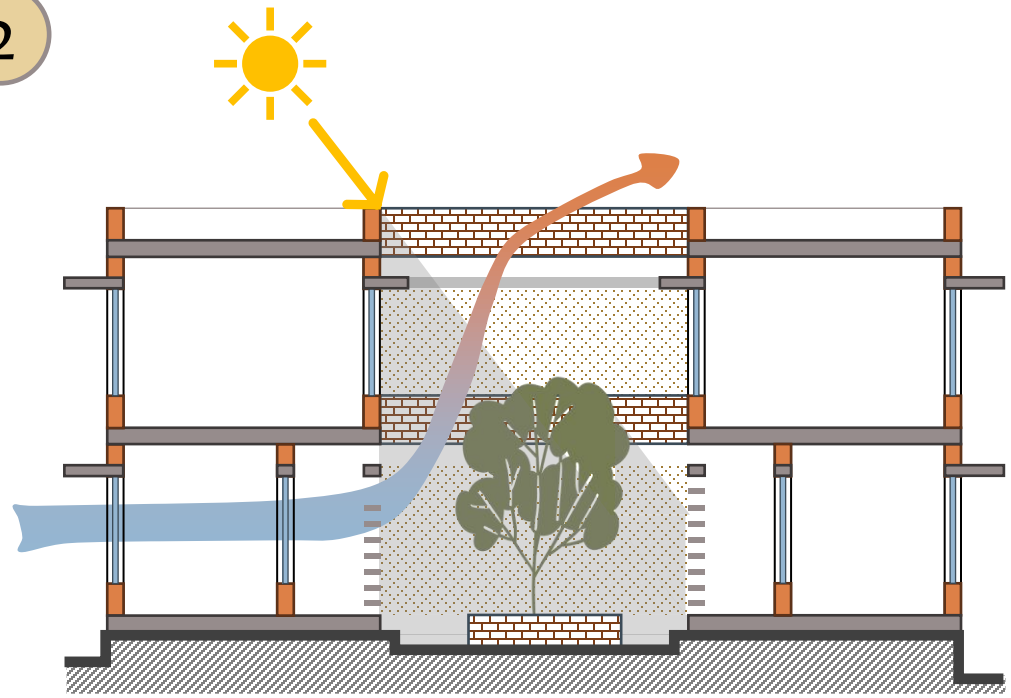
Heat builds up in the structure throughout the day. As the night temperatures are cooler, this heat build-up is expelled outdoors.



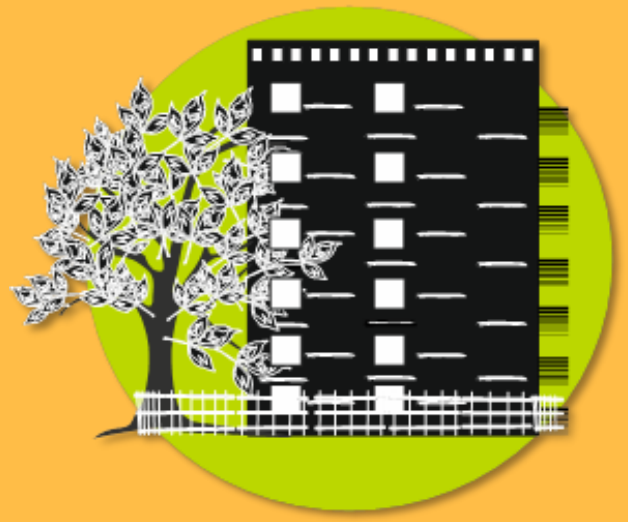
Heat builds up in the structure is transferred into the space relatively faster, warming up the indoor space.

Courtyard cooling

2



Courtyards get heated during the day, creating a relatively low pressure area. This induces cross ventilation. At night, due to radiative night-sky cooling the airflow reverses with the courtyard providing cooler air.



Understanding Warm-Humid Climate

Seasonal Characteristics

27 - 32°C

Day-time mean-max temperature range

21 - 27°C

Night-time mean-min temperature range

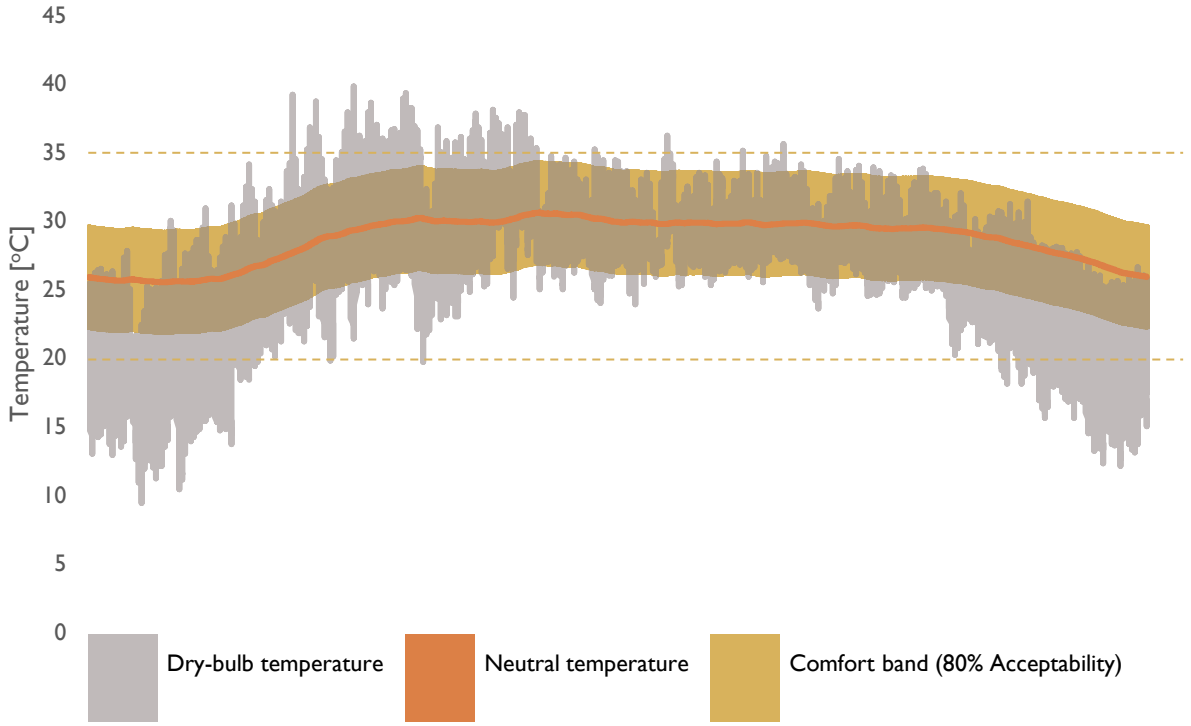
55 - 100%

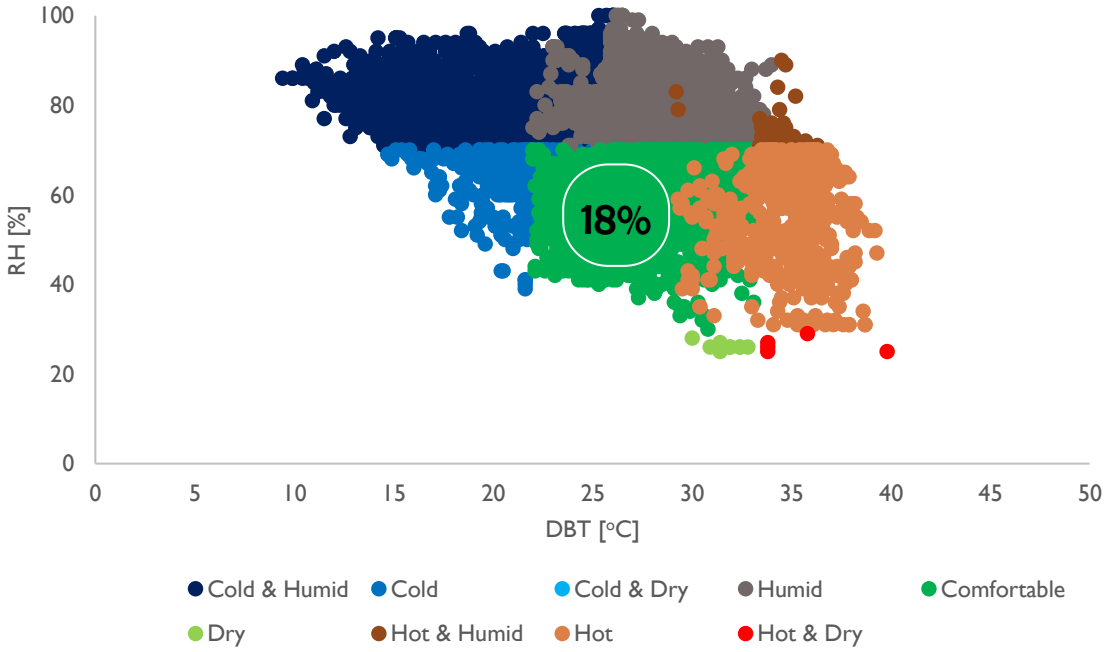
Typical humidity range

Warm-humid climate is characterised hot, sticky conditions nearly throughout the year. The narrow diurnal and annual range also point to vey little seasonal variation throughout the year.

- High humidity affects material durability, leading to mold, rot, and rust.
- Vapor diffusion through building materials can impact occupants' health.
- Selecting materials and using vapor barriers is crucial in design.
- Insects are common in humid climates, impacting ventilation.
- Integrated insect screens can encourage window ventilation.

Thermal Comfort Potential





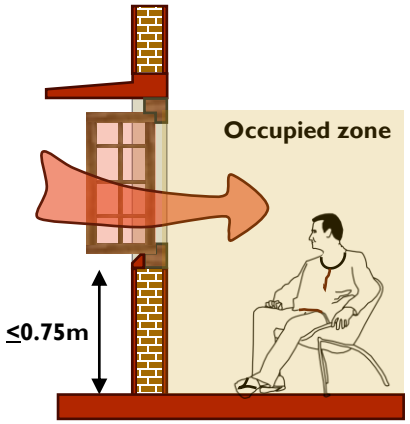
80% acceptability criterion defined by the adaptive comfort model indicates that the comfort band (inclusive of adaptations such as clothing, ceiling fan operation, etc.) lies between 19 and 35oC dry-bulb temperature.

The warm-humid climate can provide comfortable conditions for only about 18% hours in a year. Relative Humidity exceeds 70% for more than 70% of the occupiable hours.

Climatic opportunities

1

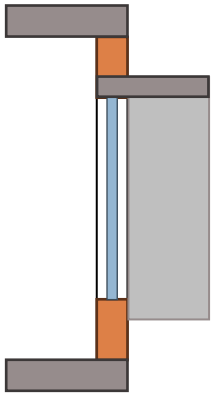
Use Enhanced Ventilation



2

Shaded windows and shutters

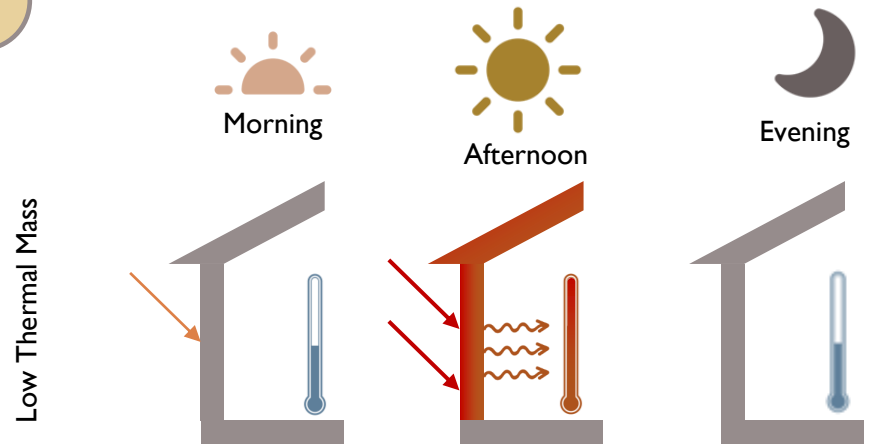
Vertical shading



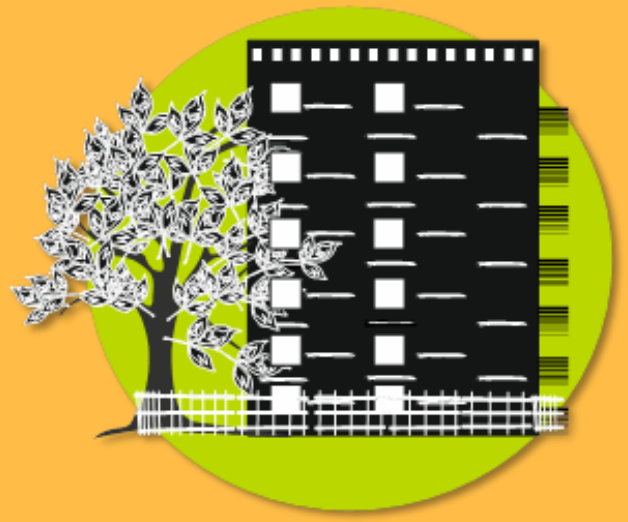
Horizontal shading

3

Thermal mass

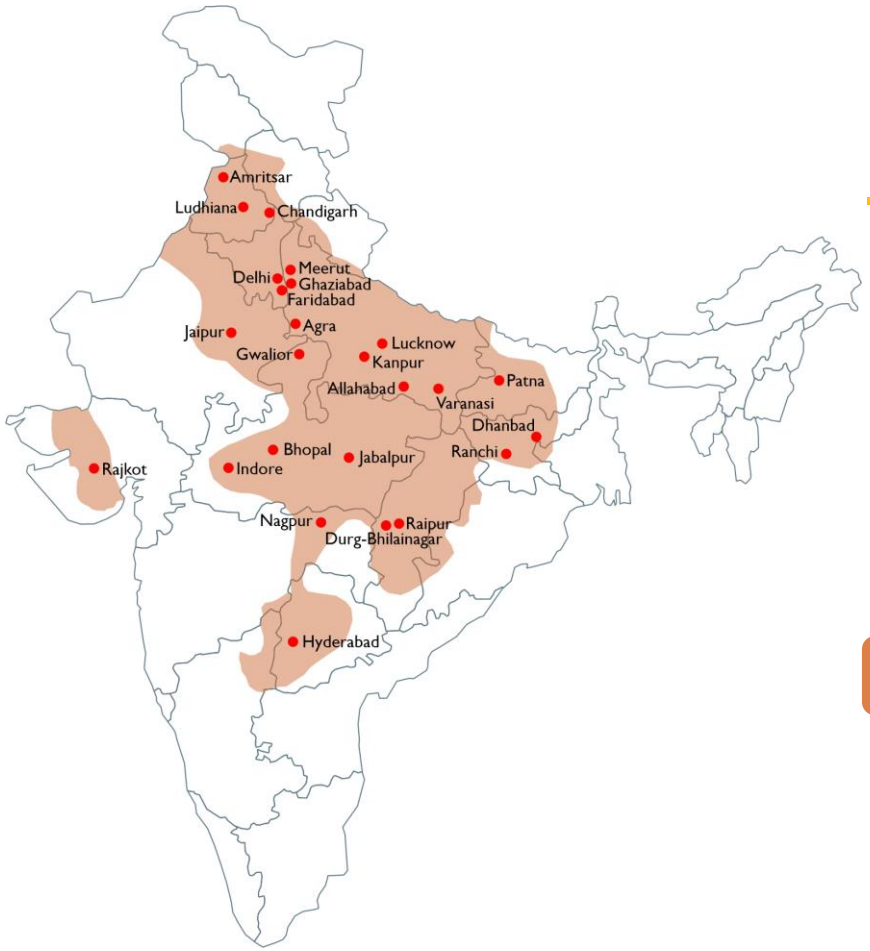


Heat builds up in the structure is transferred into the space relatively faster, warming up the indoor space.



Understanding Composite Climate

Seasonal Characteristics



32 - 43°C

Day-time mean-max temperature range

- 27°C

Day-time mean-max temperature range

24 - 32°C

Temperature range

21 - 27°C

Night-time mean-min temperature range

4 - 10°C

Night-time mean min

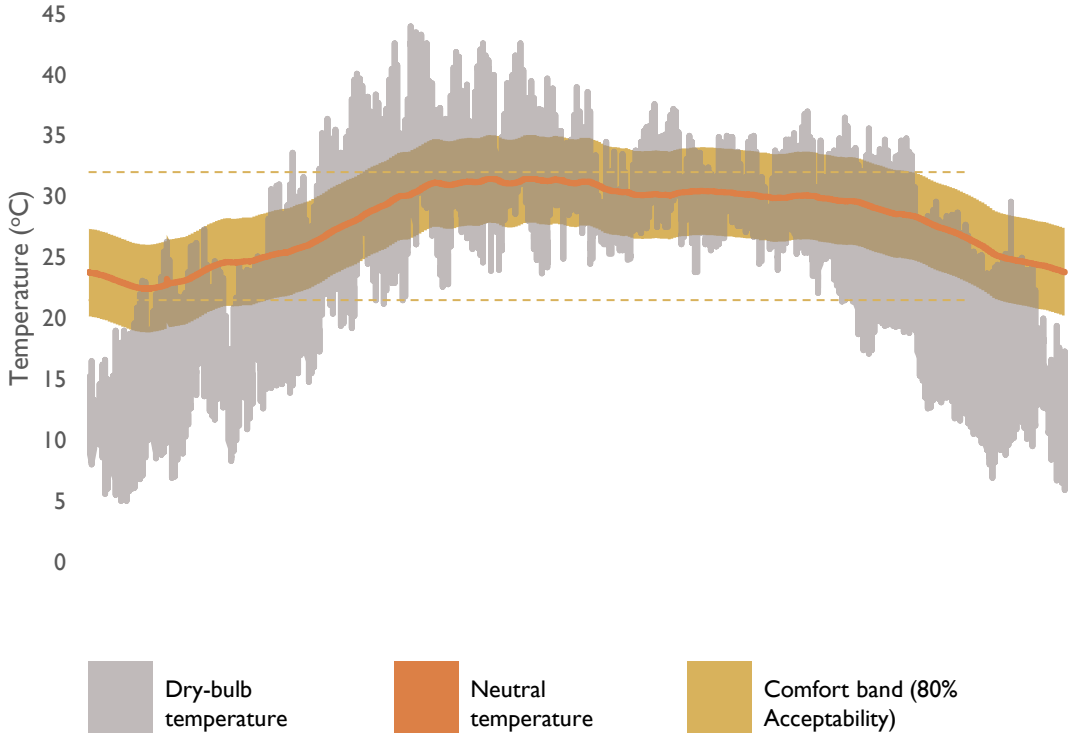
55 - 100%

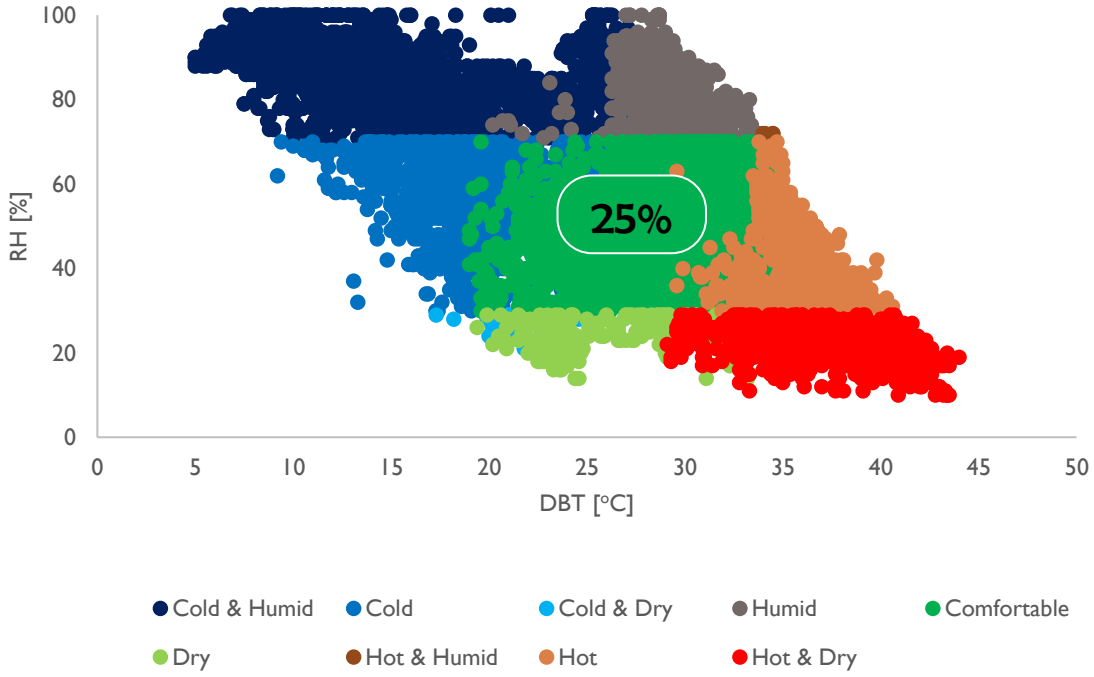
Night-time mean min

Summer period | **Winter period** | **Monsoon period**

Composite climate is characterised by three seasons; hot and dry summers, harsh winters and warm-humid monsoons. Daily extremes in summers and winters i.e., hot days and cool nights in summers and warm days and cold nights in winters are a characteristic feature of Composite climate.

Thermal Comfort Potential





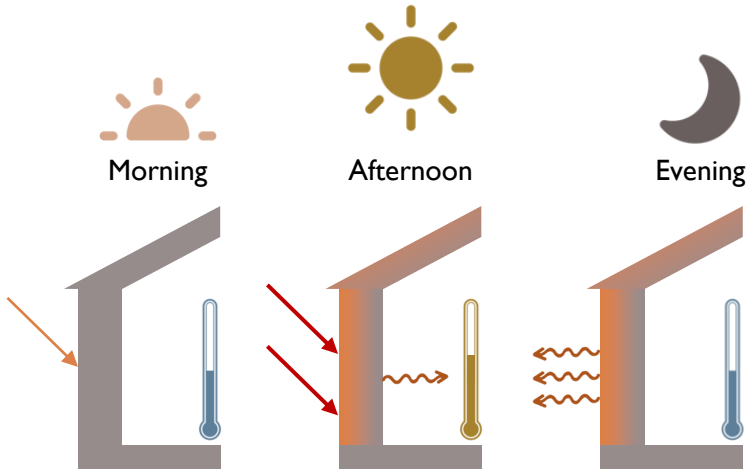
80% acceptability criterion defined by the adaptive comfort model indicates that the comfort band (inclusive of adaptations such as clothing, ceiling fan operation, etc.) lies between 19 and 35oC dry-bulb temperature.

The composite climate can provide comfortable conditions for about 25% hours in a year. In terms of severity, interventions in the built environment are required for hot-dry, hot, cold and cold-humid conditions.

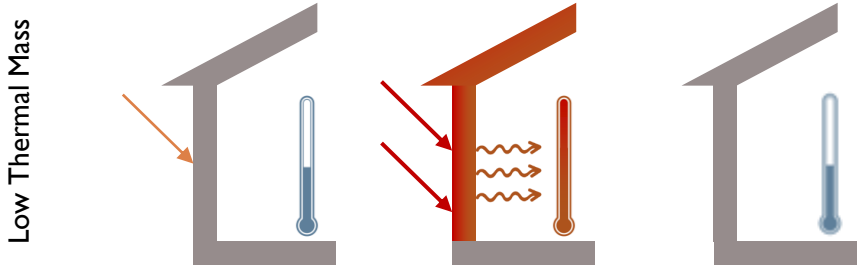
Climatic opportunities

Thermal mass

1



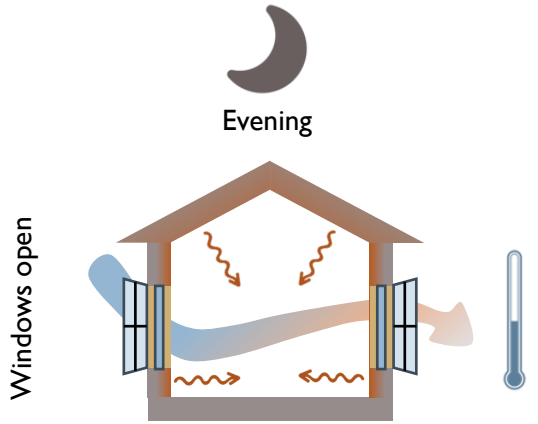
Heat builds up in the structure throughout the day. As the night temperatures are cooler, this heat build-up is expelled outdoors.



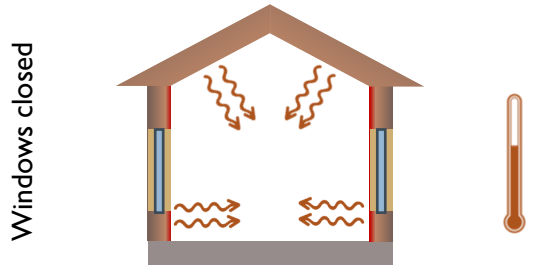
Heat builds up in the structure is transferred into the space relatively faster, warming up the indoor space.

Night-time ventilation

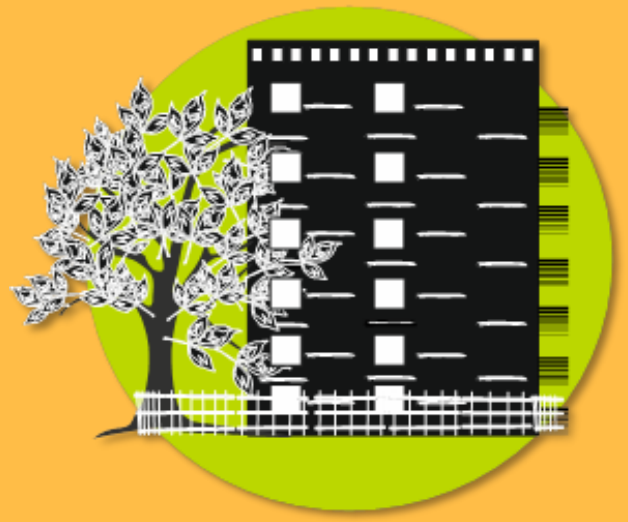
2



Heat accumulated indoors through the day can be carried away by cooler night-time air. Mechanical fans can aid effectiveness of heat exchange.



Closed windows and limited ventilation mean that heat accumulated during day-time stays trapped for longer.



Understanding Temperate Climate

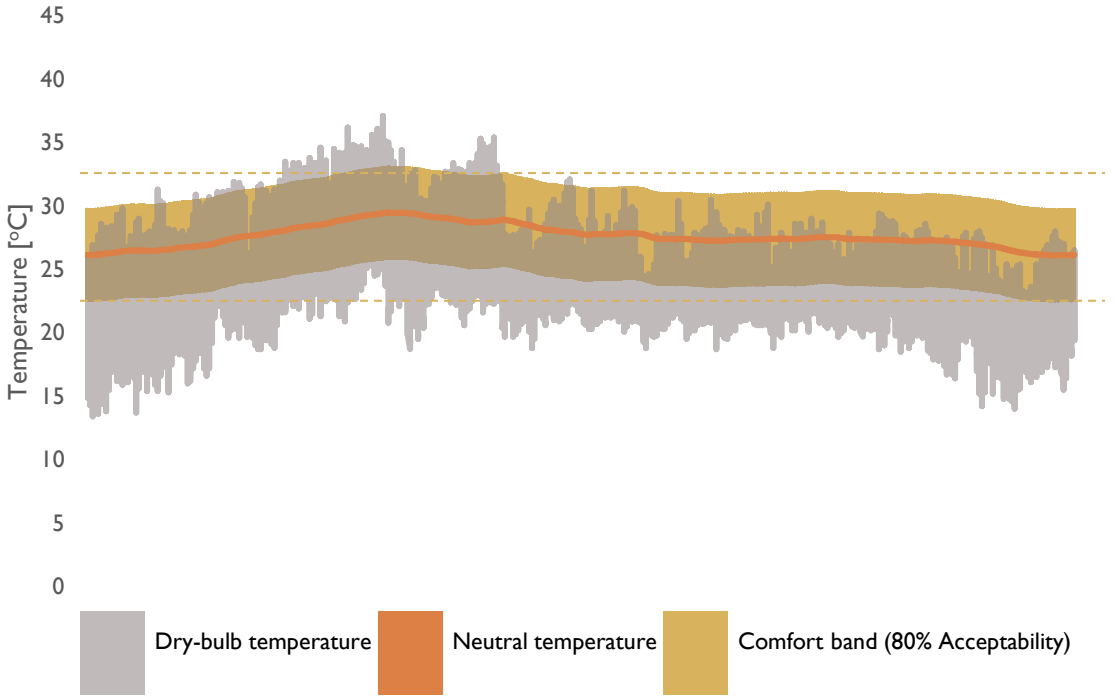
Seasonal Characteristics

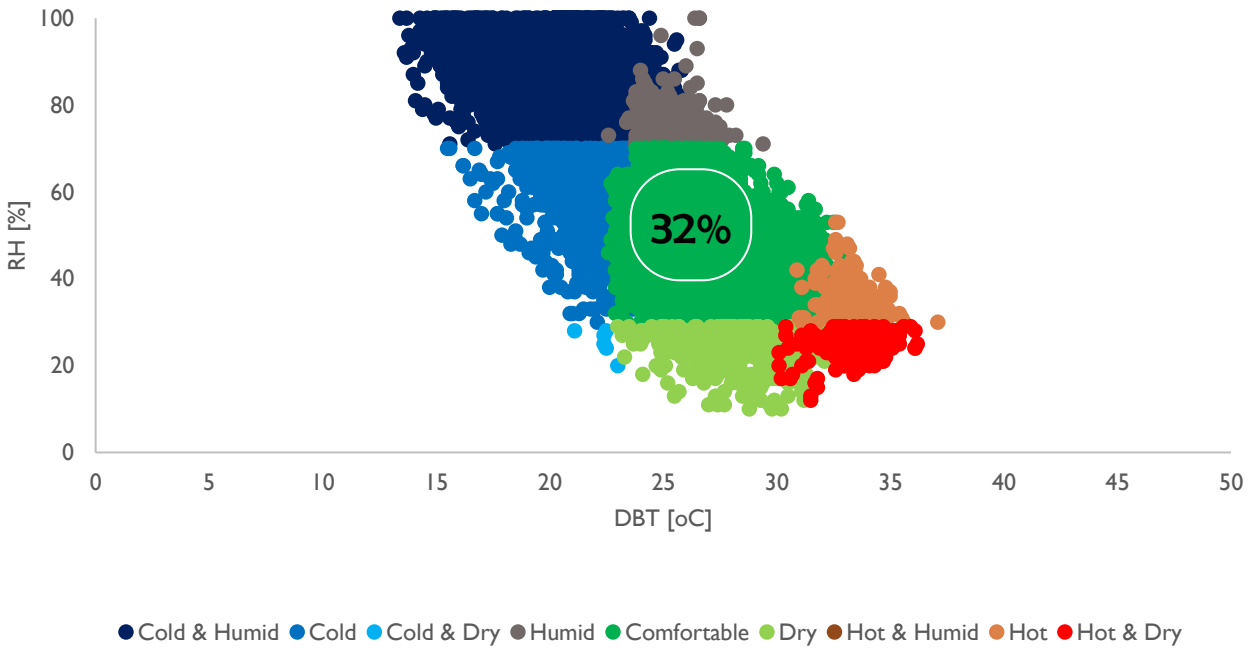
28 - 37°C	26 - 34°C	18 - 31°C
Day-time mean-max temperature range	Day-time mean-max temperature range	Daily Temperature range
24 - 33°C	13 - 27°C	30 - 68%
Night-time mean-min temperature range	Night-time mean min temperature range	Average monthly humidity range
Summer period	**Winter period**	**Monsoon period**

Note: Statistics compiled from Bengaluru's climate. Assumed Dec – Mar as winter period, Apr – Jul summer period and Jul – Oct as monsoon period.

Temperate climate is characterized by warm summers and cool winters. The temperatures are moderate throughout the year.

Thermal Comfort Potential





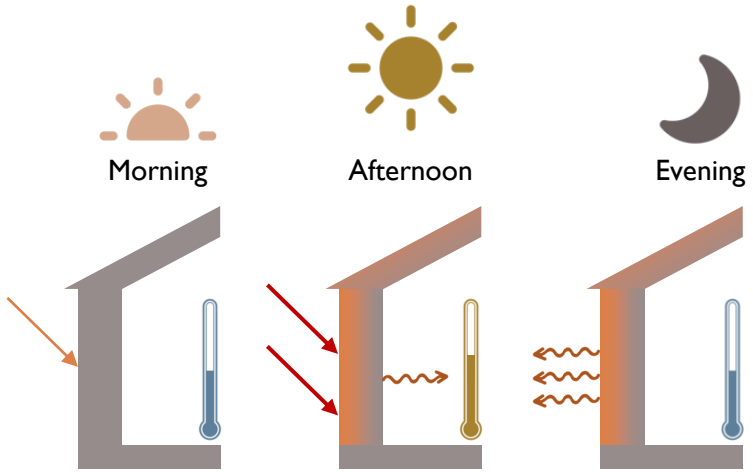
80% acceptability criterion defined by the adaptive comfort model indicates that the comfort band (inclusive of adaptations such as clothing, ceiling fan operation, etc.) lies between 22 and 33oC dry-bulb temperature.

The temperate climate can provide comfortable conditions for about 32% hours in a year.

Climatic opportunities

Thermal mass

1



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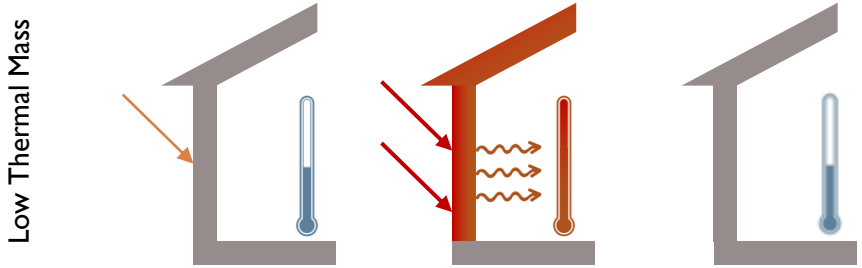

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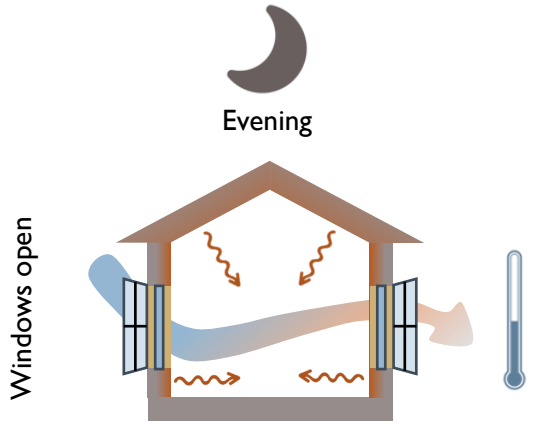
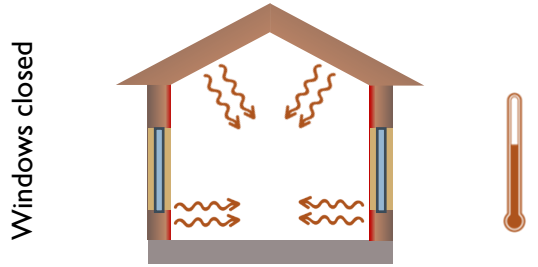
Night-time ventilation

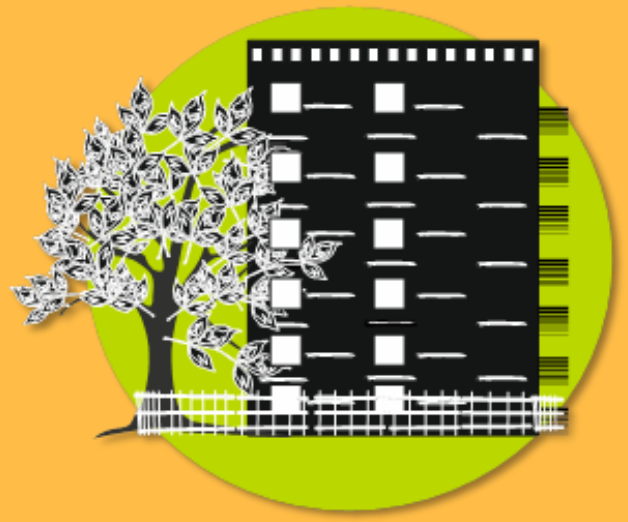
2



Heat accumulated indoors through the day can be carried away by cooler night-time air. Mechanical fans can aid effectiveness of heat exchange.

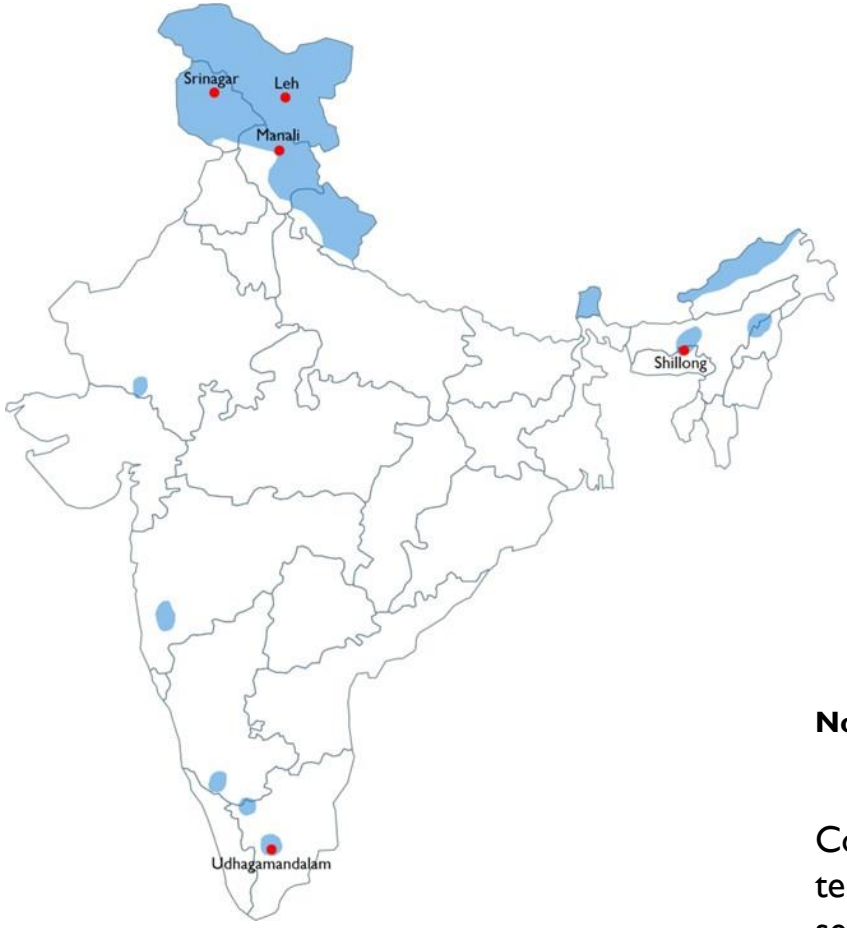


Closed windows and limited ventilation mean that heat accumulated during day-time stays trapped for longer.



Understanding Cold Climate

Seasonal Characteristics

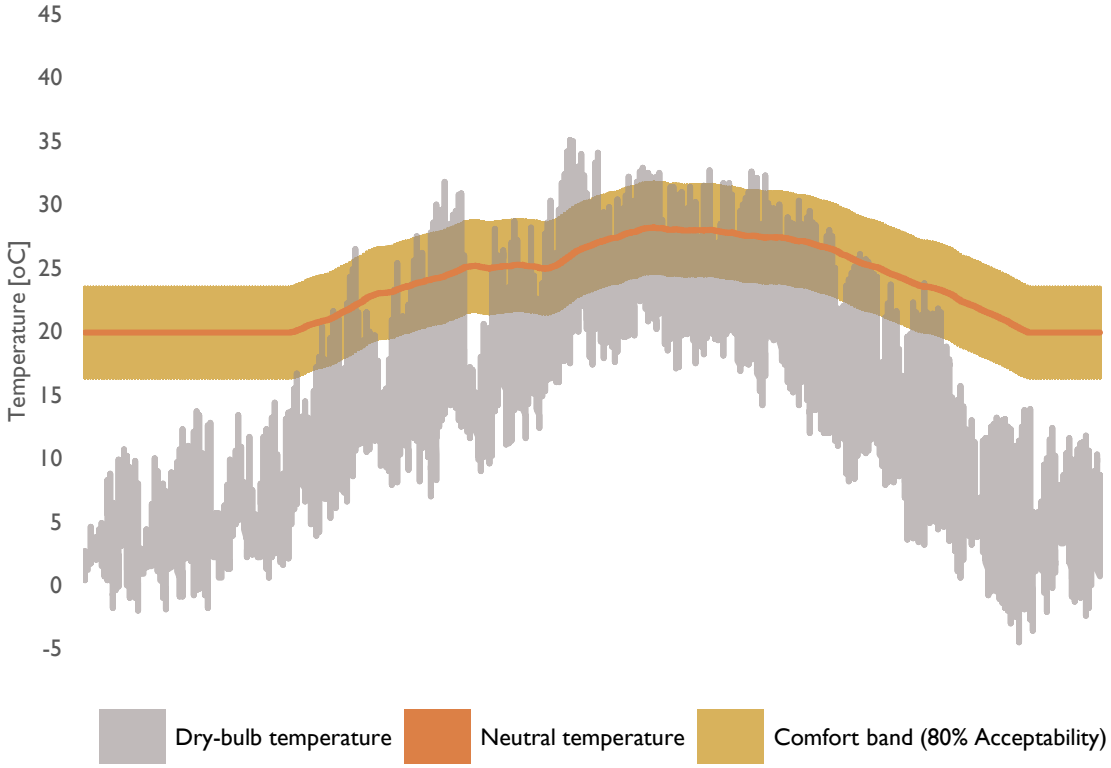


Summer period	Winter period
24 - 35°C	9 - 26°C
Day-time mean-max temperature range	Day-time mean-max temperature range
7 - 19°C	-4 to 5°C
Night-time mean-min temperature range	Night-time mean min

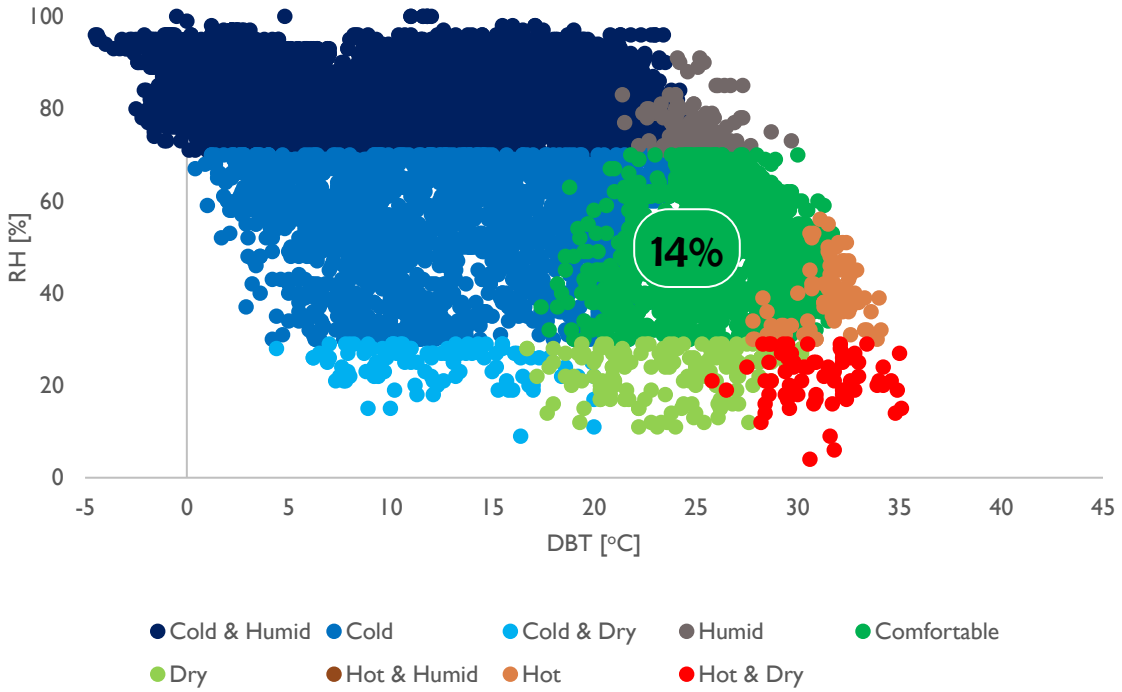
Note: Statistics compiled from Srinagar's climate. Assumed Oct – Mar as winter period, and May – Aug summer period.

Cold climate is characterised by harsh winters and mild summers. The diurnal variation in temperatures can exceed 20°C implying that cold discomfort can occur even in warm season.

Thermal Comfort Potential



80% acceptability criterion defined by the adaptive comfort model indicates that the comfort band (inclusive of adaptations such as clothing, ceiling fan operation, etc.) lies between 16 and 32oC dry-bulb temperature.

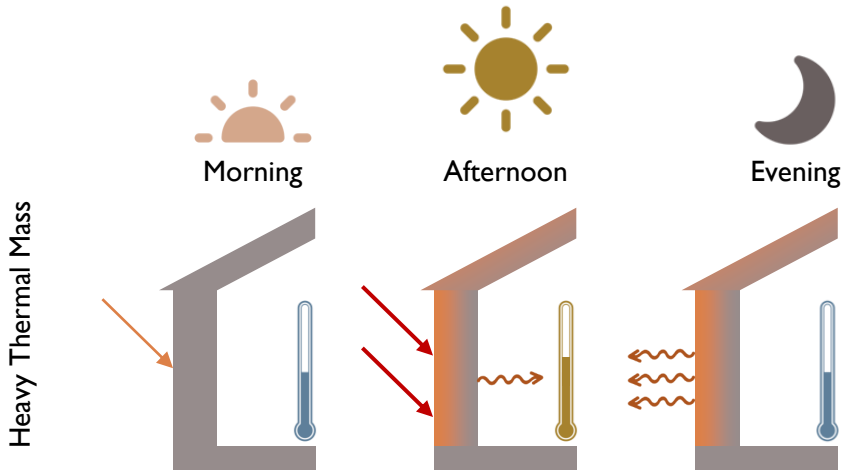


Cold climate can provide comfortable conditions for about 14% hours in a year. In terms of severity, interventions in the built environment are required for cold and cold-humid conditions. While summer discomfort is negligible, care must be taken to avoid direct radiation which can lead to overheating in summers.

Climatic opportunities

1

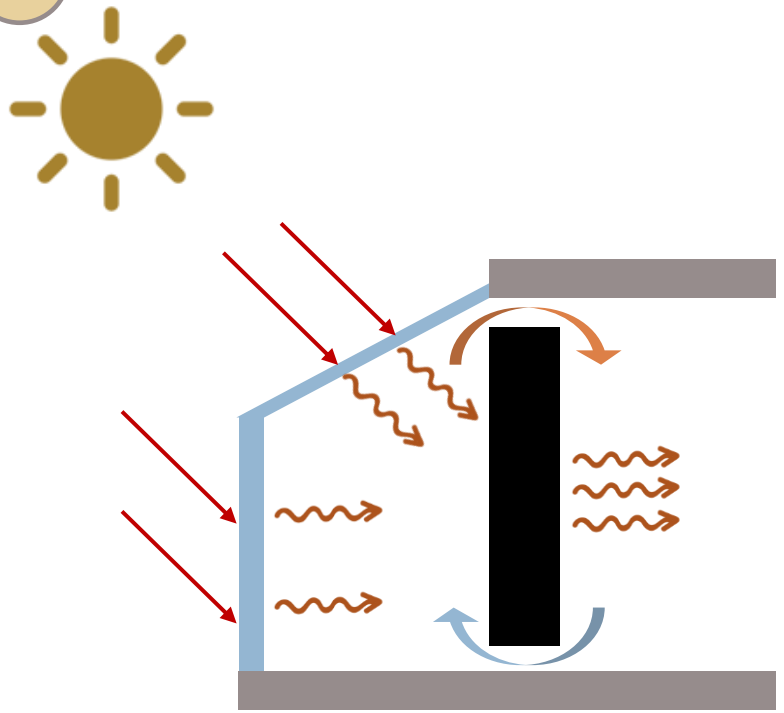
Thermal mass

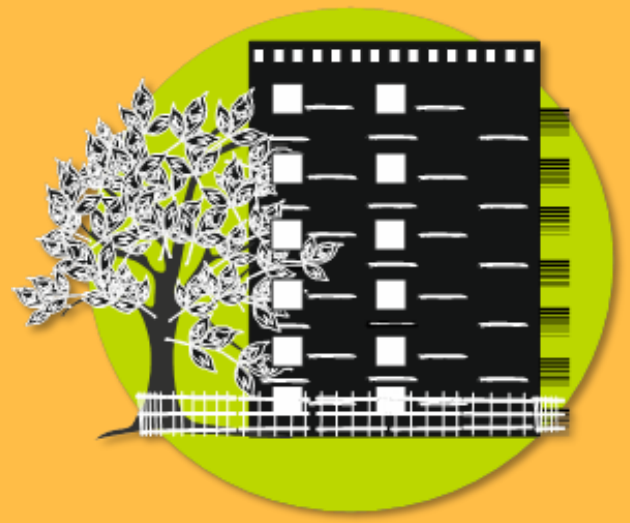


Heat builds up in the structure throughout the day. As the night temperatures are cooler, this heat build-up is expelled outdoors.

2

Solarium/sun-space





Thanks!