WRI INDIA
—ROSS CENTER

Capacity Building for Improving the Implementation of Affordable Housing in Indian Cities

Thermal Comfort Using Passive Design

FORD
FOUNDATION

Introduction

Module Overview

Objective

To build a comprehensive understanding to achieve thermal comfort in affordable housing using passive design strategies.

Outcomes

Learners will get familiarized with basic knowhow of passive design strategies and its importance to achieve thermal comfort through different design principles. They will further be equipped with recommendations toward decision making and implementation through case studies.

Image Source: Associated Press

Significance

Economy

Lower Operating Costs -25% and 50% in energy saving.

Sustainable buildings achieve higher demand because of lower operating costs, thus average 7% higher property valuations than non-green buildings.

Environment

Unmaintained ACs consume up to 20% more electricity and emit harmful refrigerants to the environment

Passive Design Strategies reduce the need for air conditioning which contributes to 10% of global GHG gas emissions

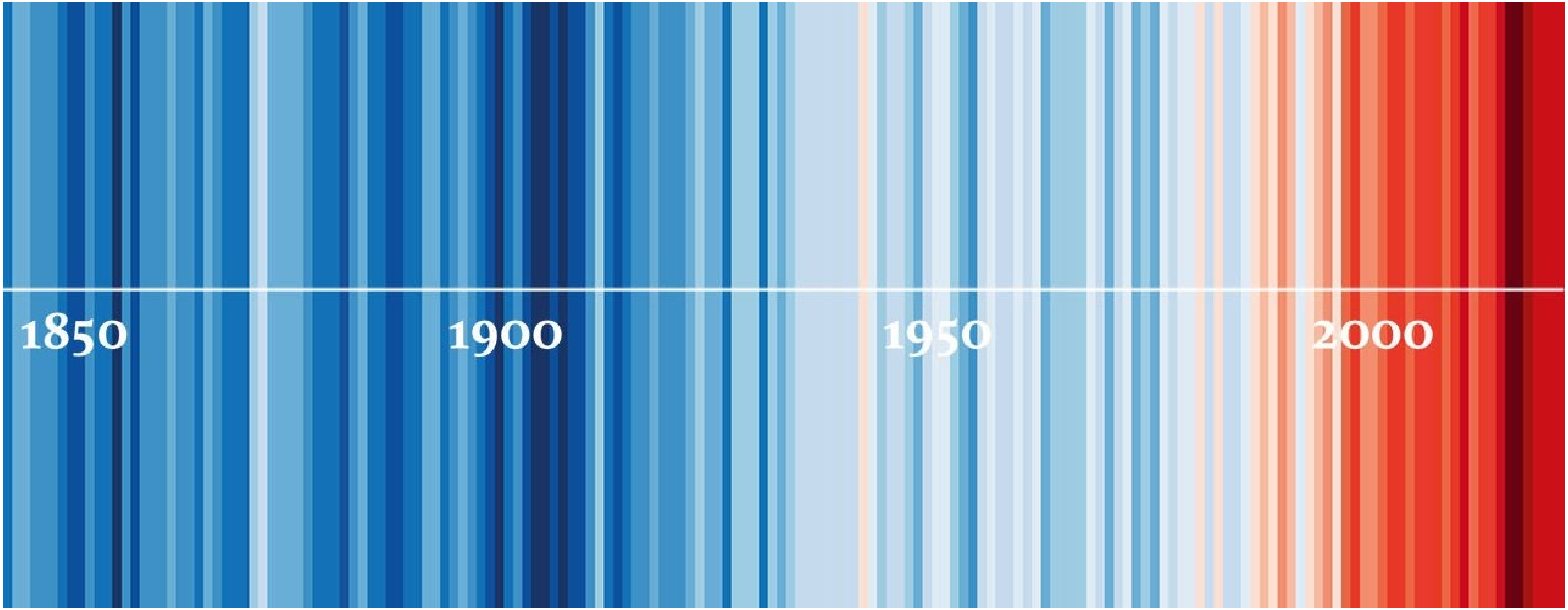
Equity

Sustainable buildings increase the overall well-being of their occupants and productivity by up to 20%.

For urban poor, income spent on illness and cooling devices can be reduced significantly.

Global Scenario

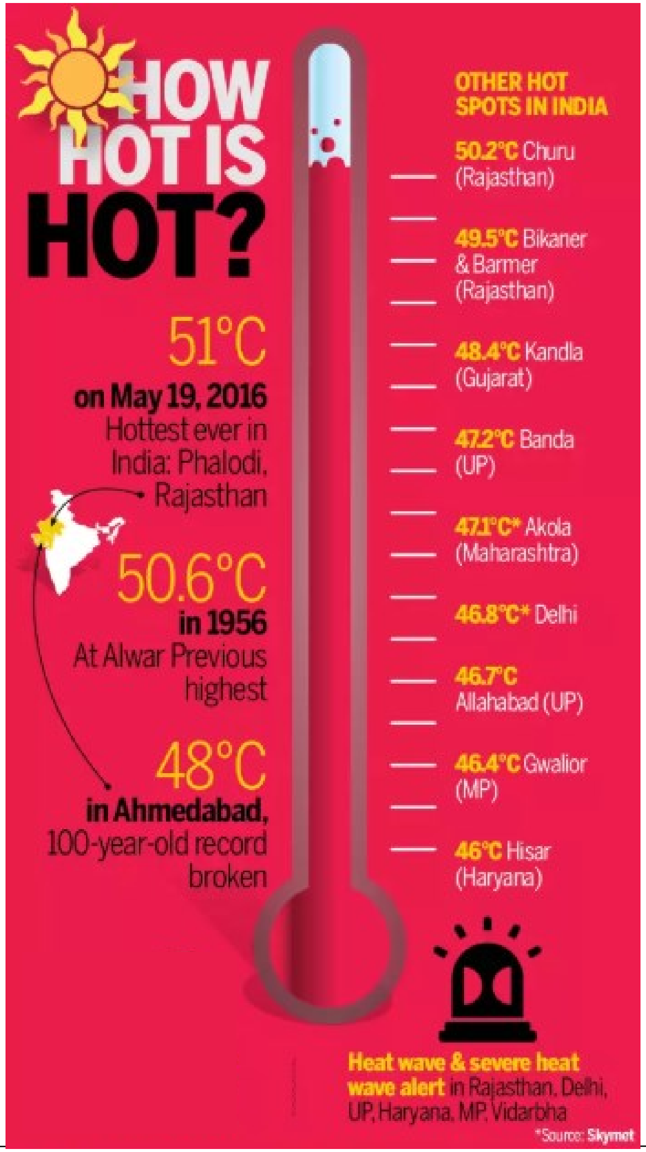
The world is becoming warmer with each passing year.

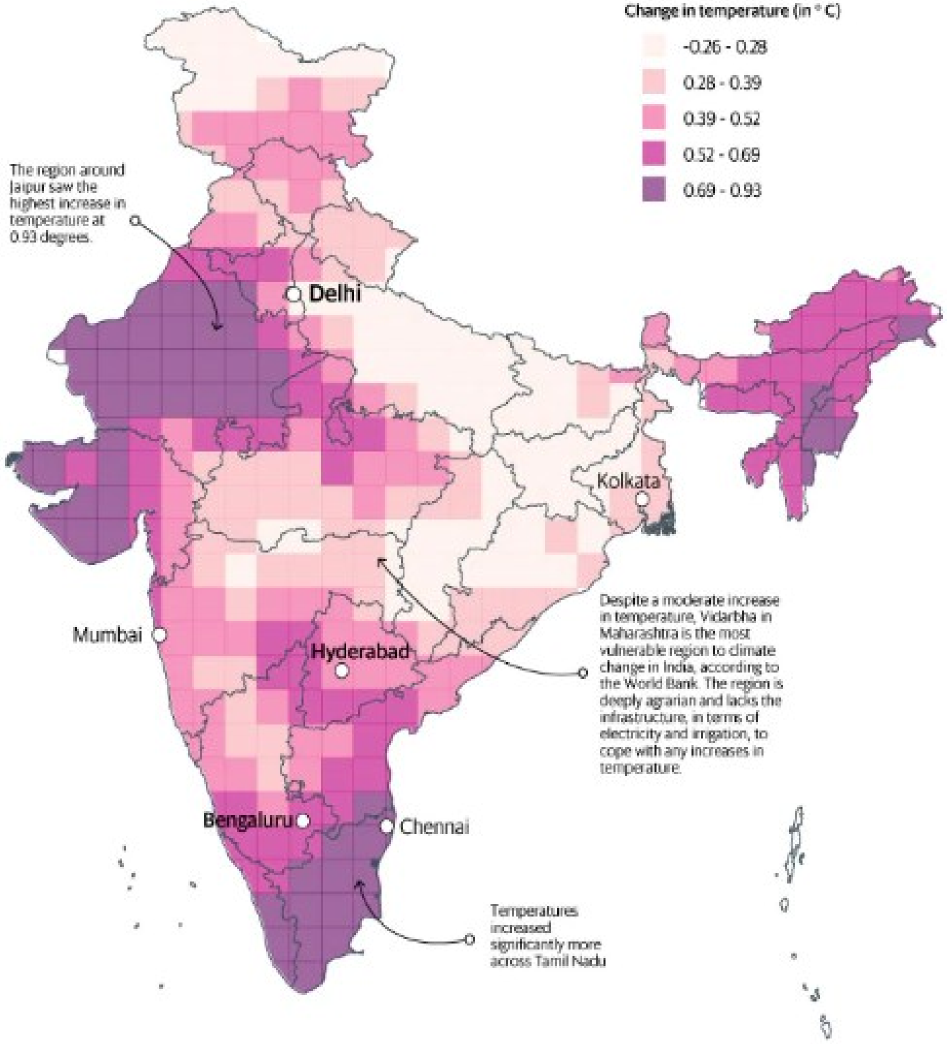


Source – Ed Hawkins

Indian Scenario

Average temperatures have been rising across most of the country.





The region around Jaipur saw the highest increase in temperature at 0.93 degrees.

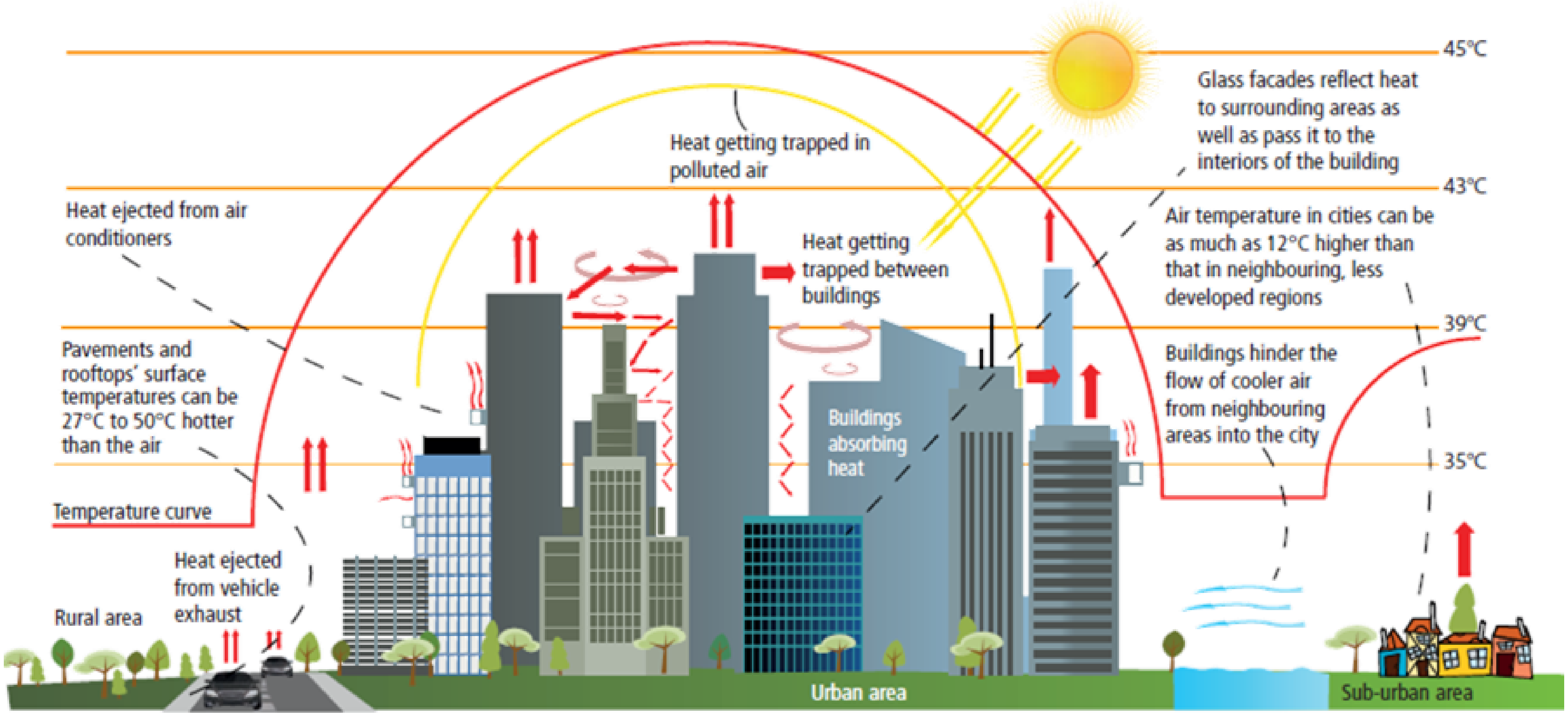
Despite a moderate increase in temperature, Vidarbha in Maharashtra is the most vulnerable region to climate change in India, according to the World Bank. The region is deeply agrarian and lacks the infrastructure, in terms of electricity and irrigation, to cope with any increases in temperature.

Temperatures increased significantly more across Tamil Nadu

Sources – Times of India, Skymet, and IMD

Impact of Global Warming

Impacts at a localized level.



Heat getting trapped in polluted air

Glass facades reflect heat to surrounding areas as well as pass it to the interiors of the building

Heat ejected from air conditioners

Heat getting trapped between buildings

Air temperature in cities can be as much as 12°C higher than that in neighbouring, less developed regions

Pavements and rooftops' surface temperatures can be 27°C to 50°C hotter than the air

Buildings absorbing heat

Buildings hinder the flow of cooler air from neighbouring areas into the city

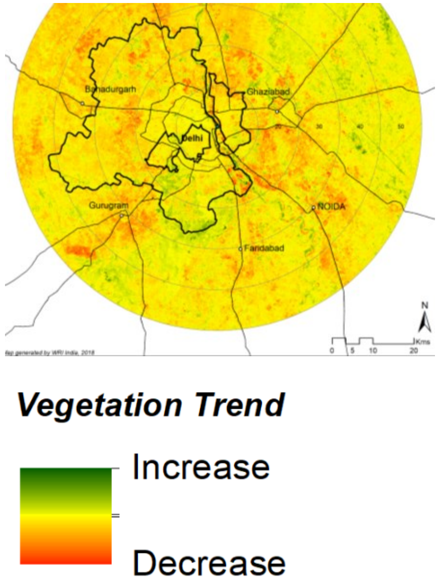
Heat ejected from vehicle exhaust

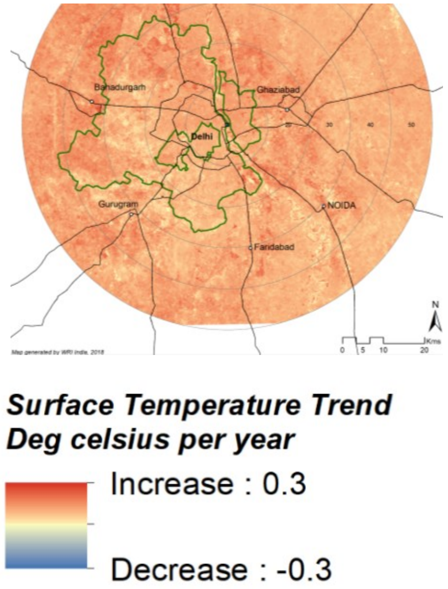
Source – CSE

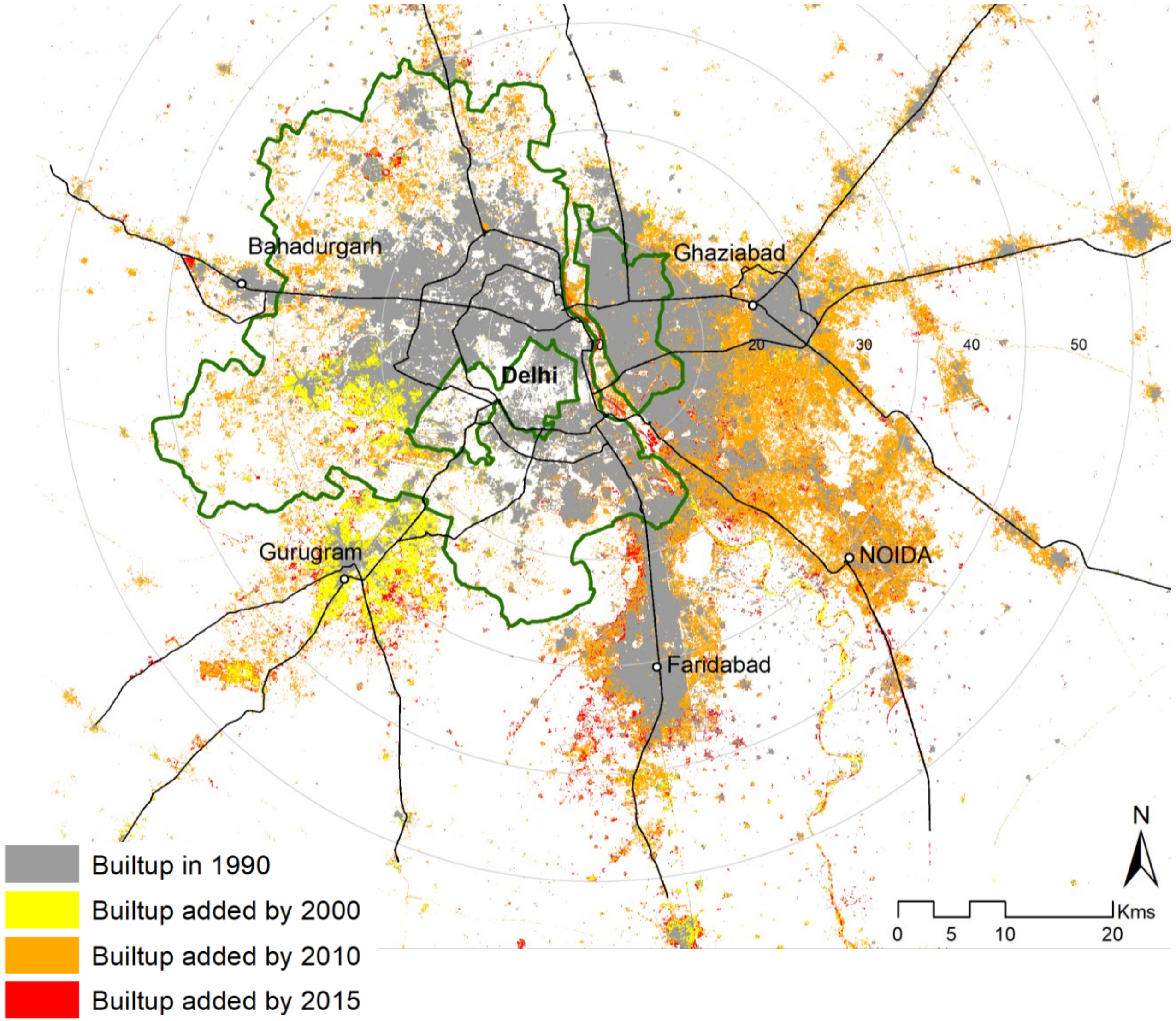
Urbanization vs. Climate Change

Delhi will become the world’s largest city by 2030, and have an estimated population of 2030.

Rapid increase in built-up area to be accompanied with drop in vegetation cover and rise in surface temperatures.







Sources – USGS/NASA; Maps generated by WRI India

Understanding Passive Design

Passive vs. Active Design

Passive Design

Design that leverages climatologically responsive design to encourage natural heating/cooling, ventilation, and lighting.

Active Design

Design that relies largely on mechanical / electrical sources of heating / cooling, ventilation, and lighting.

Passive design needs **active users.**

Active design needs **passive users.**

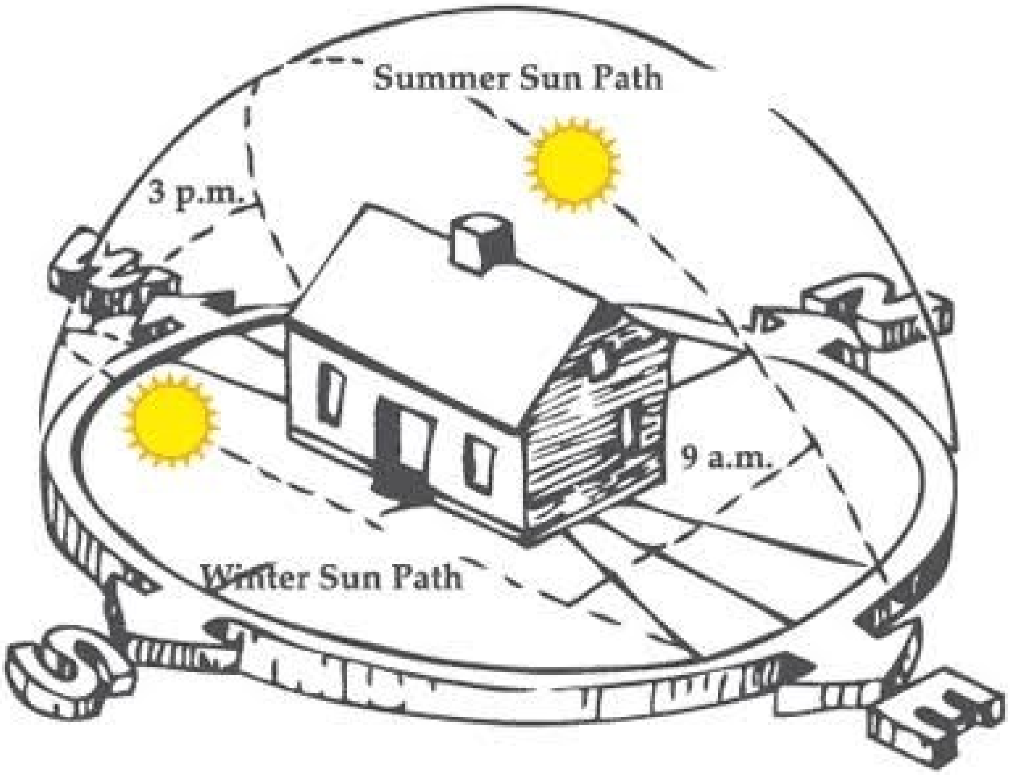


Image Source: Associated Press

Climate Types in India

Zones

Hot-dry – Much of Rajasthan, parts of Gujarat and Maharashtra

Warm-humid – Much of peninsular India, West Bengal, and Northeast

Composite – Much of the Northern Plains and parts of Central India

Temperate – Hilly tracts in the Northeast and along the Western Ghats

Cold – Himalayan regions

Key Considerations

Temperature, humidity, pressure, precipitation, sky conditions, solar radiation, and wind speed

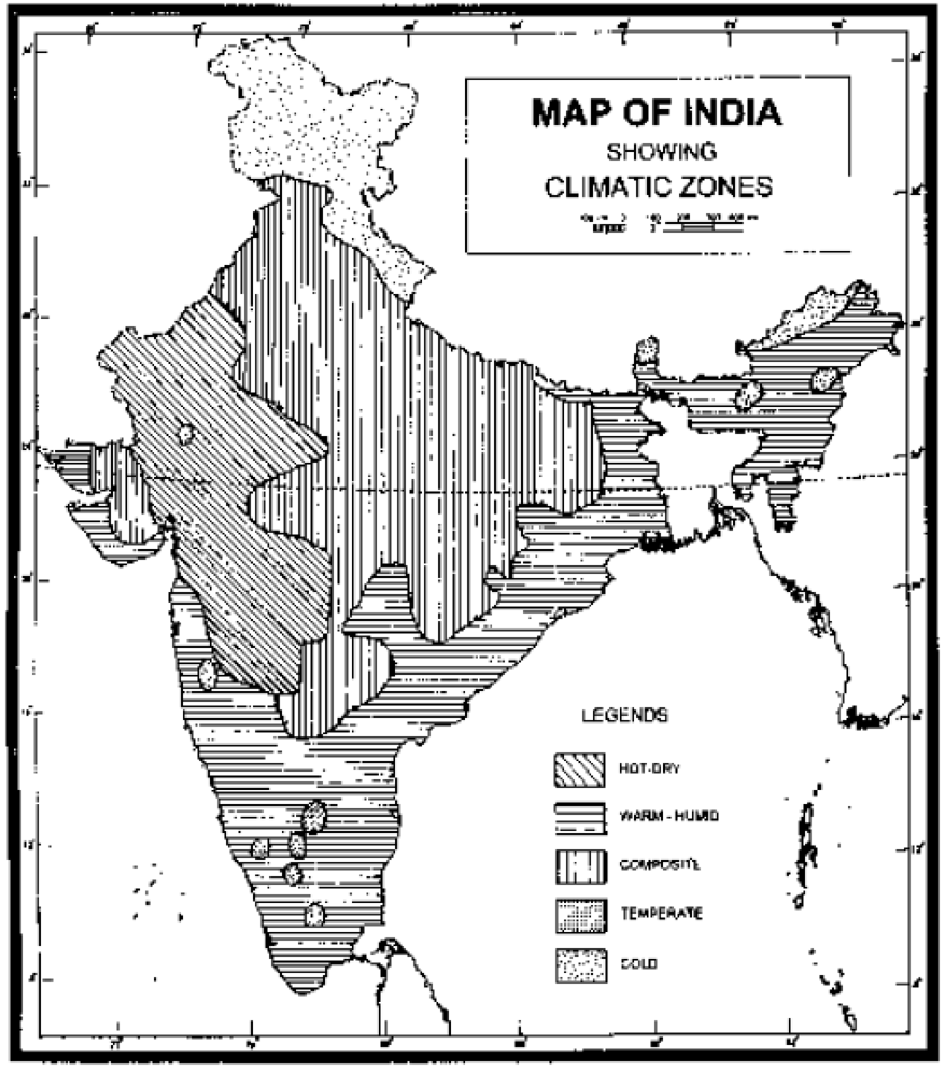


Image Source: National Building Code

Image Source: Associated Press

Thermal Comfort

Conditions

When at least 80% of a space's users feel comfortable for more than 80% of the time spent in the space. Optimum temperature, natural lighting, and fresh are key components of thermal comfort.

Air temperature, radiant temperature, air velocity, and humidity are the measurement factors considered in calculating thermal comfort.

Significance

We spend 90% of our time indoors. Thermal comfort not only enhances ease of living, but also reduces dependence on active heating/cooling, ventilation, and lighting.

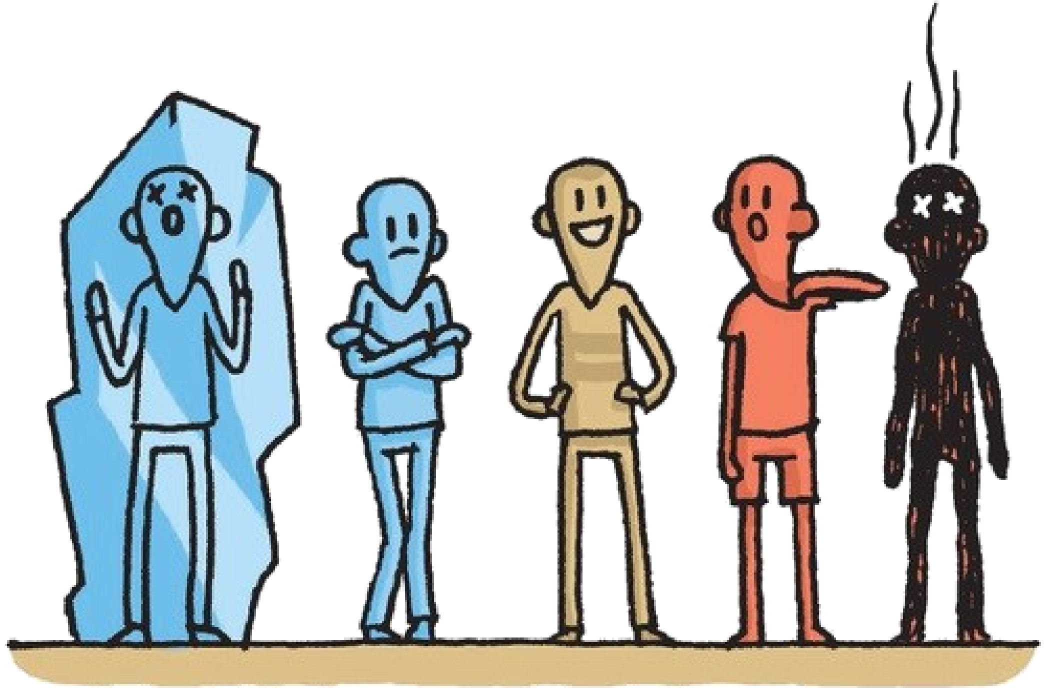


Image Source: Archdaily

Traditional Solutions

Each region has historically evolved its own building typology that responds prevalent climatological conditions through passive design.

An example of Delhi's havelis is provided here.

Roof Overhangs
Provide shading and protection from rain

Windows
Provide cross-ventilation on humid days

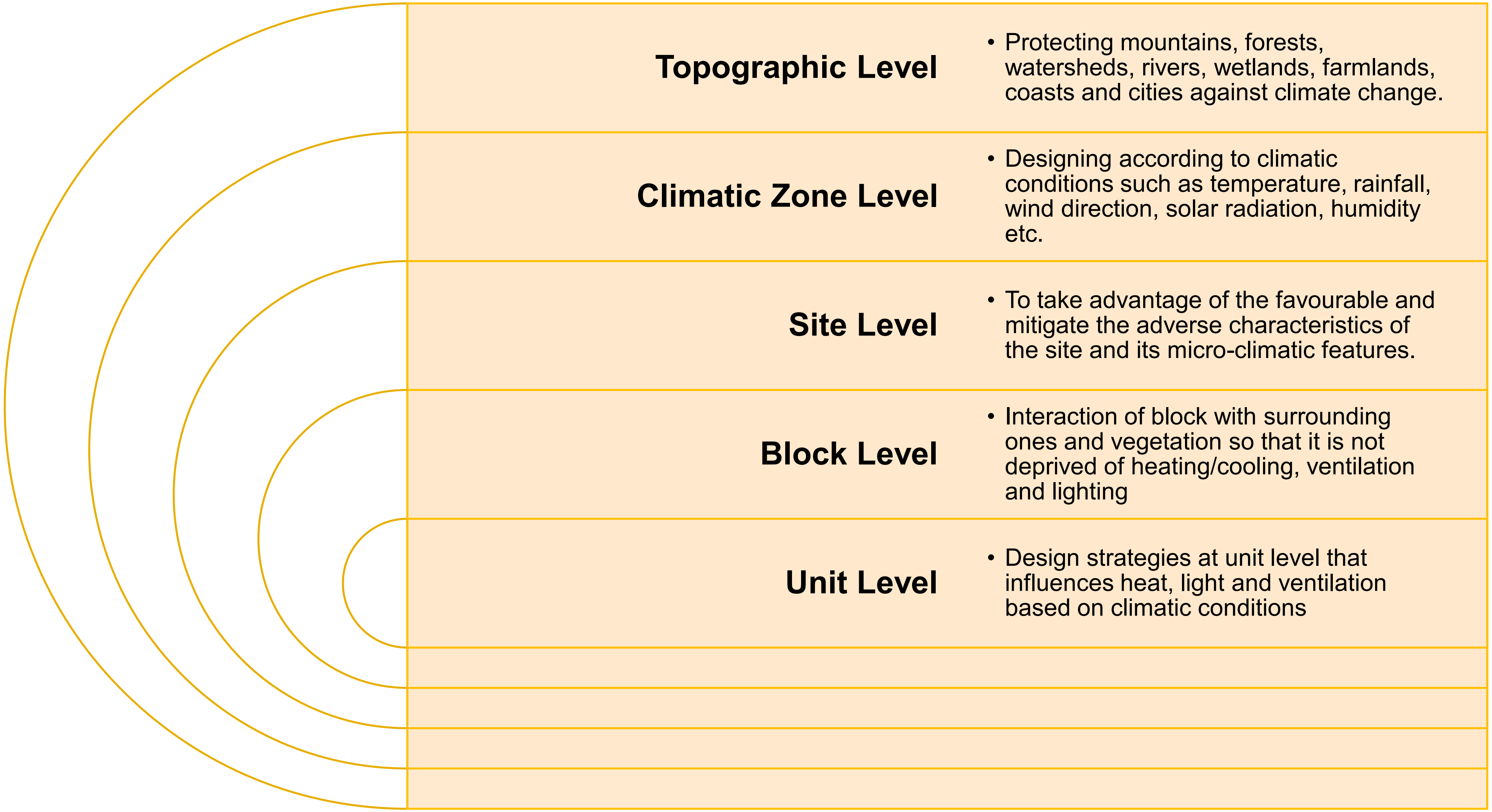
Recessed Entrance
Create a heat buffer

Raise`d Plinth
Protect from flooding / waterlogging

Image Source: Akanksha Gupta

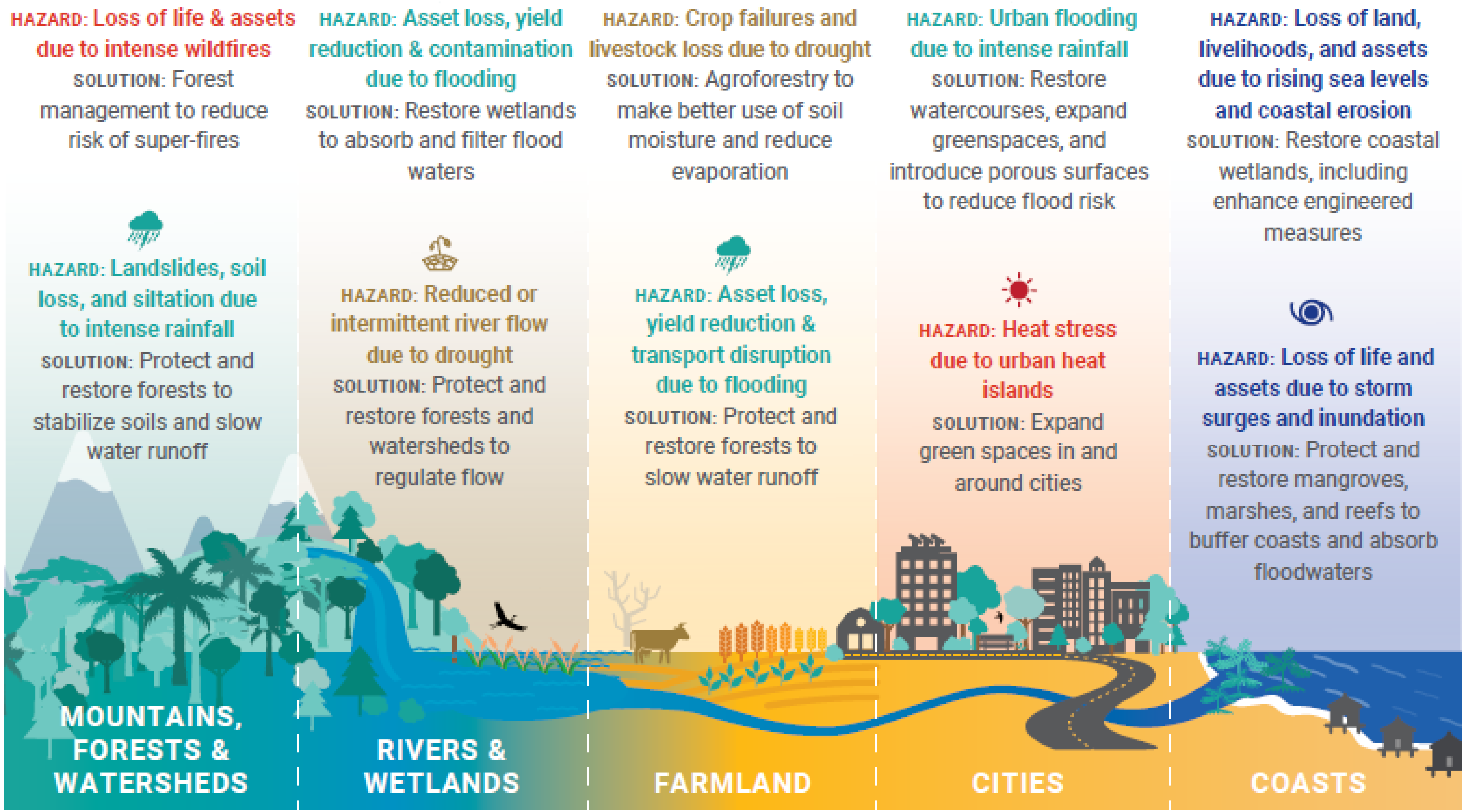
Strategies for Passive Design

Levels of Response



Topographic Level	• Protecting mountains, forests, watersheds, rivers, wetlands, farmlands, coasts and cities against climate change.
Climatic Zone Level	• Designing according to climatic conditions such as temperature, rainfall, wind direction, solar radiation, humidity etc.
Site Level	• To take advantage of the favourable and mitigate the adverse characteristics of the site and its micro-climatic features.
Block Level	• Interaction of block with surrounding ones and vegetation so that it is not deprived of heating/cooling, ventilation and lighting
Unit Level	• Design strategies at unit level that influences heat, light and ventilation based on climatic conditions

Topographic Level



HAZARD: Loss of life & assets due to intense wildfires
SOLUTION: Forest management to reduce risk of super-fires

HAZARD: Landslides, soil loss, and siltation due to intense rainfall
SOLUTION: Protect and restore forests to stabilize soils and slow water runoff

HAZARD: Asset loss, yield reduction & contamination due to flooding
SOLUTION: Restore wetlands to absorb and filter flood waters

HAZARD: Reduced or intermittent river flow due to drought
SOLUTION: Protect and restore forests and watersheds to regulate flow

HAZARD: Crop failures and livestock loss due to drought
SOLUTION: Agroforestry to make better use of soil moisture and reduce evaporation

HAZARD: Asset loss, yield reduction & transport disruption due to flooding
SOLUTION: Protect and restore forests to slow water runoff

HAZARD: Urban flooding due to intense rainfall
SOLUTION: Restore watercourses, expand greenspaces, and introduce porous surfaces to reduce flood risk

HAZARD: Heat stress due to urban heat islands
SOLUTION: Expand green spaces in and around cities

HAZARD: Loss of land, livelihoods, and assets due to rising sea levels and coastal erosion
SOLUTION: Restore coastal wetlands, including enhance engineered measures

HAZARD: Loss of life and assets due to storm surges and inundation
SOLUTION: Protect and restore mangroves, marshes, and reefs to buffer coasts and absorb floodwaters

Source: WRI

Climatic Zone Level

Best exemplified by vernacular / traditional architectural typologies that respond to the specific climate of the region.

Examples:

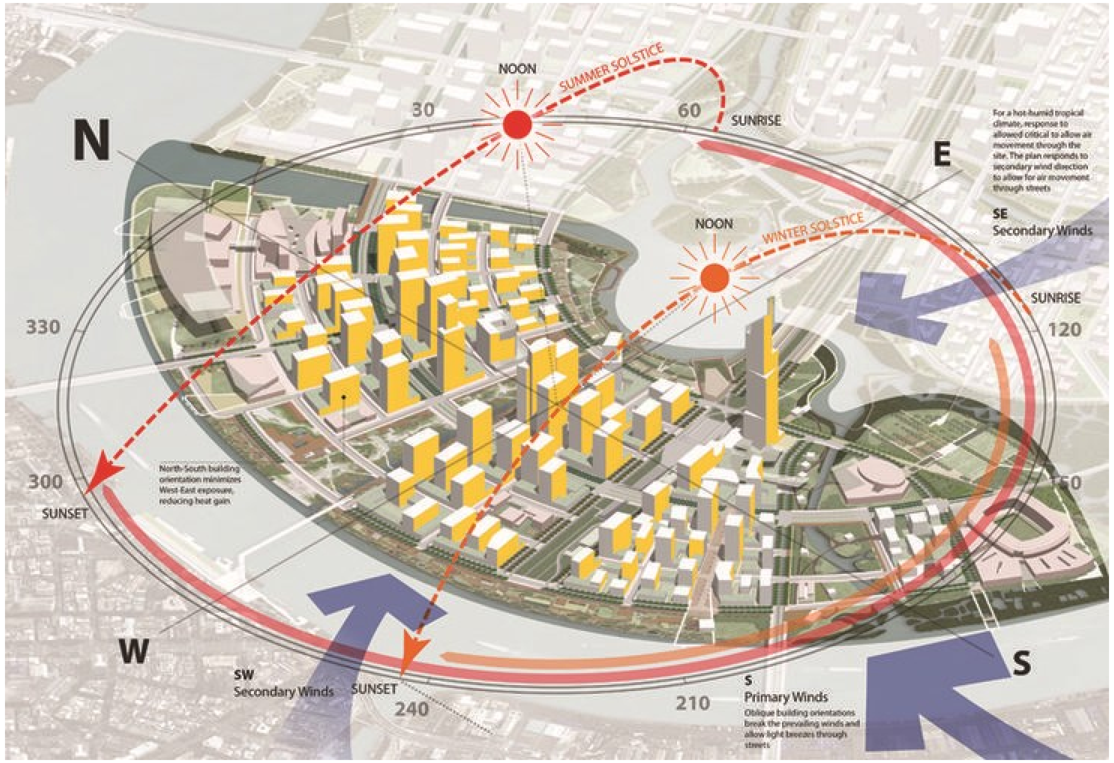
- Earth architecture with thick walls and small windows for maximum insulation in Ladakh
- Courtyard havelis in Rajasthan which leverage pressure differences and mutual shading for natural cooling and ventilation.
- Sloping roofs and to protect from heavy rains in Kerala

Source: Prayash Giria

Site Level

Reducing ‘heat island’ effect by techniques such as:

- Building around courtyards / open courts
- Leveraging mutual shading of blocks
- Creating wind passages through site massing
- Reducing hard paving to allow water absorption
- Using complimentary vegetation that control sunlight penetration through seasonal changes

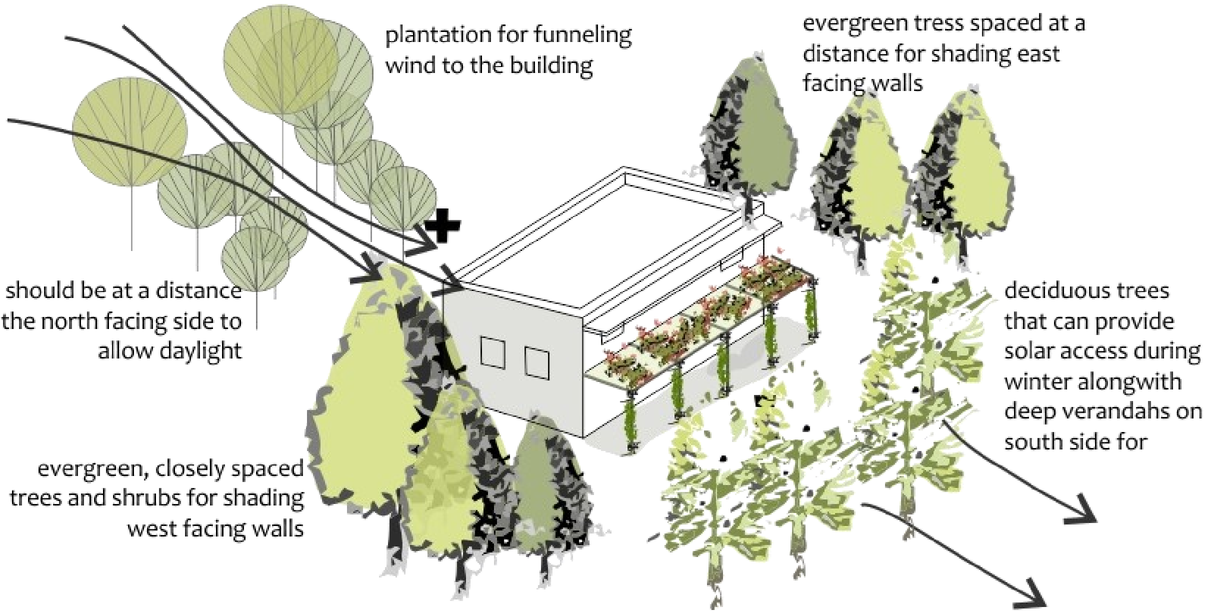


Sources: University of Waterloo; Tropical Climate Analyst

Site Level: Leveraging Plantations

Appropriate plantation of trees to promote shading and ventilation can temper extreme weather to a significant degree.

In Adelaide, a study estimated that districts with higher vegetation cover remained cooler by up to 6°C during heatwave conditions.



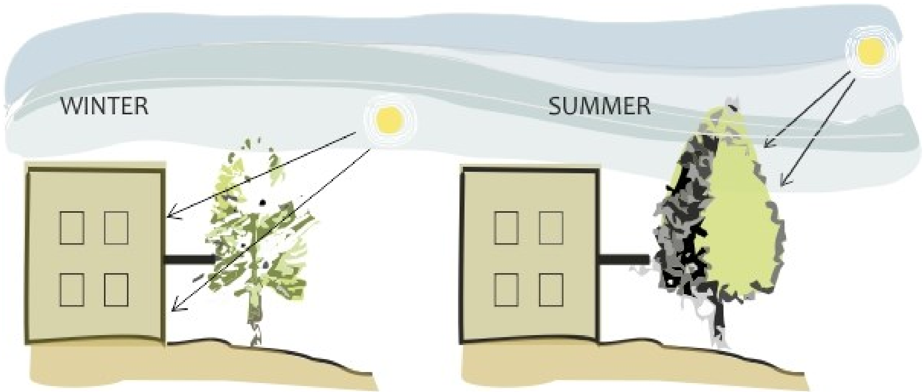
plantation for funneling wind to the building

evergreen tress spaced at a distance for shading east facing walls

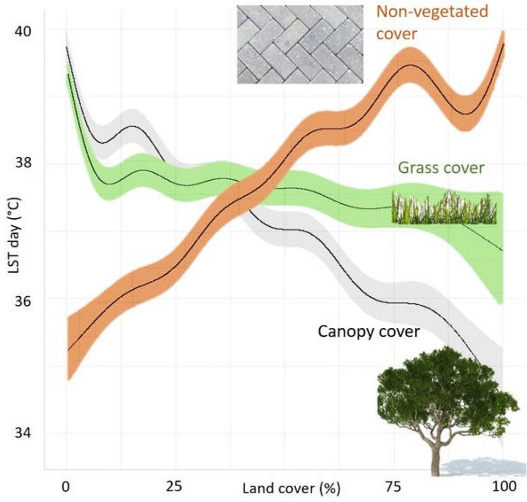
trees should be at a distance from the north facing side to allow daylight

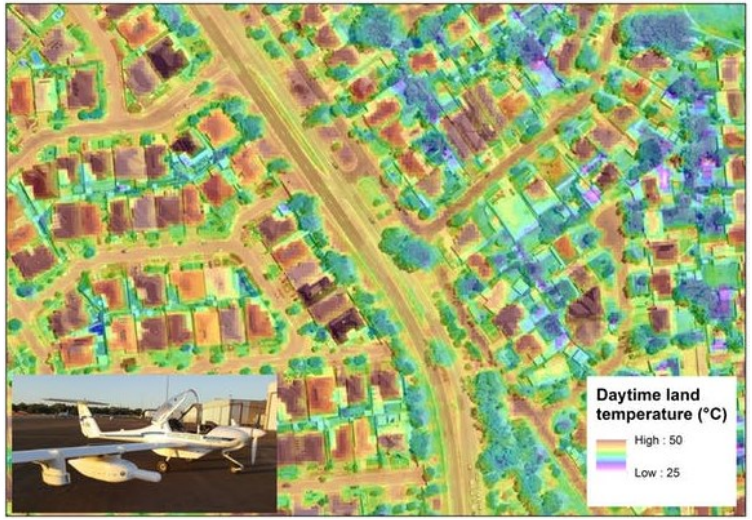
deciduous trees that can provide solar access during winter alongwith deep verandahs on south side for

evergreen, closely spaced trees and shrubs for shading west facing walls



deciduous trees allow sun penetration in winter and block sun access during summer



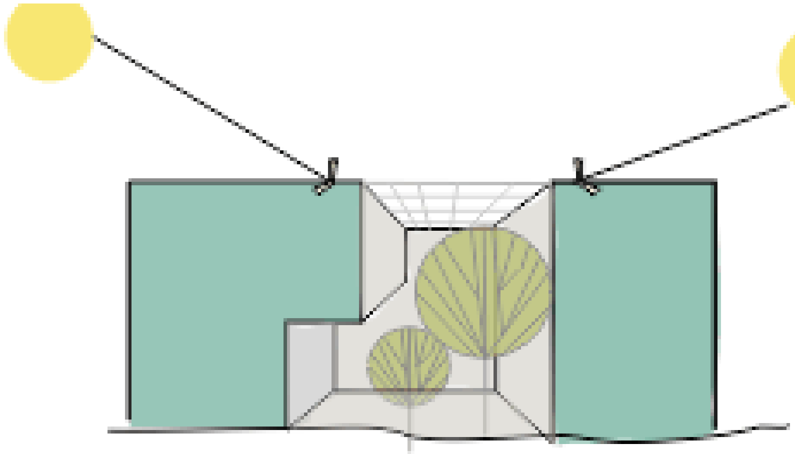


Sources: The Conversation; NZEB

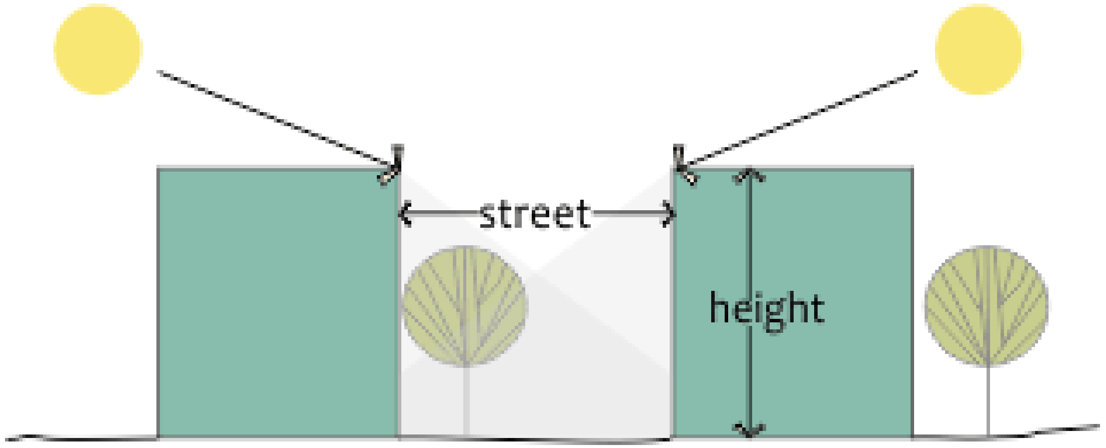
Block Level

Heating / Cooling Strategies

Arrange blocks such that mutual shading is achieved, thereby preventing solar heat gains in warm months.

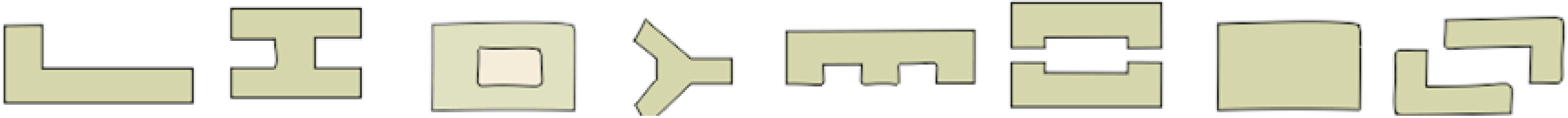


closely placed forms



narrow streets - keep building height to street width ratio minimal

Arrange longer facades along North / South to encourage glare-free lighting in summer, and maximize solar penetration in winter.

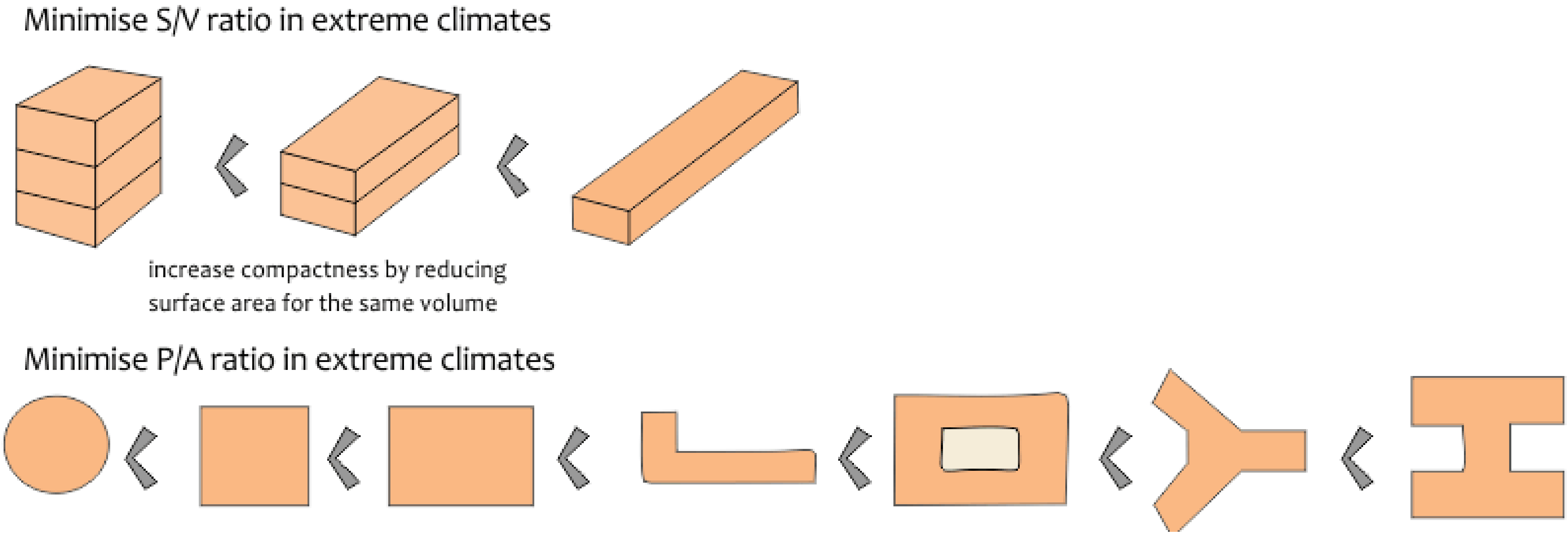


Source: NZEB

Block Level

Heating / Cooling Strategies

Minimize surface area to building volume and perimeter to area ratios in extreme climate zones to minimize exposure to solar radiation.

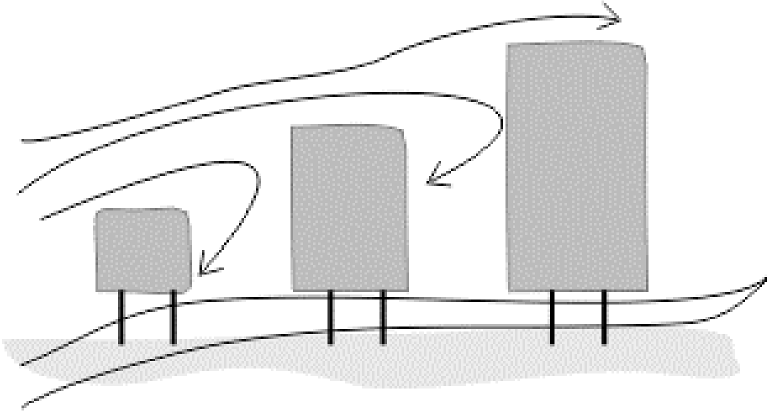


Source: NZEB

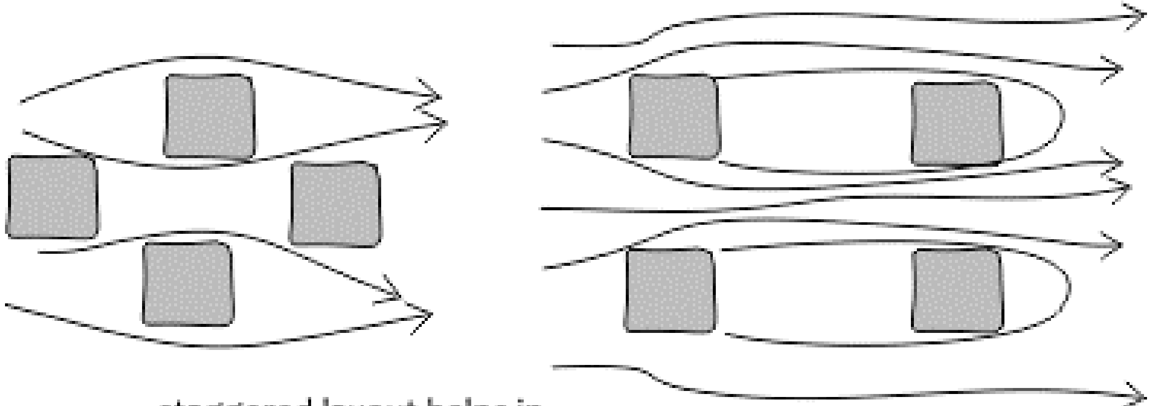
Block Level

Ventilation Strategies

Buildings should be oriented to avoid creation of 'wind shadows'



if a site has multiple buildings, they should be arranged in ascending order of their heights and be built on stilts to allow ventilation



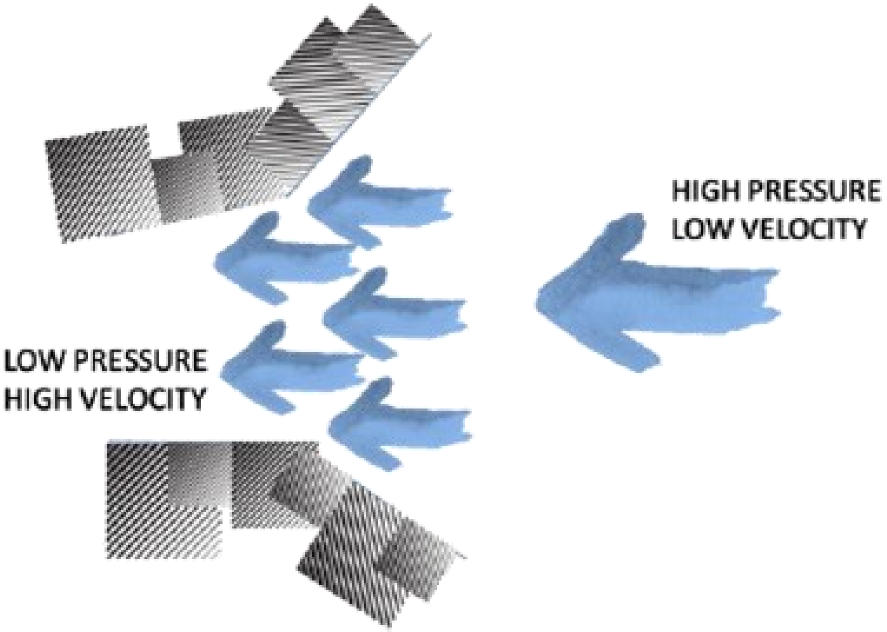
staggered layout helps in accentuating wind movement

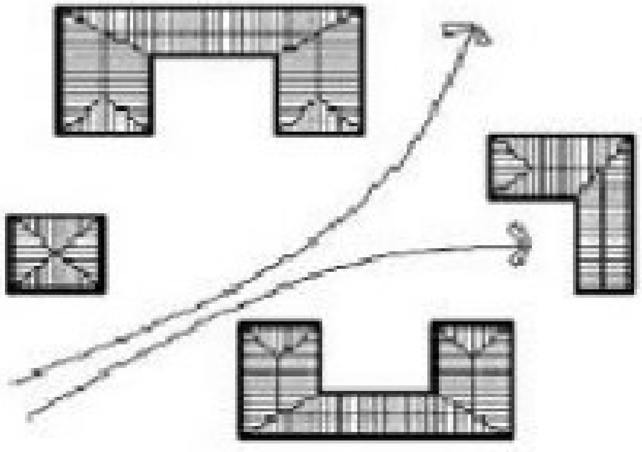
Source: NZEB

Block Level

Ventilation Strategies

Wind flows can be harnessed by creating variably sized courts and catchment areas. This can enhance ventilation and serve an overall cooling effect for the blocks.



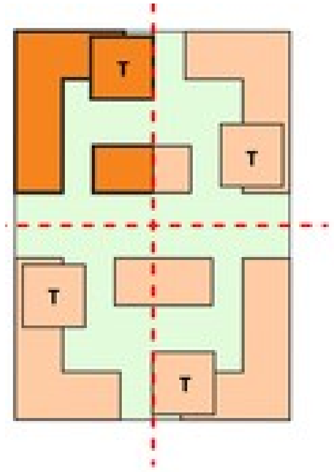


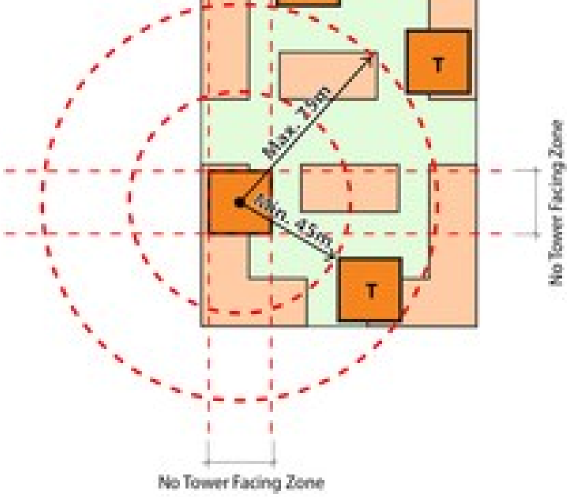
BUILDING SPACING SUCH THAT AIR FLOW IS PROMOTED

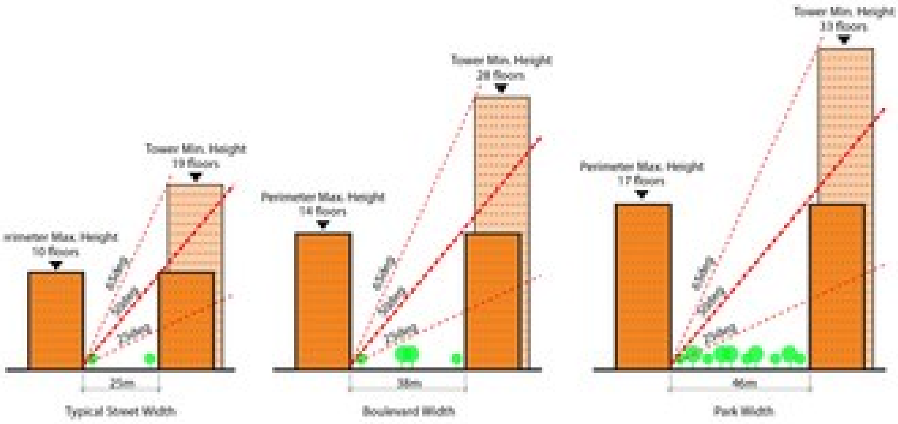
Source: MaS-SHIP

Block Level

Lighting Strategies







RULE 1-1
Since full block is optimal, each zone as a potential small block is also optimal.

RULE 1-2
Generally, 1 tower per each zone.

RULE 2-1
Any tower should be separated a minimum of 45m center the of a tower to minimize the impact on each other.

RULE 2-2
Towers should be located at no more 75m apart to maintain typology efficiency. Additionally, towers should not directly face each other.

RULE 3-1
The tower and perimeter block height is defined by the street or courtyard width and a range of BRE recommended obstruction angles.

25 deg (BRE recommended) : conventional window design will usually give reasonable result.
65 deg (BRE recommended) : it is very difficult to provide adequate daylight, unless very large windows are used.
50 deg (KPF recommended): it provides higher density with reasonable solution to improve daylight condition through designing adequate room layout and enlarged windows

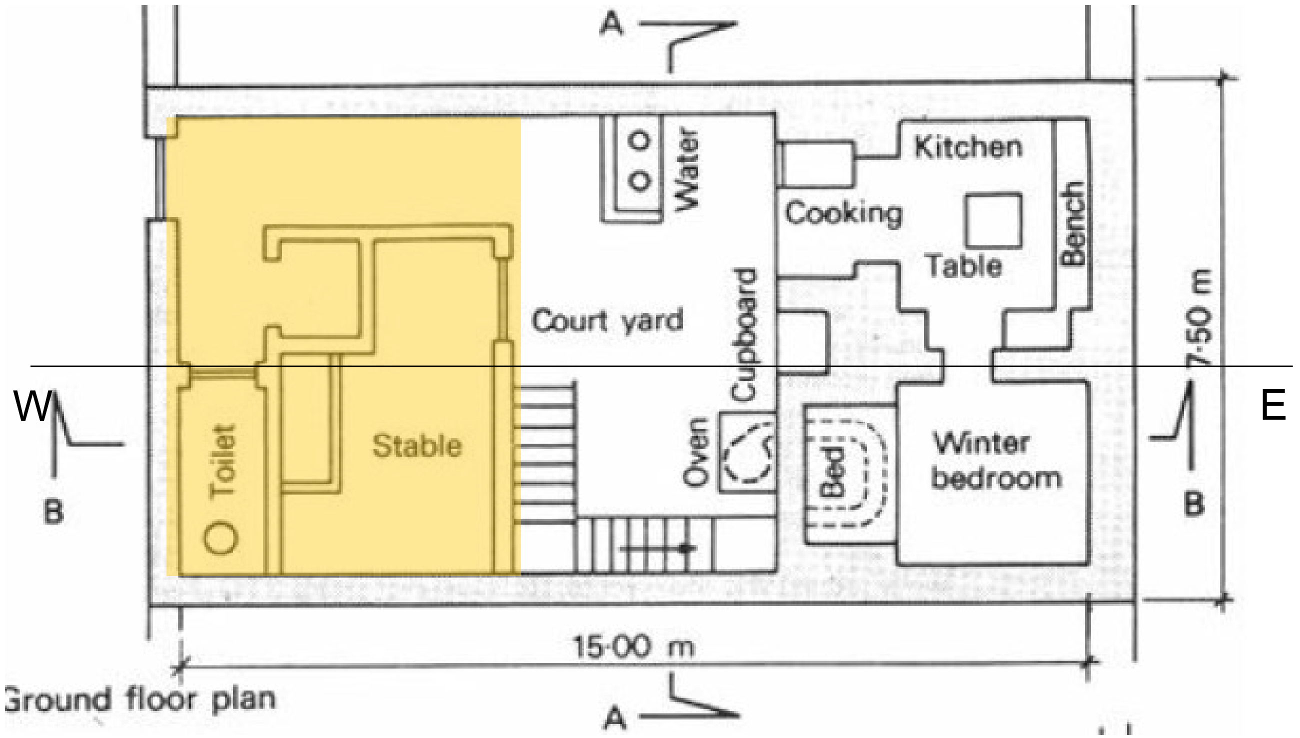
Source: ui.kpf.com

Unit Level

Heading / Cooling

Form & Orientation

- The alteration in solar path affects solar radiation penetration patterns during different seasons and consequently, heat gain and loss in a building.
- Moderately compact courtyard type internal planning. Lesser exposure to sun on East-West external walls to minimize heat gain.
- Non-habitable rooms (stores, toilets, etc.), can be effectively used as thermal barriers if planned and placed on the east and, especially, the west end of the building.



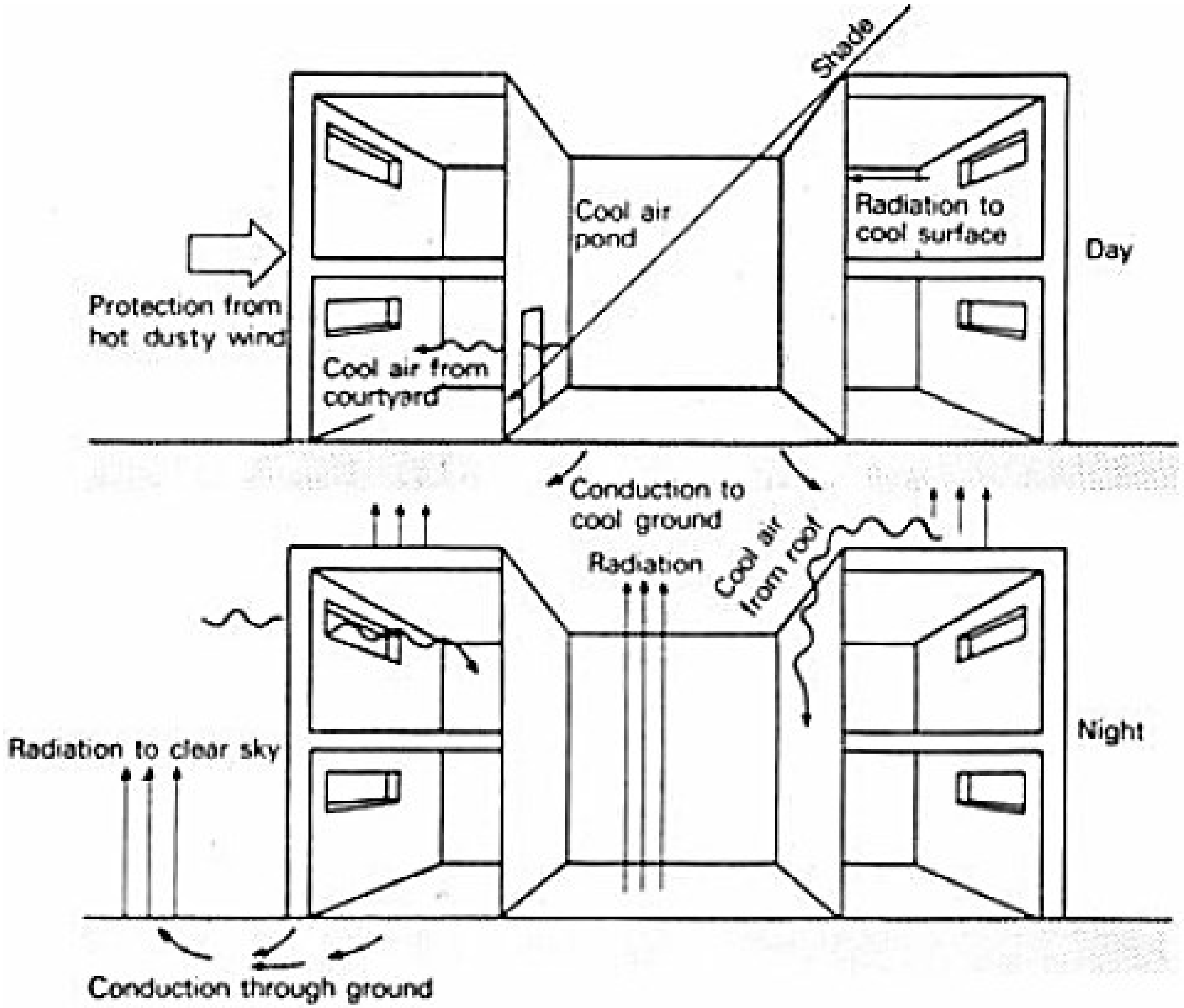
Source: http://www.nzeb.in

Unit Level

Heading / Cooling

Form & Orientation

- Courtyard Effect - high walls cut off the sun, and large areas of the inner surfaces and courtyard floor are shaded during the day.
- Cooler air, cooler surfaces, the earth beneath the courtyard will draw heat from the surrounding areas, reemitting it to the open sky during the night.



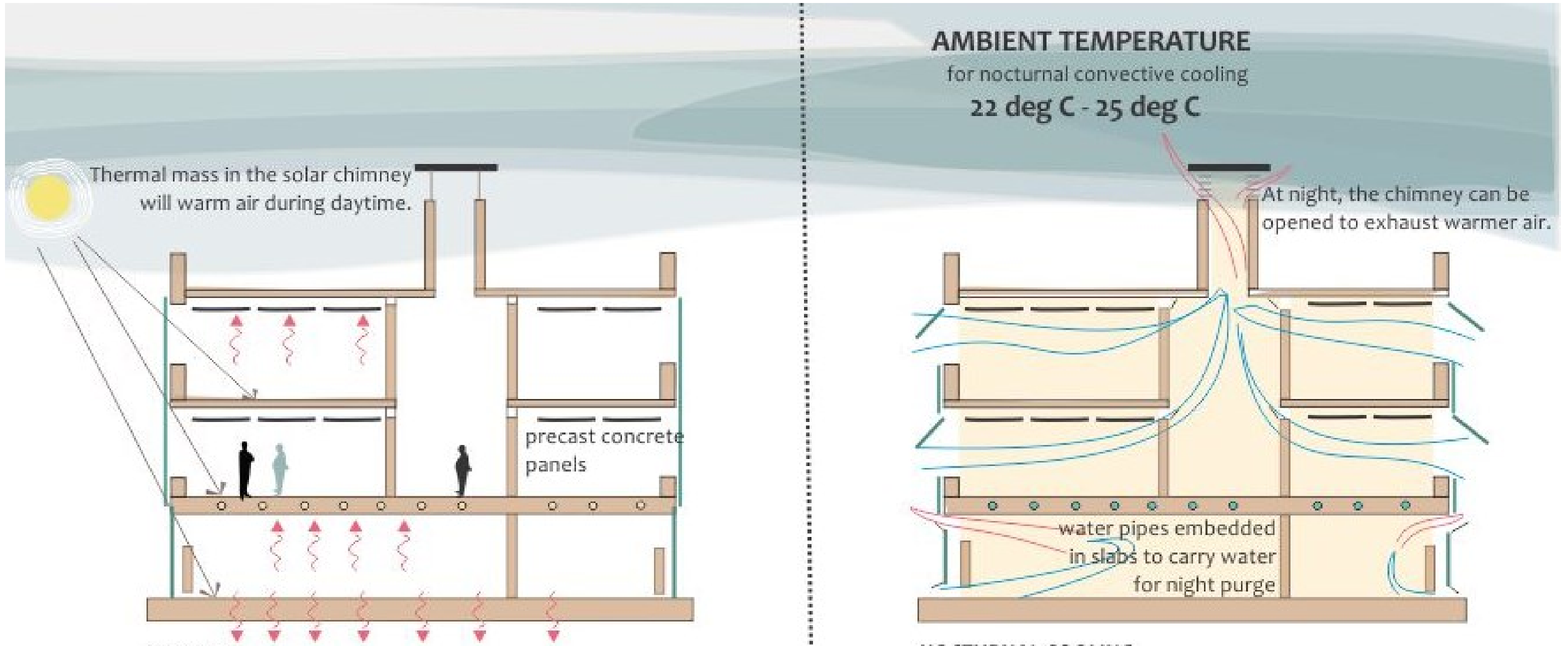
Source: Konigsberger

Unit Level

Heating / Cooling

Thermal Mass

- Thermal mass can be used with nocturnal convective cooling or ‘night cooling’ for cooling buildings passively.
- Diurnal swing must be high for thermal mass to be an effective passive cooling and heating strategy.



DAYTIME

Heat gain through solar radiation, occupants & equipment is stored in the thermal mass during daytime. Concrete slabs, precast ceiling panels, heavy weight mass walls, can add thermal mass to buildings.

NOCTURNAL COOLING

Water or outside air is passed through the building at night to carry the heat stored in the thermal mass during daytime.

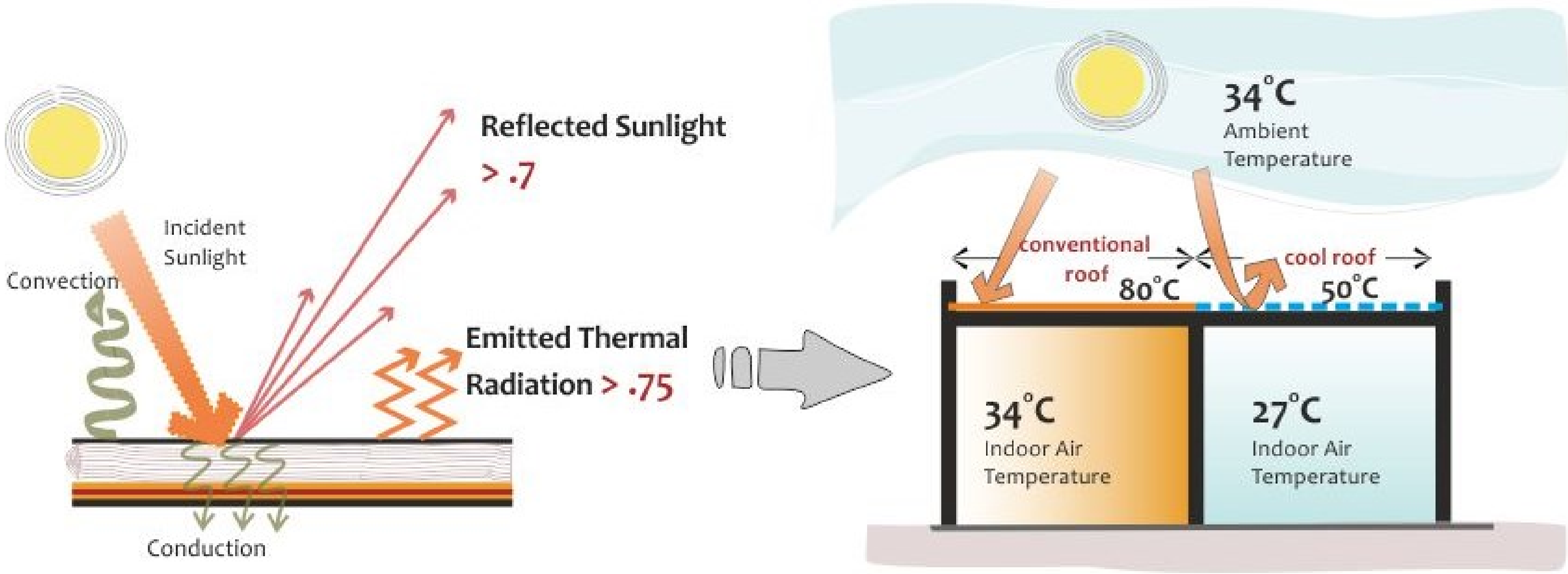
Source: NZEB

Unit Level

Heading / Cooling

Cool Roofs

- Thermal emittance (re-radiation of absorbed heat), and solar reflectance of cool roofs is much higher than conventional roofs, which enables them to prevent solar radiation from being passed on to the interior of a building. Cool Roofs reduce annual air conditioning energy use of a single story building by up to **15%.**



Performance of cool roofs can be assessed in terms of thermal emittance, solar reflectance or Solar Reflectance Index (SRI), which is a measure of both emittance and reflectance.

Cool roofs are able to maintain a temperature differential of 6-8 deg celcius between ambient and indoor air temperature due to high thermal emittance and solar reflectance.

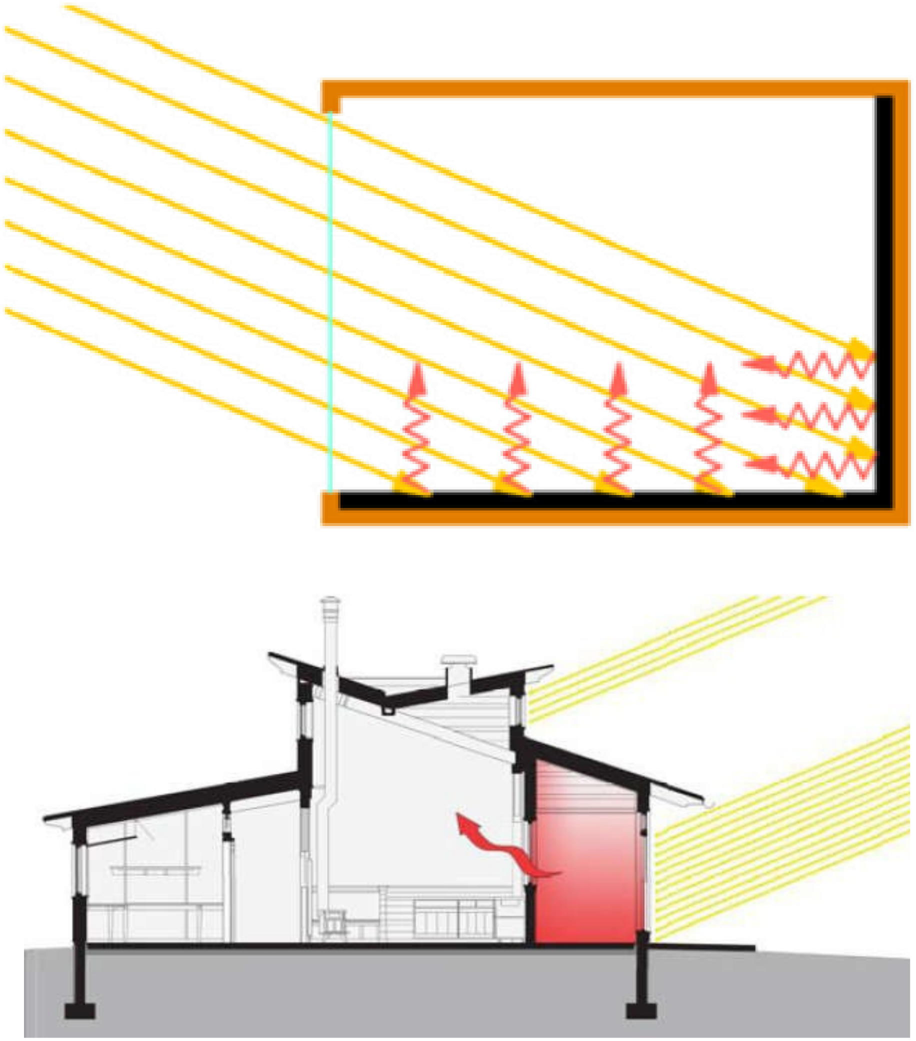
Source: NZEB

Unit Level

Heading / Cooling

Direct Heat Gain

- Sunlight is admitted into the living spaces, directly through openings or glazed windows, to heat the walls and floors and thereby the air inside.
- The glazed windows are generally located facing south to receive maximum sunlight during winter (in northern hemisphere). They are generally double glazed, with insulating curtains, to reduce heat loss during night time.
- Glazed corridors and verandahs can also be used to trap sunlight transfer heat to living / working spaces beyond. At night, these buffers can help retain heat in living areas.



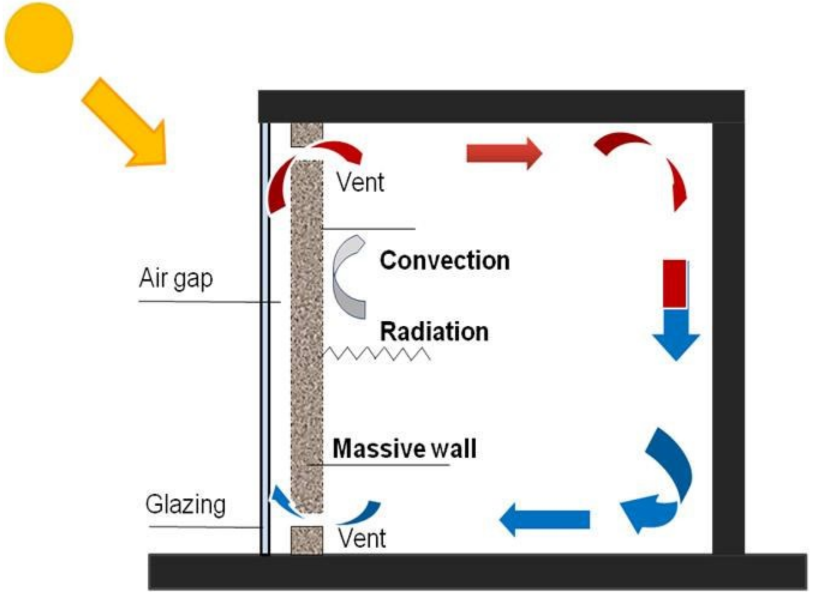
Source: https://www.new-learn.info/packages/clear/thermal/buildings/passive_system/passive_heating

Unit Level

Heading / Cooling

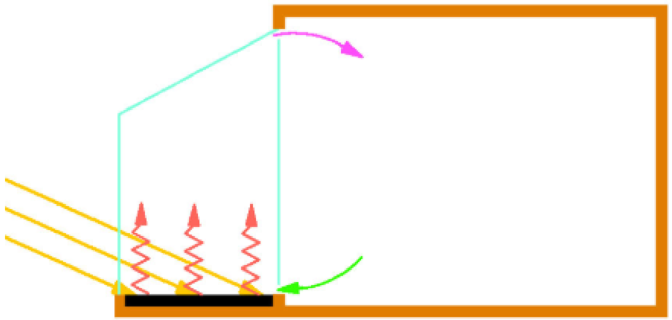
Indirect Heat Gain

- Trombe walls, thick solid walls with vents along the lower and upper ends, can be used in conjunction with glazing along south facades to have a heating effect on internal air circulation.



Isolated Heat Gains

- A south-facing sunspace can be created with glazing, wherein sunlight heats trapped air, and convection enables it internal circulation.



Isolated Gain: Sunspace

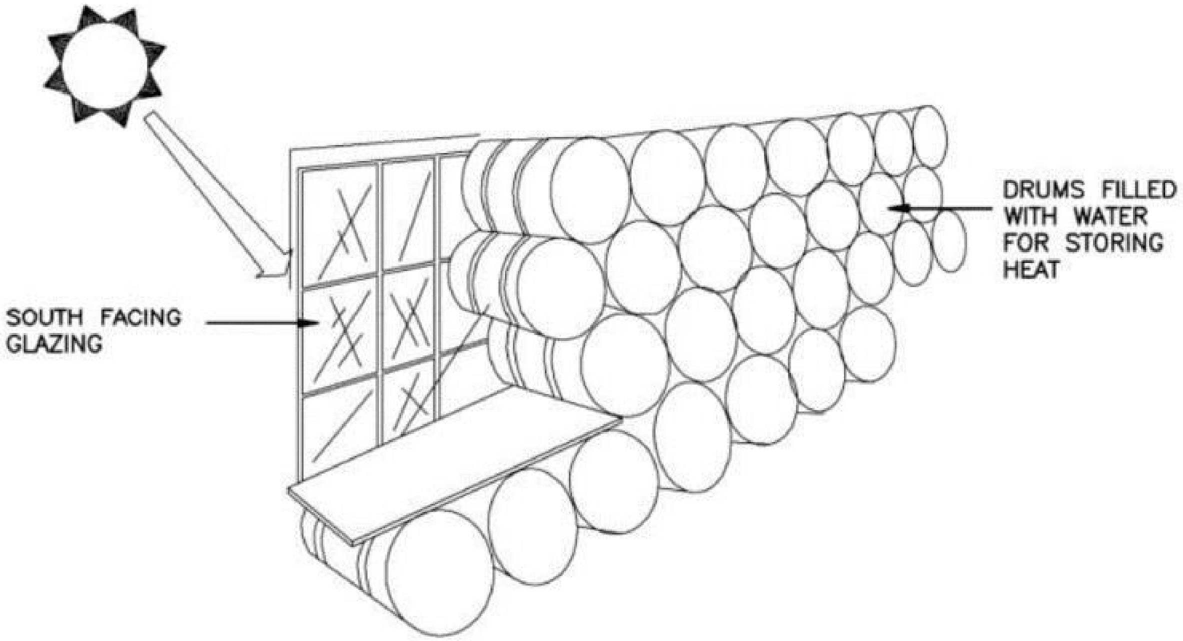
Source: Göksal Özbalta, Türkan & Kartal, Semiha. (2010)

Unit Level

Heading / Cooling

Water Walls

- Water walls are based on the same principle as that of the Trombe wall, except that they employ water as the thermal storage material. Water walls are thermal storage wall made up of drums of water stacked up behind glazing. It is painted black externally to increase the absorption of radiation. This setup can store more heat than concrete walls due to higher specific heat.



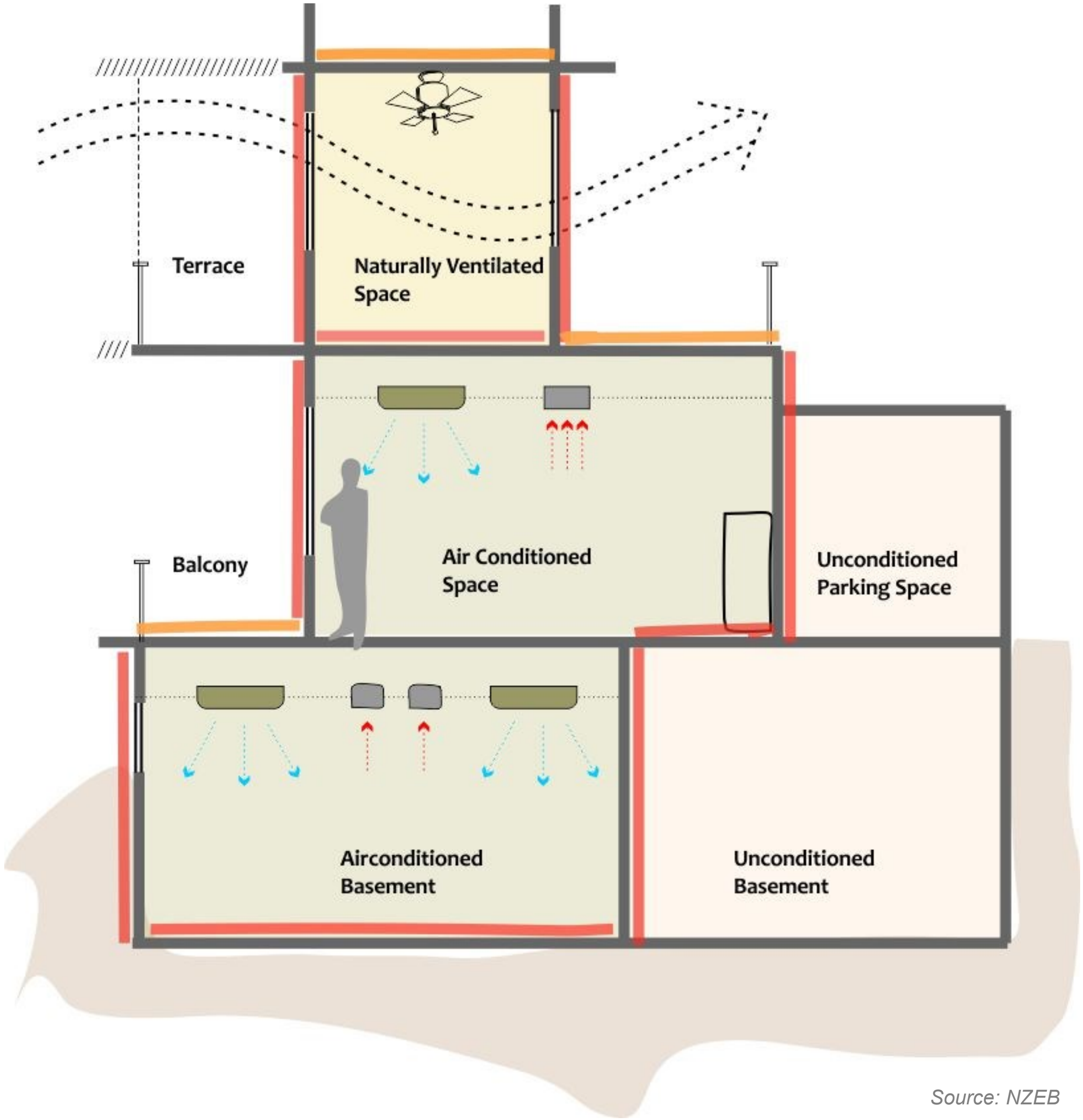
Source: NZEB

Unit Level

Heating / Cooling

Insulation

- Insulation should always be placed on the warmer side of the envelope.
- In warm climates, insulation should be installed on the outside and in cold climates, on the inside.
- Insulation is rated in terms of R-value. Higher R-values denote better insulation and translate into more energy savings.
- Providing insulation beyond 100mm thickness does not provide a much further benefit in terms of energy efficiency. Provision of the initial 25mm of insulation, provides the highest incremental energy saving.
- As the insulation material becomes incrementally thicker, the incremental energy saved becomes smaller and smaller until it is almost insignificant, especially after an insulation thickness of 100mm onwards.



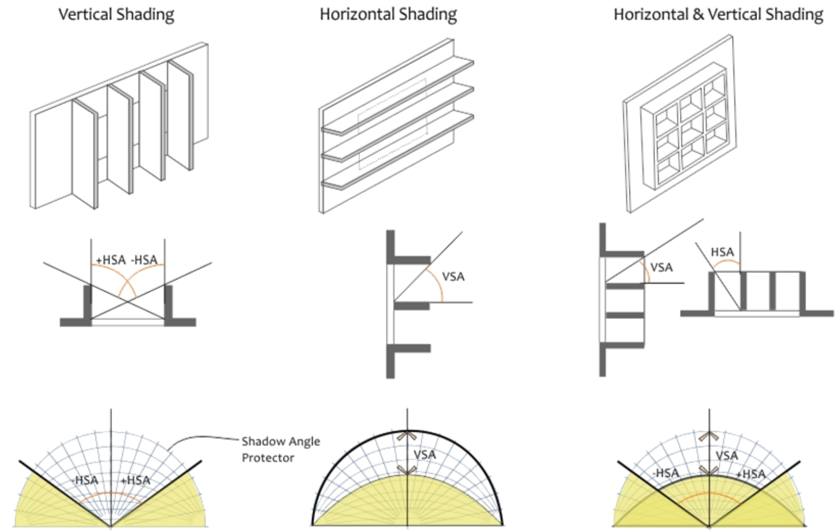
Source: NZEB

Unit Level

Heading / Cooling

Shading

- Plants like creepers may be used to promote shading.
- Fenestrations and shades / chajjas may be designed to optimize solar radiation as per climate type.



Shading mask of vertical shading device

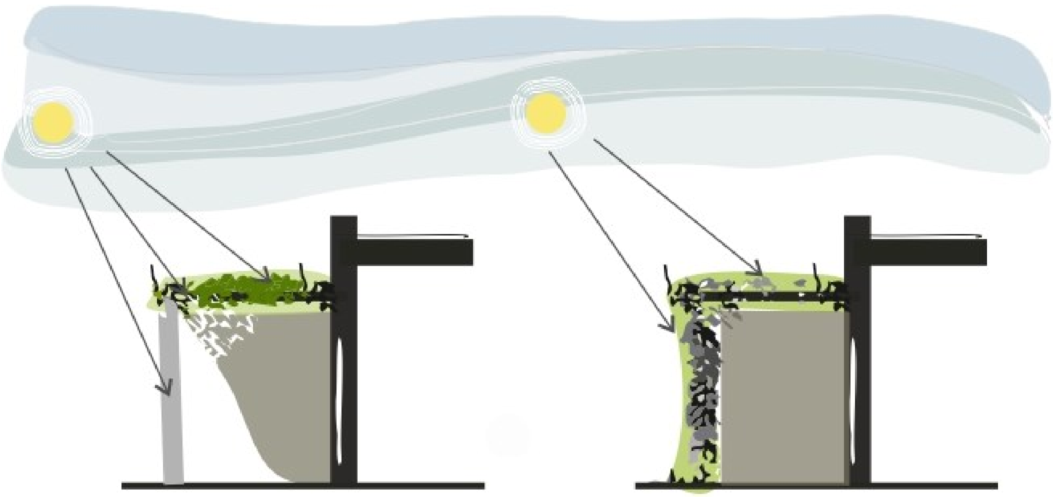
vertical shading devices protect from sun at sides of the elevation such as east and west side

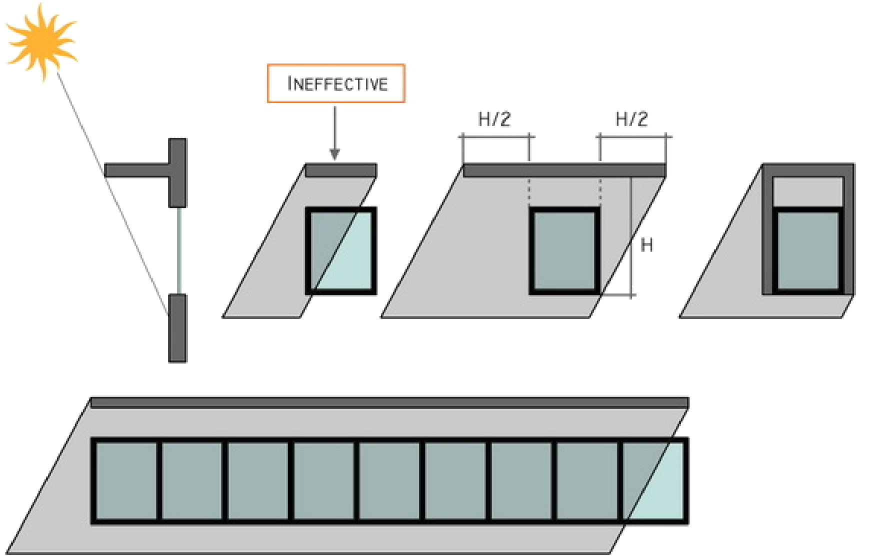
Shading mask of horizontal shading device

horizontal shading devices protect from sun at high angles and opposite to the wall to be shaded such as north and south sides

Shading mask of egg crate shading device

comination of horizontal and vertical shading devices protect from sun in all orientations





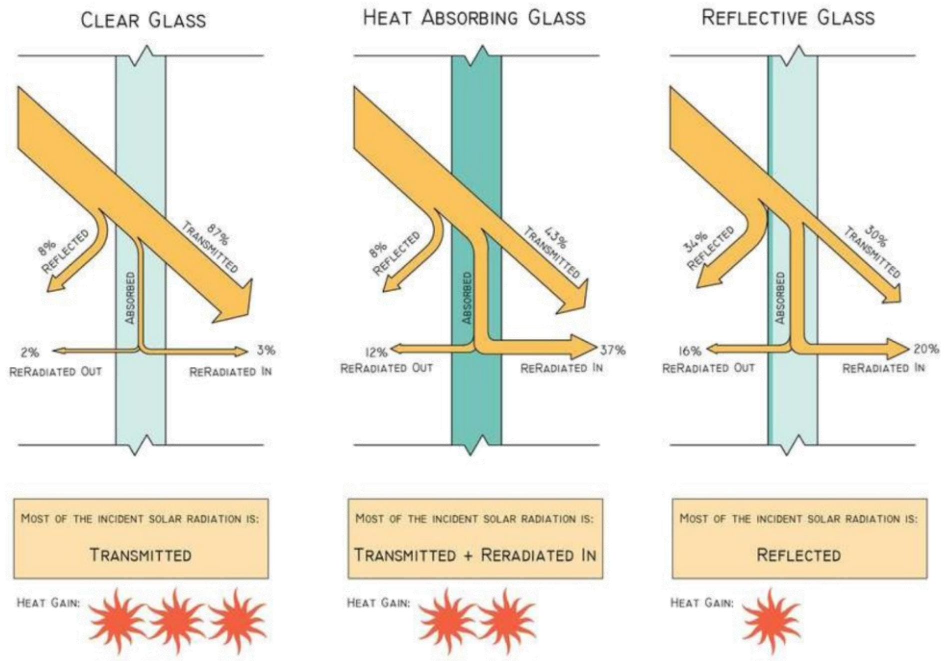
Source: NZEB

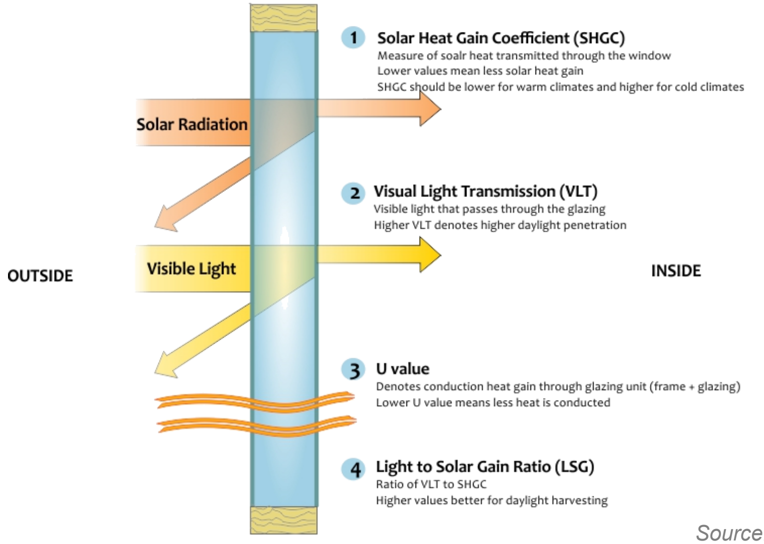
Unit Level

Heating / Cooling

Glazing

- Location, sizing and glazing of windows can be used judiciously to reducing cooling load, and resultantly, smaller building cooling systems.
- Achieving a balance between daylight penetration and heat gain requires a careful calibration between visual and heat transmission qualities of glazing, and the orientation and sizing of opening.
- Reduce Solar Heat Gain Coefficient (SHGC) as less heat will be transferred into the building.
- Reduce the U-Value of glazing and also lower the SHGC except for the cold climate where higher SHGC is recommended.





Source: University of Waterloo

Unit Level

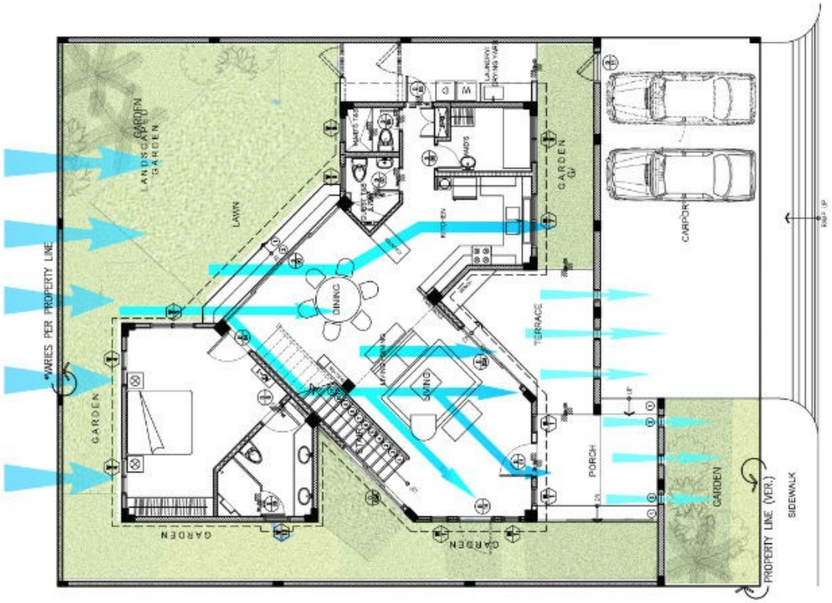
Ventilation

Orientation

- Buildings can be oriented at an angle between 0° to 30° with respect to the prevailing wind direction.
- Buildings that feature a courtyard (in climates where cooling is desired), orienting the courtyard 45° from the prevailing wind maximizes wind flow into the courtyard and enhances cross ventilation in the building.

Creating Pressure Differences

- When wind enters through a smaller opening and exits through a bigger opening, that's a 'squeeze point.' This creates a natural vacuum which increases wind velocity.
- Total area of openings should be a minimum of 30% of floor area.
- Window-Wall-Ratio (WWR) should not be more than 60%.



Unit Level

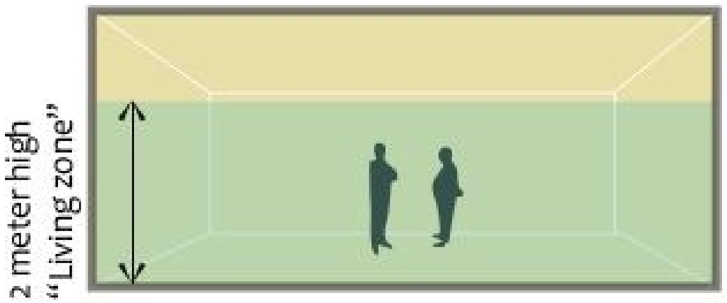
Ventilation

Openings

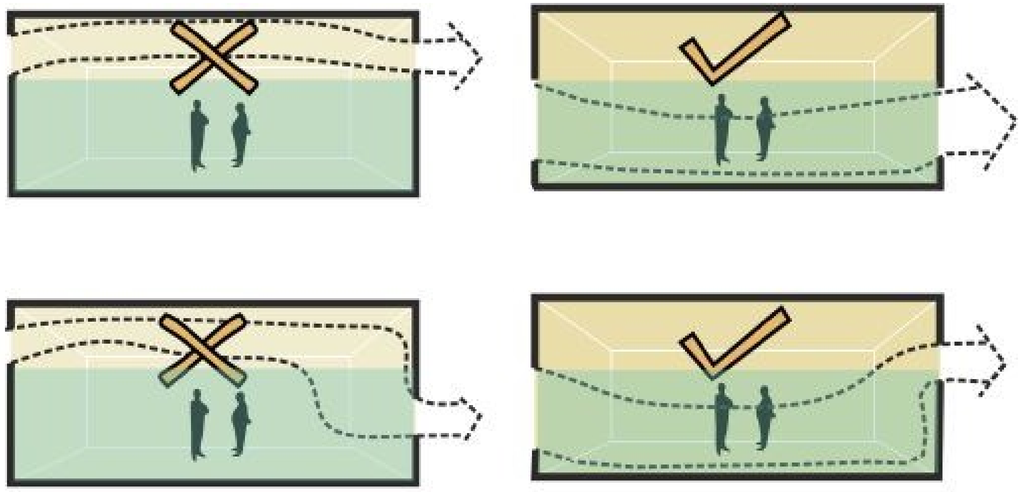
- Maximum air movement is achieved by keeping the sill height at 85% of the critical height.
- Greatest flow per unit area of the opening is achieved by keeping the inlet and the outlet of nearly same sizes at nearly same levels.

Stack Ventilation

- Stack ventilation is a form of cross ventilation that enhances air circulation inside a space by combination of buoyancy and venturi effect. It is good for cooler temperatures.
- The lighter warm air rises to escape the building through window openings at high level and is replaced by cool night time air or day time air drawn from shaded external areas from inlets at lower level.



Living zone is the space commonly used by occupants. Air movement should be directed through this space.



inlet openings placed at high level deviate air flow away from the living zone irrespective of outlet position

Source: NZEB

Unit Level

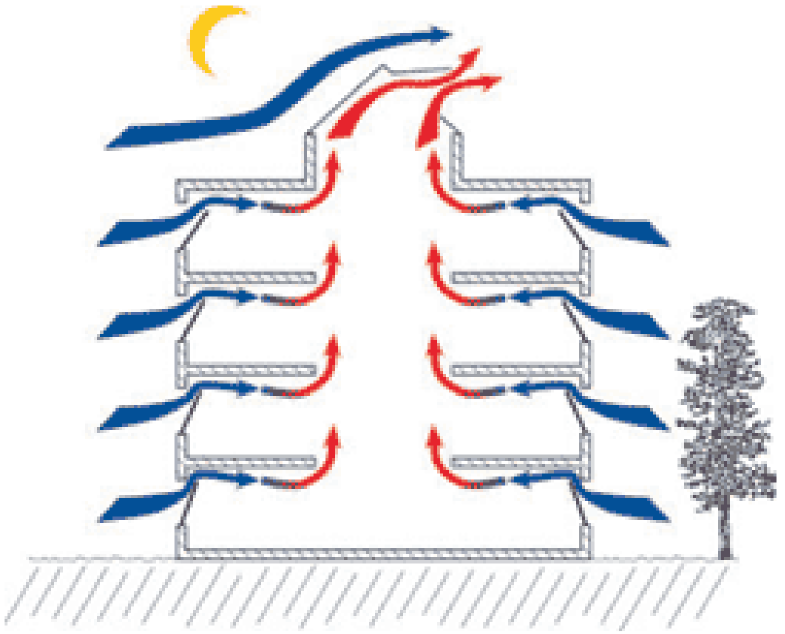
Ventilation

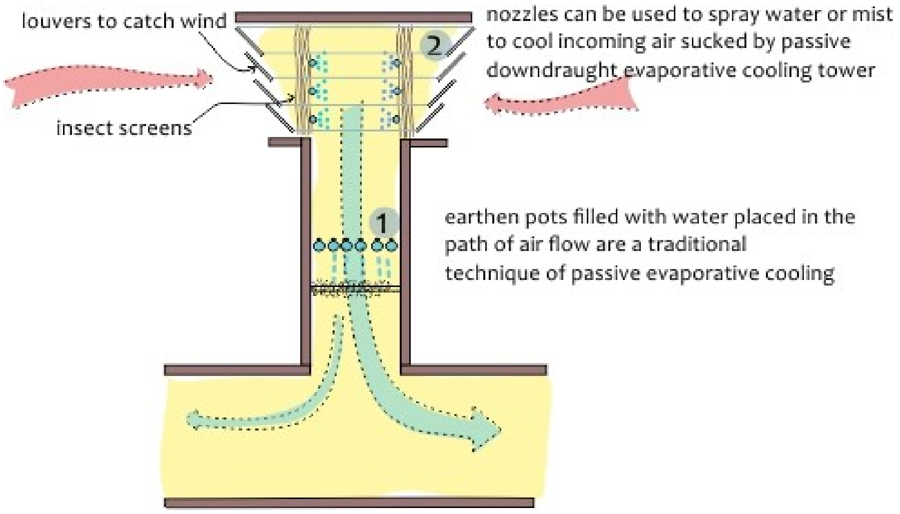
Wind Towers

- The cardinal principle behind its operation lies in changing the temperature and thereby density of the air in and around the tower.
- The difference in density creates a draft, pulling air either upwards or downwards, through the tower.

Downdraught Evaporative Cooling

- Passive downdraught towers catch hot ambient air through wind scoops at the top. This air is cooled either through mechanical systems like nozzle sprays or through passive systems like water filled vessels. The heavy cool air sinks to the bottom zone of habitable spaces. Efficiency depends on the temperature differential between the warm outside air and cool air inside the tower.





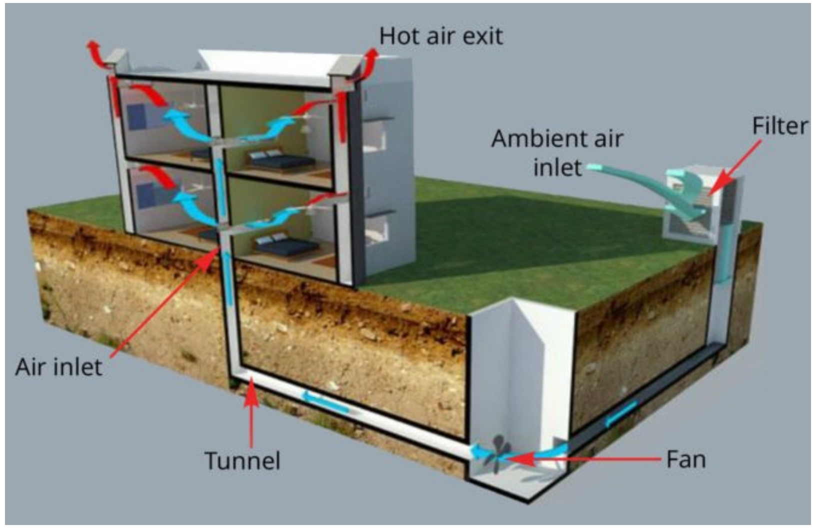
Sources: MaS-SHIP; NZEB

Unit Level

Ventilation

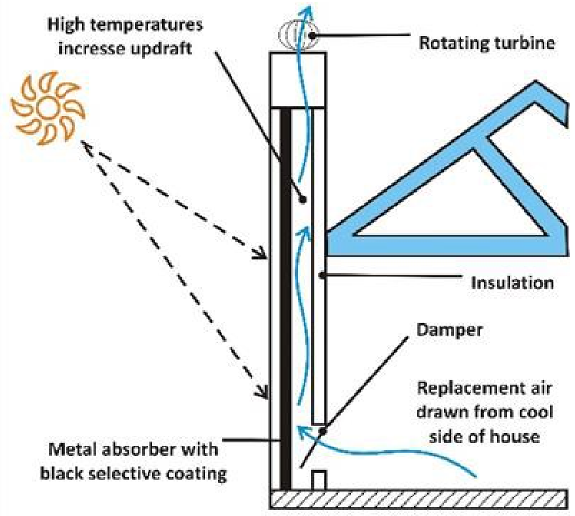
Air Earth Heat Exchanger

- A pre-cooling or pre-heating system which consists of a pipe or network of pipes buried at reasonable depth below the ground surface. It either cools the air by rejecting heat to the ground or heats the air absorbing heat from the ground. It utilizes the fact that the deep earth temperature remains almost same as the annual average mean air temperature of the location.



Solar Chimney Wall

- Solar Chimney, on an external wall, enhances stack ventilation by providing additional height and well-designed air passages thereby increasing the air pressure differential.
- Via solar radiation, the chimneys warm the rising air which increases the difference between the temperatures of incoming and outflowing air. These measures increase the natural convection and enhance the draw of air through the building.



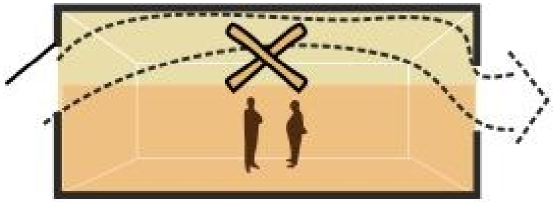
Sources: MaS-SHIP; BEEP

Unit Level

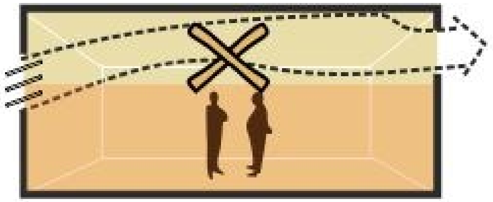
Ventilation

Directing Air Flow through Openings

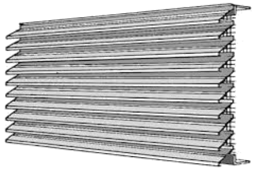
- Louvres and shades can be so designed as to direct air in specific directions, while protecting from sun and rain.

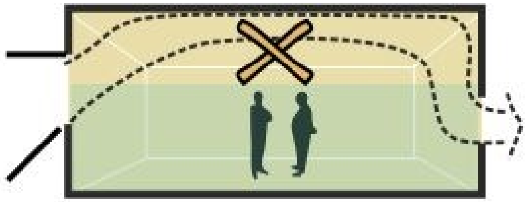


Sashes

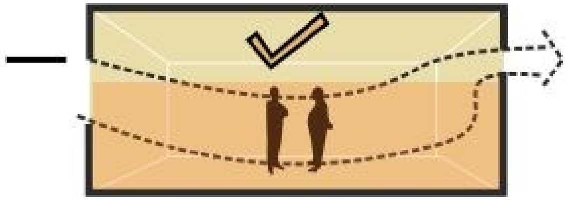


Louvres





Canopies



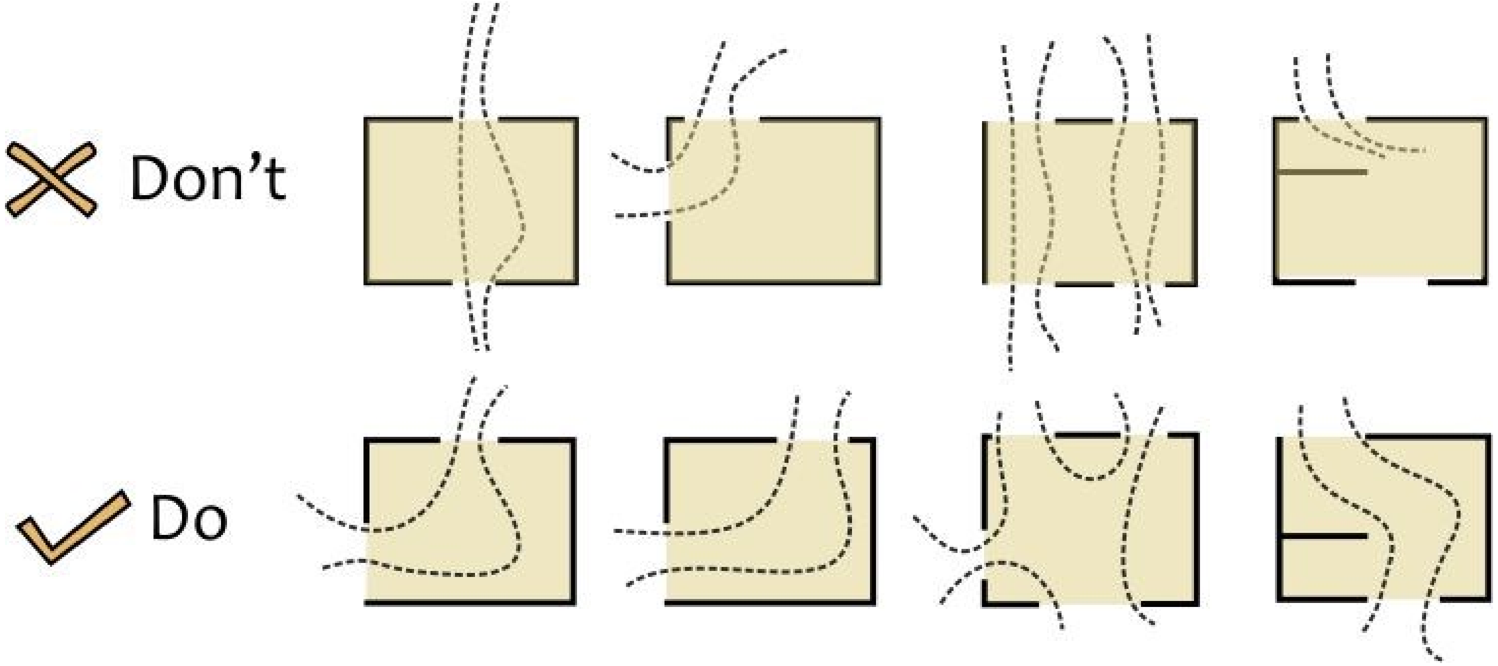
Sources: NZEB

Unit Level

Ventilation

Positioning of Openings

- To encourage ample ventilation, openings should be positioned on opposite walls, diagonally across rooms.



Sources: NZEB

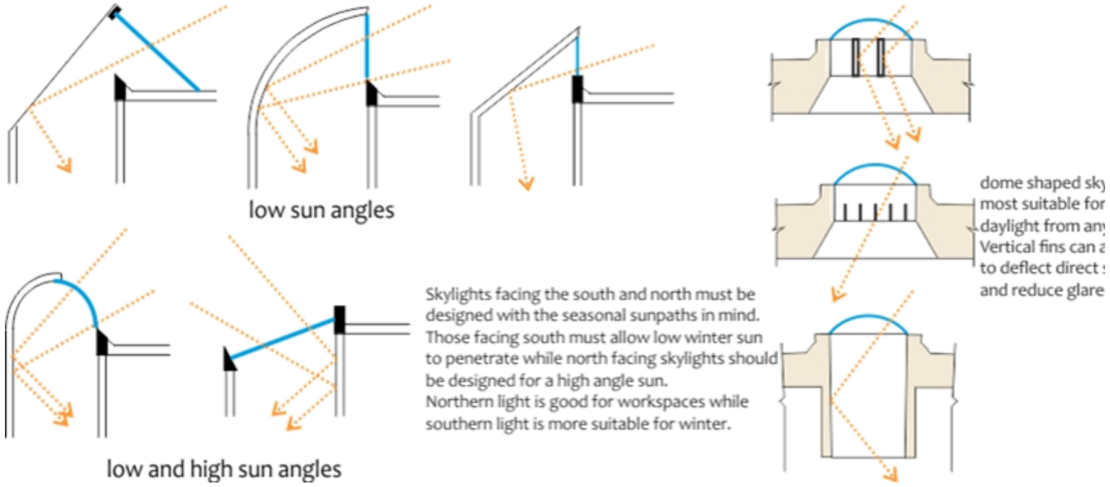
Unit Level

Lighting

Good lighting strategies can bring down energy demand by 20-30%. Windows / fenestrations can be designed in unique ways to encourage such savings.

<u>Skylights</u>

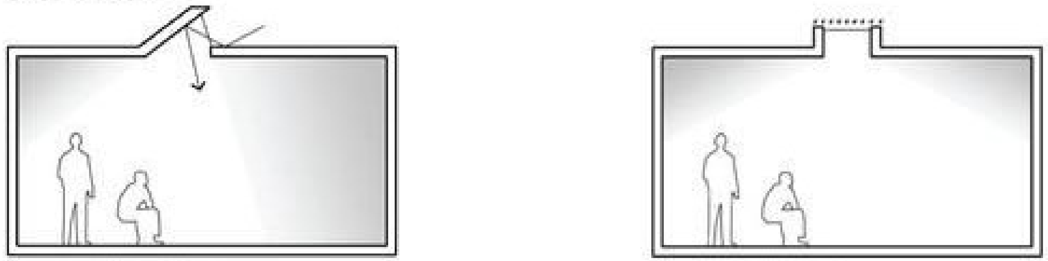
- Top lighting is an effective daylighting solution for wide buildings where side lighting cannot be used for adequate lighting of the deeper areas of the floorplate.
- To reduce glare, skylights must be designed with reflective surfaces that redirects direct sunlight into the space.
- Higher positioning of windows also enables deeper and wider penetration of natural light in the interiors. Combining with lighter coloured interior surfaces further improves internal visibility.



Skylights facing the south and north must be designed with the seasonal sunpaths in mind. Those facing south must allow low winter sun to penetrate while north facing skylights should be designed for a high angle sun.
Northern light is good for workspaces while southern light is more suitable for winter.

dome shaped sk
most suitable for
daylight from an
Vertical fins can
to deflect direct
and reduce glare

TOP LIGHTING



REFLECTED LIGHT

DIFFUSED LIGHT

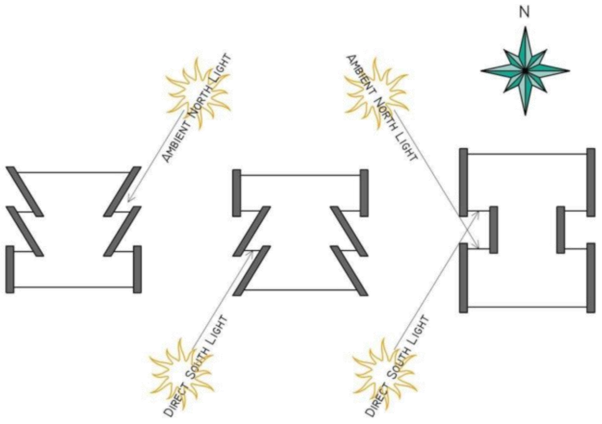
Sources: NZEB

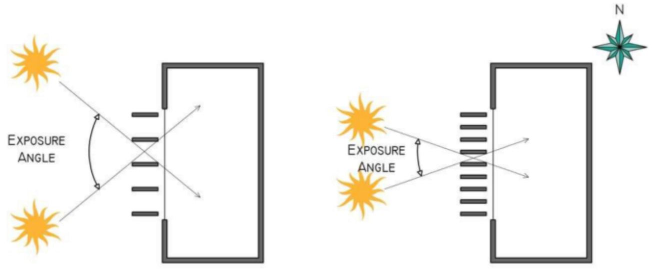
Unit Level

Lighting

<u>Directional Modifications</u>

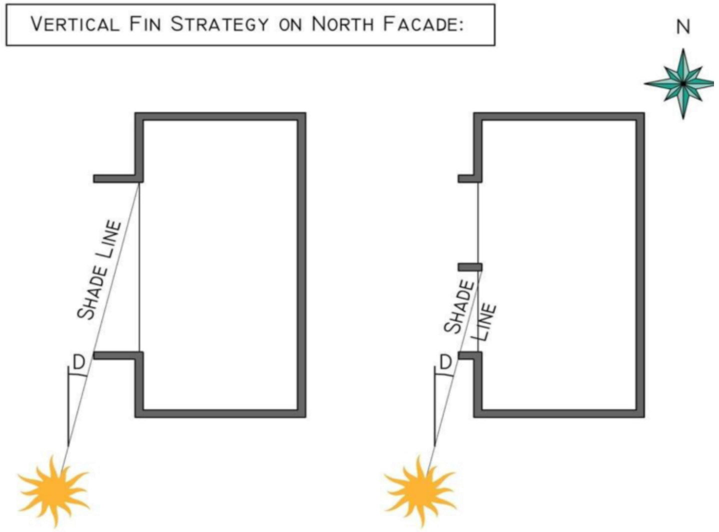
- Ambient, glare free light comes from the North, while direct light comes from the South.
- East / West light has a lot of glare as it is generally at a lower angle.
- Orient windows along the East and West façade such that they are angled toward North / South.
- Alternatively, incorporate fins along East / West façade windows.
- Shading is generally not required along North facades, or only minimal shading interventions may be necessary.
- Window shades can be used to optimize light coming from the South.



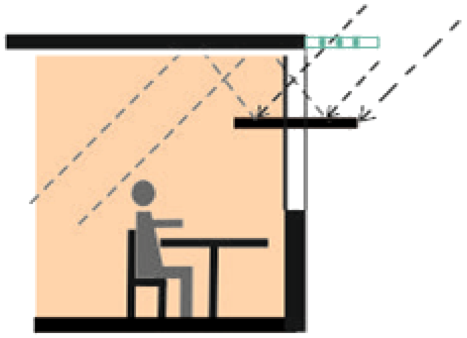


Solar Penetration is Reduced by Moving Fins Closer Together, Making Them Deeper, or Both.

Vertical Fin Strategy on North Facade:



The "Shade Line" at Angle "D" determines fin spacing & Depth.



external/ internal light shelves allow deeper diffused light penetration and shade.

Sources: NZEB

Exercise

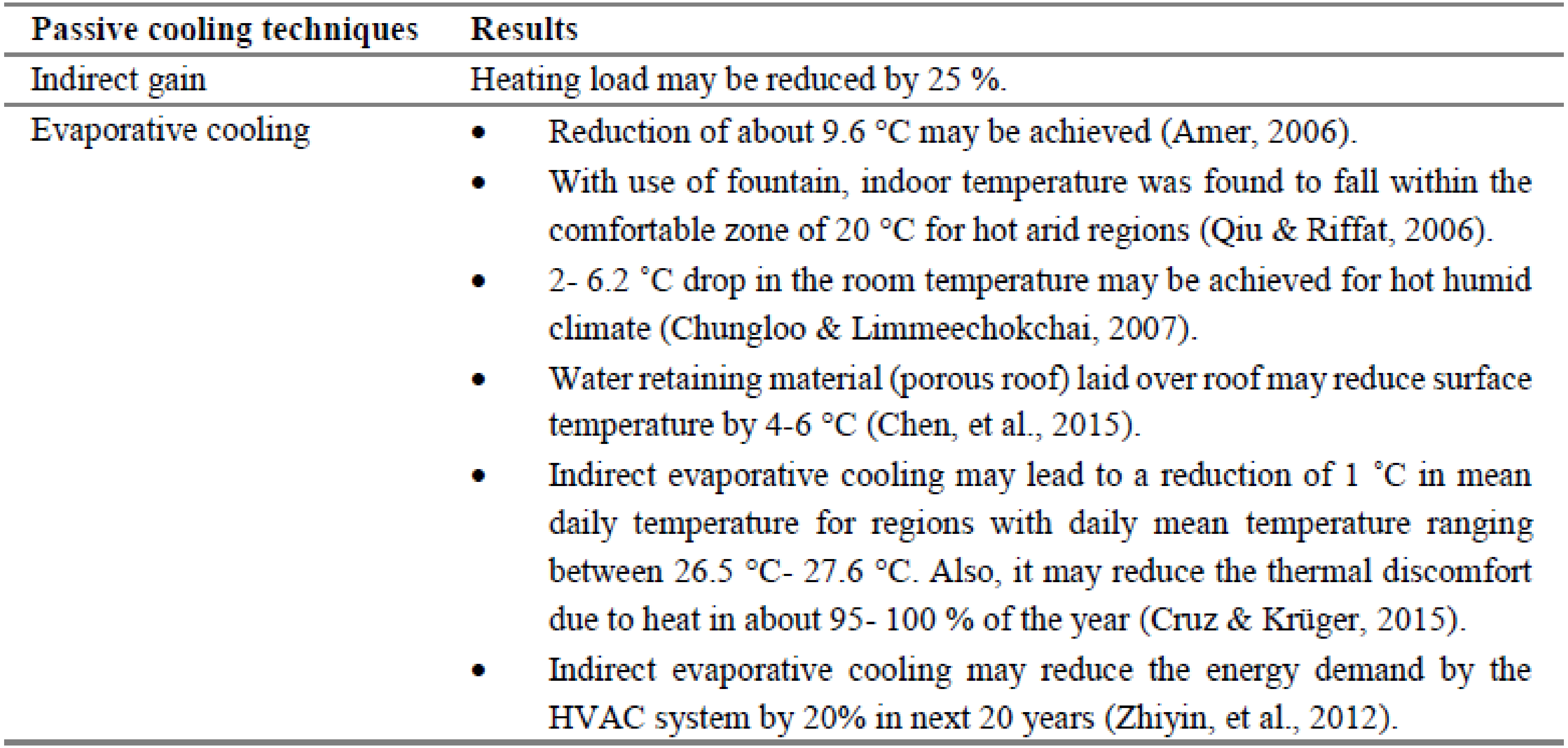
- Divide into groups.
- From the deck of cards draw one and put it under the category mentioned on the sheets provided as under:

Start	Stop	Continue

- The deck of cards contains certain passive/active cooling practices in India or some innovative suggestions or non-recommended solutions in the field of passive design.

Sources: NZEB

Traditional Solutions

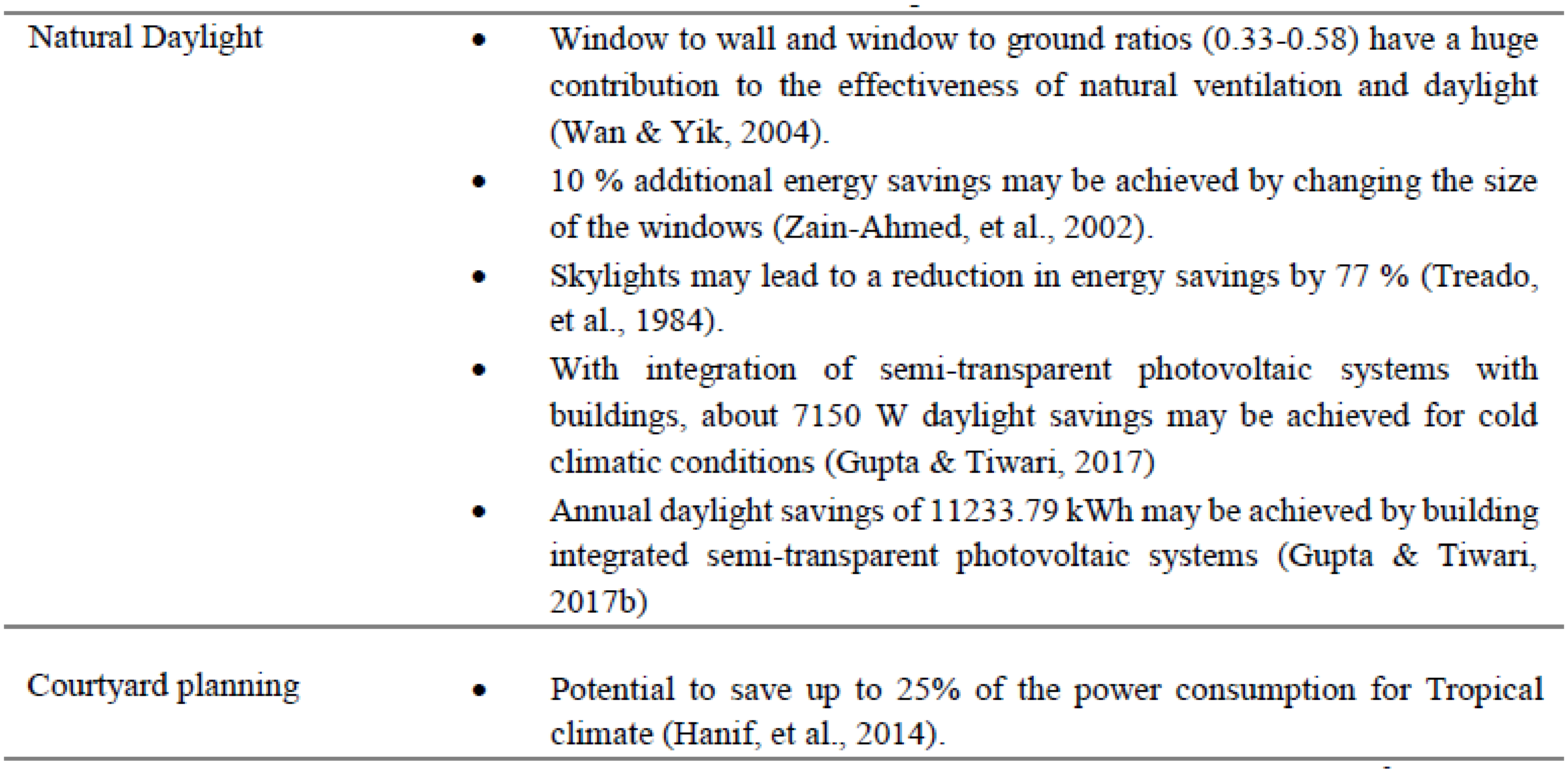


Passive cooling techniques	Results
Indirect gain	Heating load may be reduced by 25 %.
Evaporative cooling	• Reduction of about 9.6 °C may be achieved (Amer, 2006). • With use of fountain, indoor temperature was found to fall within the comfortable zone of 20 °C for hot arid regions (Qiu & Riffat, 2006). • 2- 6.2 °C drop in the room temperature may be achieved for hot humid climate (Chungloo & Limmeechokchai, 2007). • Water retaining material (porous roof) laid over roof may reduce surface temperature by 4-6 °C (Chen, et al., 2015). • Indirect evaporative cooling may lead to a reduction of 1 °C in mean daily temperature for regions with daily mean temperature ranging between 26.5 °C- 27.6 °C. Also, it may reduce the thermal discomfort due to heat in about 95- 100 % of the year (Cruz & Krüger, 2015). • Indirect evaporative cooling may reduce the energy demand by the HVAC system by 20% in next 20 years (Zhiyin, et al., 2012).

Sources: Journal of Buildings & Sustainability, 2017

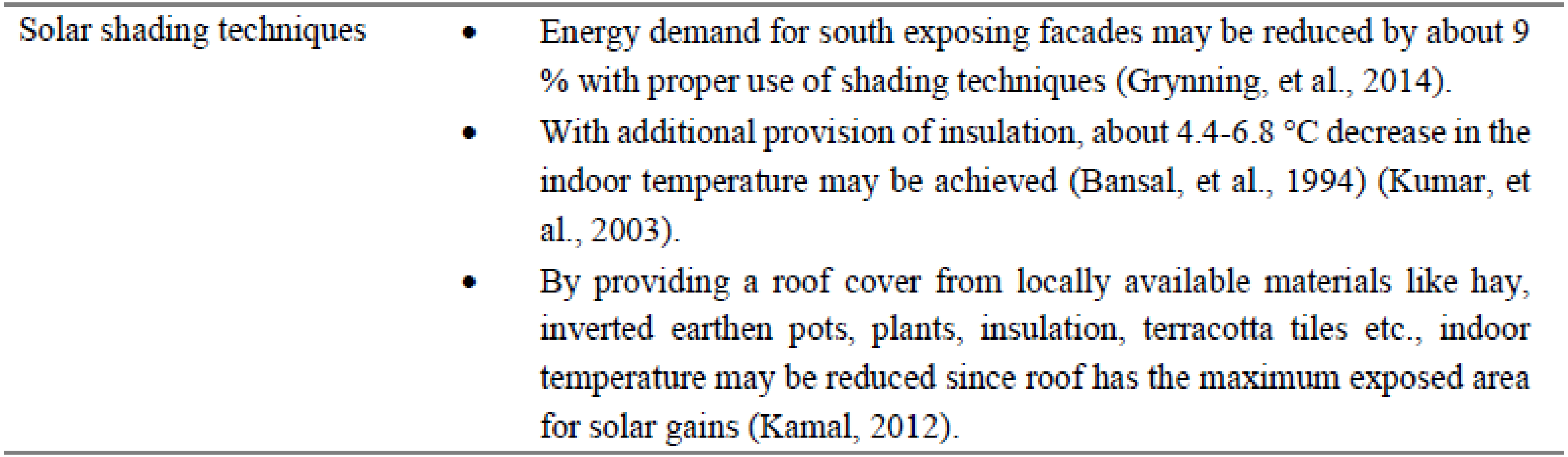
Natural ventilation	• More than 30 % energy savings may be achieved (Ciampi, et al., 2005). • Recommended value of air movement is 0.2 m/s for winters and 0.4 m/s for summers (Tiwari, 2012). • For living rooms, dining areas, mean window to wall ration should be 0.34. The same for bedroom should be 0.27 in high rise buildings (Wan & Yik, 2004). • Artificial mechanical airflow systems should not disturb the natural ventilation (Pfafferott, et al., 2004). • Comfortable indoor thermal conditions may be achieved with air movement of 2-3 m/s (Gupta & Tiwari, 2017).
Wind tower	• About 12-15 °C decrease in the indoor temperature can be achieved (Hughes, et al., 2012). • Reduction of up to 17.6 ˚C in room air temperature may be achieved by using wetted surface design for hot dry regions (Bouchahm, et al., 2011). • With introduction of evaporative cooling concept in terms of 10 m high wet columns may reduce the inside temperature by 12 ˚C and a drop in relative humidity by 22% for hot arid areas (Benhammou, et al., 2015). • For windy areas, new installation of wind towers was introduced which could align itself in the pre dominant wind direction. Also, transparent

Sources: Journal of Buildings & Sustainability, 2017

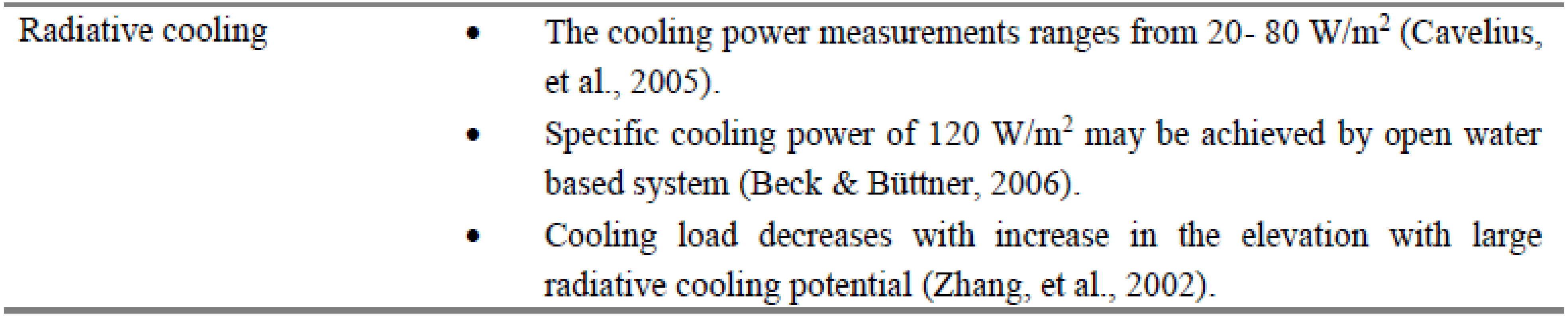


Natural Daylight	• Window to wall and window to ground ratios (0.33-0.58) have a huge contribution to the effectiveness of natural ventilation and daylight (Wan & Yik, 2004). • 10 % additional energy savings may be achieved by changing the size of the windows (Zain-Ahmed, et al., 2002). • Skylights may lead to a reduction in energy savings by 77 % (Treado, et al., 1984). • With integration of semi-transparent photovoltaic systems with buildings, about 7150 W daylight savings may be achieved for cold climatic conditions (Gupta & Tiwari, 2017) • Annual daylight savings of 11233.79 kWh may be achieved by building integrated semi-transparent photovoltaic systems (Gupta & Tiwari, 2017b)
Courtyard planning	• Potential to save up to 25% of the power consumption for Tropical climate (Hanif, et al., 2014).

Sources: Journal of Buildings & Sustainability, 2017

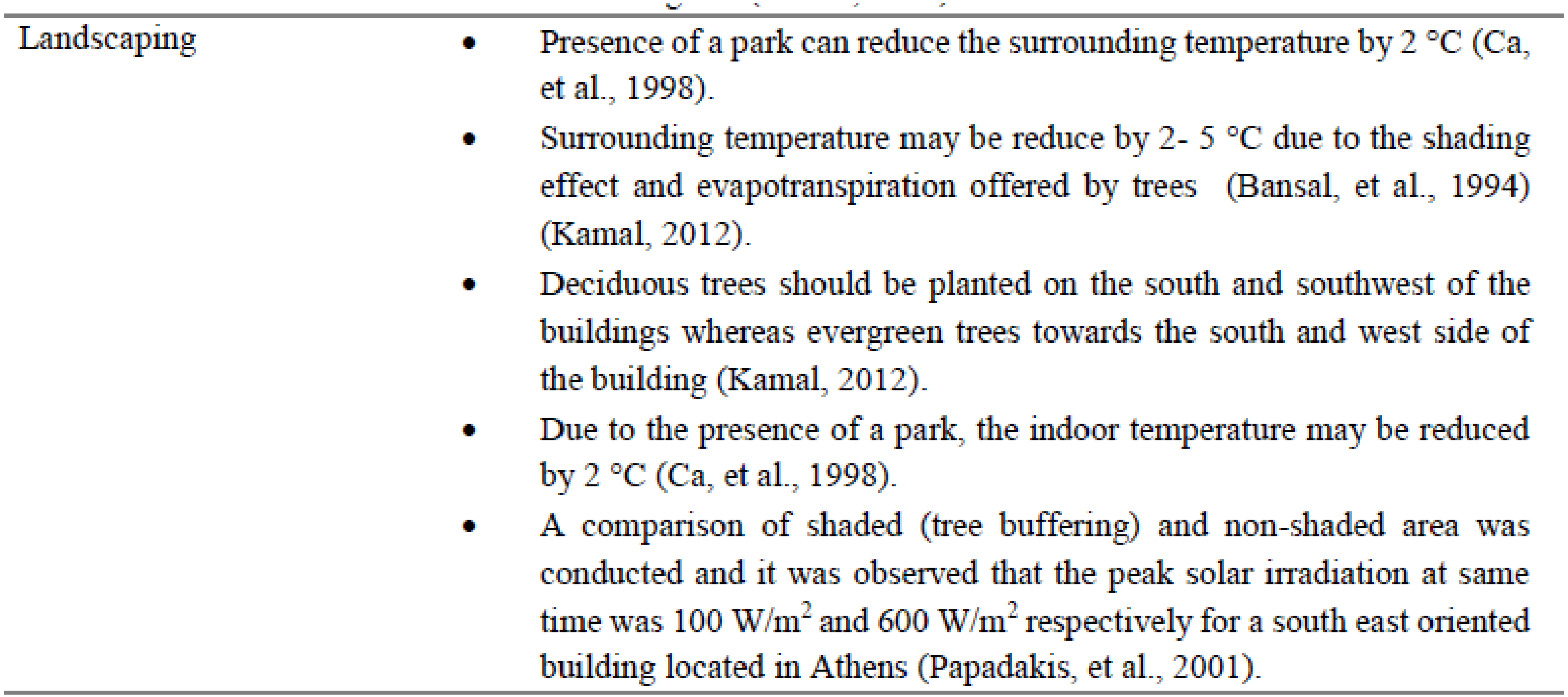


Solar shading techniques	• Energy demand for south exposing facades may be reduced by about 9 % with proper use of shading techniques (Grynning, et al., 2014). • With additional provision of insulation, about 4.4-6.8 °C decrease in the indoor temperature may be achieved (Bansal, et al., 1994) (Kumar, et al., 2003). • By providing a roof cover from locally available materials like hay, inverted earthen pots, plants, insulation, terracotta tiles etc., indoor temperature may be reduced since roof has the maximum exposed area for solar gains (Kamal, 2012).



Radiative cooling	• The cooling power measurements ranges from 20- 80 W/m^2 (Cavelius, et al., 2005). • Specific cooling power of 120 W/m^2 may be achieved by open water based system (Beck & Büttner, 2006). • Cooling load decreases with increase in the elevation with large radiative cooling potential (Zhang, et al., 2002).

Sources: Journal of Buildings & Sustainability, 2017



Landscaping	- Presence of a park can reduce the surrounding temperature by 2 °C (Ca, et al., 1998). - Surrounding temperature may be reduce by 2- 5 °C due to the shading effect and evapotranspiration offered by trees (Bansal, et al., 1994) (Kamal, 2012). - Deciduous trees should be planted on the south and southwest of the buildings whereas evergreen trees towards the south and west side of the building (Kamal, 2012). - Due to the presence of a park, the indoor temperature may be reduced by 2 °C (Ca, et al., 1998). - A comparison of shaded (tree buffering) and non-shaded area was conducted and it was observed that the peak solar irradiation at same time was 100 W/m^2 and 600 W/m^2 respectively for a south east oriented building located in Athens (Papadakis, et al., 2001).

Sources: Journal of Buildings & Sustainability, 2017

Earth Shelter	• About 7.0-8.5 °C decrease in the indoor temperature can be achieved (Tiwari, et al., 2014). • For desert climatic conditions, reduction of 2.8 °C in room temperature was observed during summer months (Al-Ajmi, et al., 2006).
Trombe wall	• Trombe walls can be seen in the great pyramid of Gizeh to maintain 23 °C in the king's and the queen's chamber throughout the year (Gupta, 1984). • Screened Trombe walls have 18 times lower heat gains when compared to the screened Trombe walls for Mediterranean type of climate (Gupta, 1984). • With introduction of cross ventilation and devices like overhangs, rolling shutters, reduction of 65 % and 72.9 % in cooling energy was observed respectively when compared to unvented Trombe wall (Gupta, 1984). • Reduction of 1.4 °C in the room temperature was observed with reduction of 0.5 MJ/m2 in daily heat gains with additional screening (Stazi, et al., 2012). • 20.7 % reduction in cooling load was observed due to storage capacity of Trombe wall (Soussi, et al., 2013).

Sources: Journal of Buildings & Sustainability, 2017

Case Studies

Smart Ghar III, Rajkot

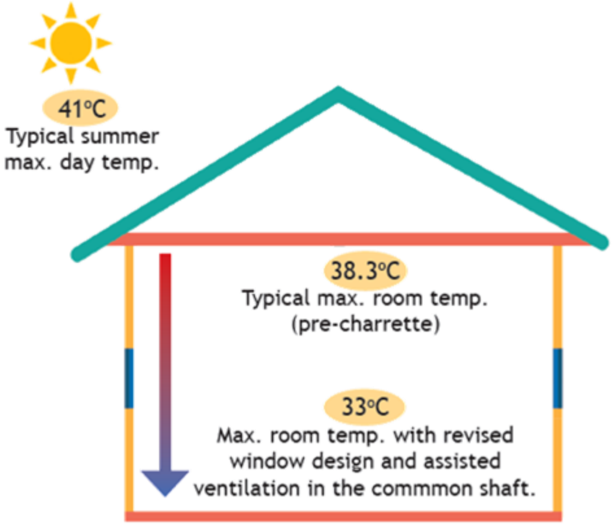
- Project: Affordable housing in Rajkot under PMAY Untenable Slum Redevelopment.
- Site area: 17,593 m2
- Built-up area: 57,408 m2
- Number of dwelling units (DU): 1176 (All 1 BHK)
- 11 residential towers : Stilt + 7

Key Features

- Sensitively designed window shades to reduce heat gains while improving day light.
- Use of a fan-serviced ventilation shaft to improve air quality inside.

Outcomes

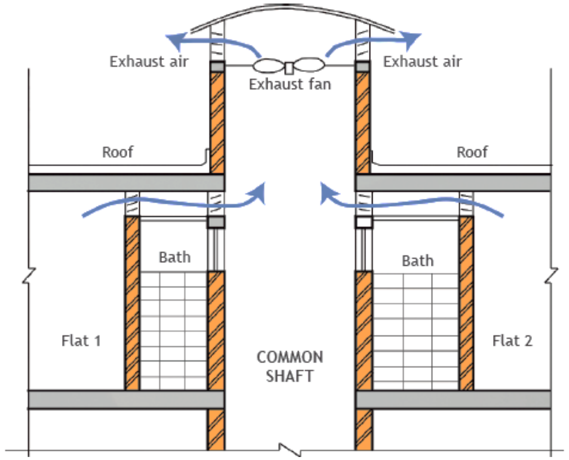
- Reduced peak summer room temperature by >5°C
- Increased number of comfortable hours from ~2600 hours to ~6300 hours.

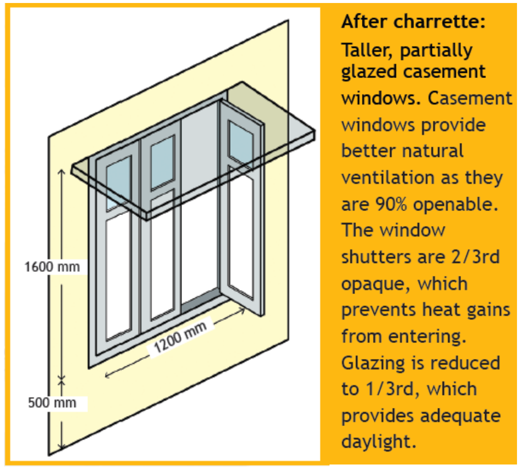


41°C Typical summer max. day temp.

38.3°C Typical max. room temp. (pre-charrette)

33°C Max. room temp. with revised window design and assisted ventilation in the commmon shaft.





After charrette: Taller, partially glazed casement windows. Casement windows provide better natural ventilation as they are 90% openable. The window shutters are 2/3rd opaque, which prevents heat gains from entering. Glazing is reduced to 1/3rd, which provides adequate daylight.

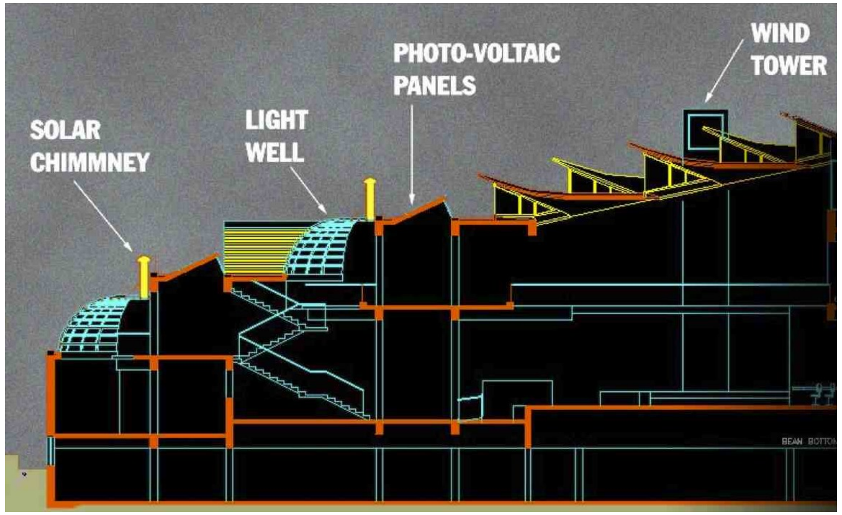
Source: BEEP

Punjab Energy Development Agency, Chandigarh

- Secretariat complex of Ministry of Environment and Forests (MoEF)

<u>Key Features</u>

- The building integrates daylight and Natural Ventilation Strategies through Light and ventilation wells with renewal energy systems, i.e. Photovoltaic and Solar Water Heating
- Light Wells: The vertical cut-outs in the floating slabs are integrated with light vaults and solar activated naturally ventilating, domical structures in the south to admit day light without glare and heat.
- The shell roof is angled in such a manner that the opening beneath the shell is shaded from the summer sun but allows the winter sun to penetrate.
- Wind towers used for ventilation
- Internal fountains used to cool inner courts.



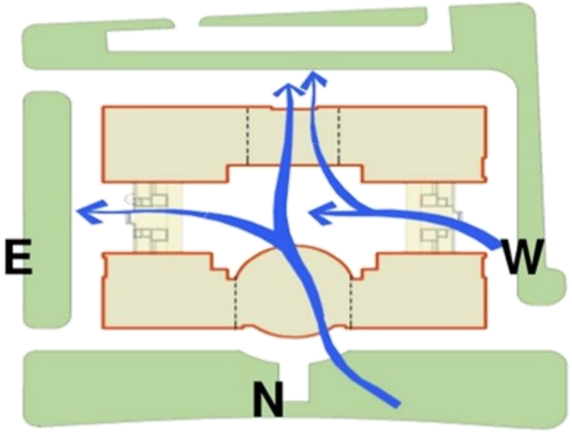
Source: BEEP

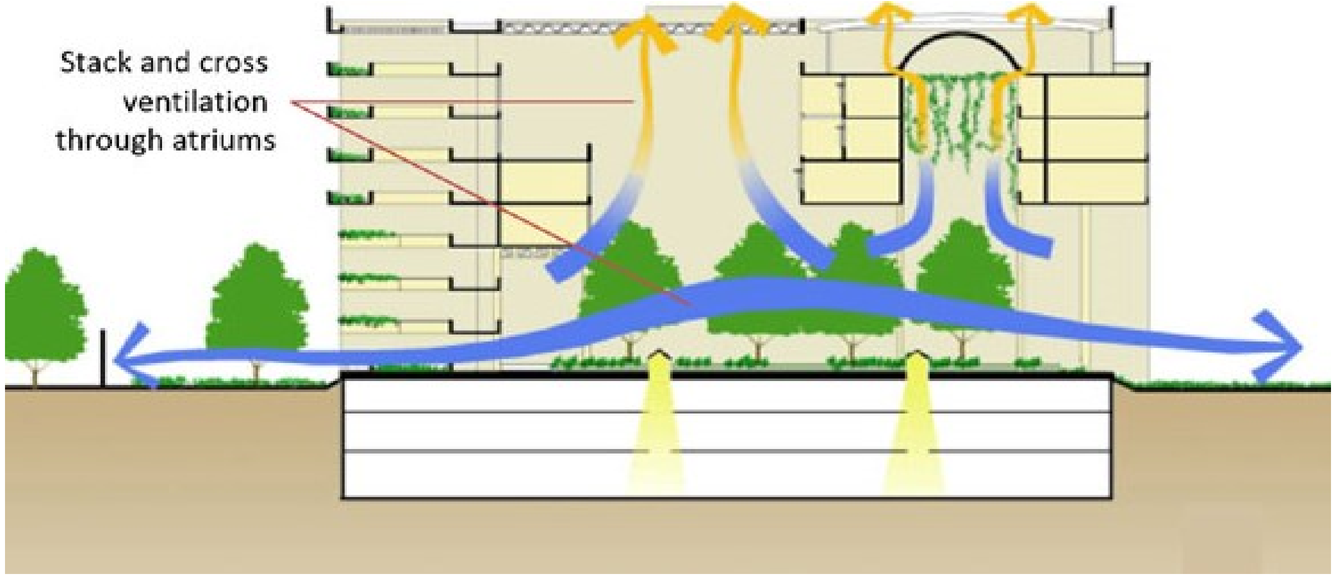
Indira Paryavaran Bhavan, Delhi

- Institutional complex in Chandigarh designed to harness natural light and ventilation

<u>Key Features</u>

- Building is north south oriented, with separate blocks connected through corridors and a huge central courtyard.
- Stack ventilation used to promote internal air circulation.
- Jaalis and windows used extensively to further boost air flow.
- Soft paving features incorporated to allow groundwater seepage.
- Solar panels placed over the roof to offset need to draw power from grid.





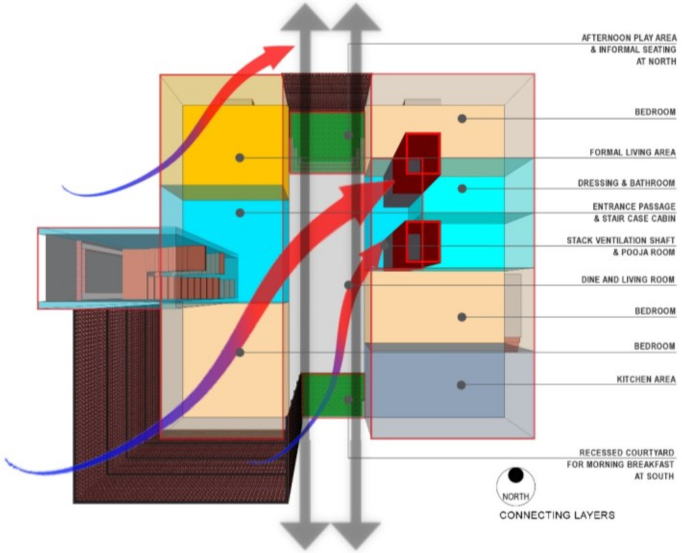
Source: CPWD

Ram Baugh, Burhanpur

- A residence which has been designed to remain cool without the use of an air conditioner.

<u>Key Features</u>

- Design relies on mutual shading and optimal building orientation.



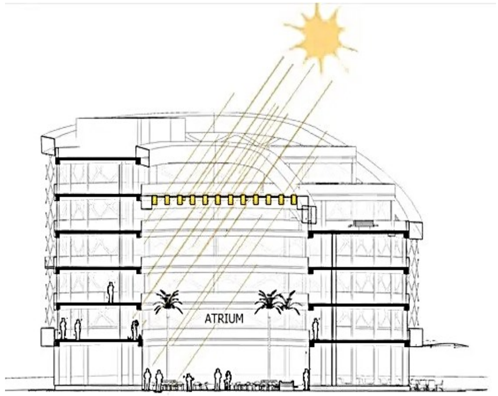
Source: Parekh Collaborative

Times Square Mall, Naya Raipur

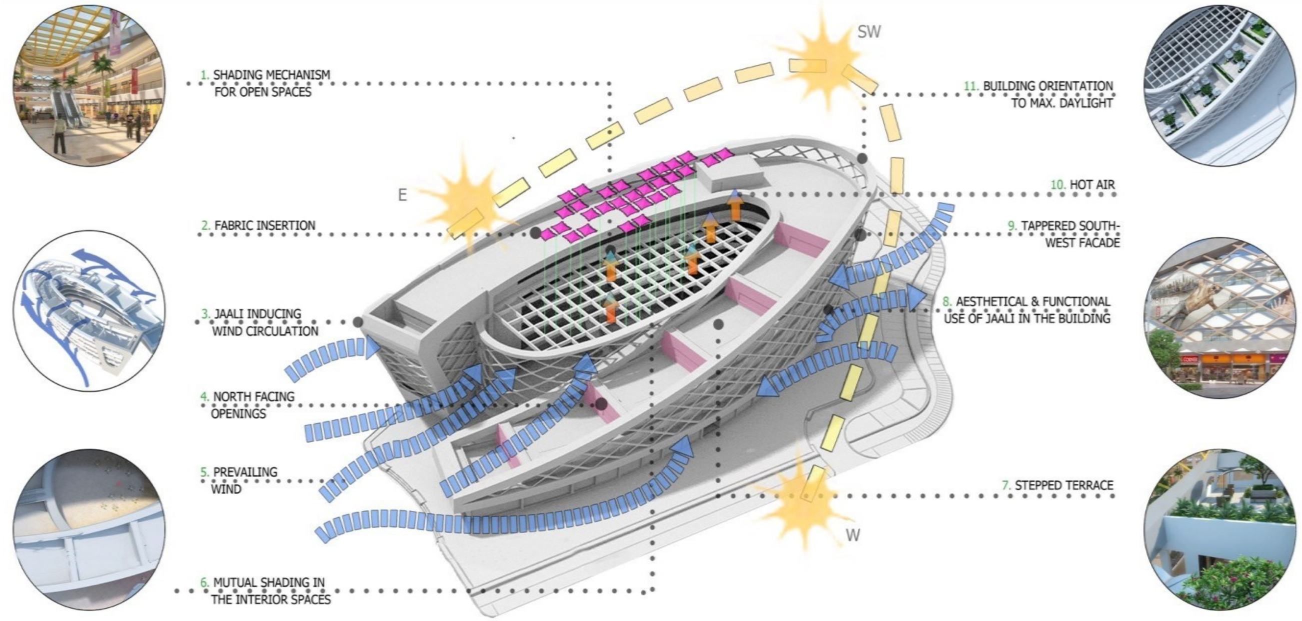
- A shopping mall that does not require air conditioning.

<u>Key Features</u>

- Building form and direction oriented toward maximal daylight and natural ventilation harnessing.
- Inner court acts as a vertical stack. It is also capped with a pergola that can be covered / uncovered with cloth to control daylighting of interior areas.
- External façade is enveloped in a large screen that aids lighting control, ventilation, and provides heating/cooling advantages.



BUILDING INTERNAL AIR CIRCULATION



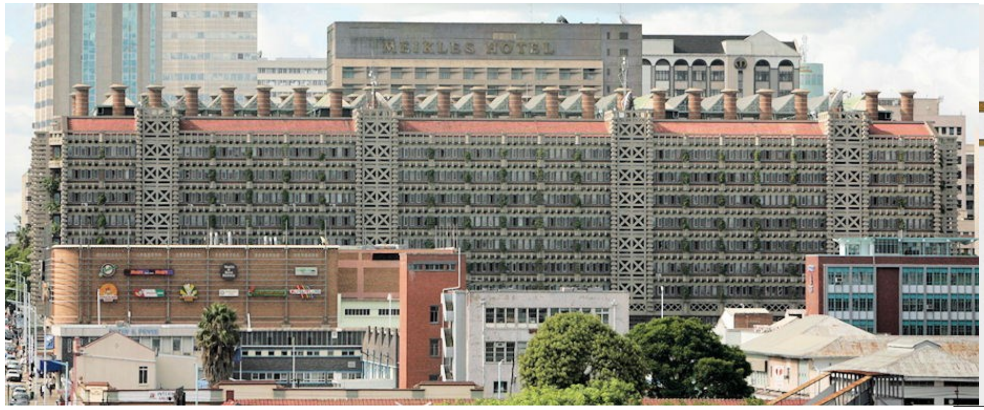
Source: Architecture Live

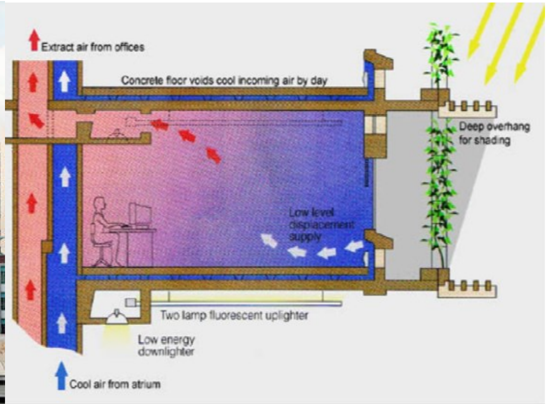
Eastgate Centre, Zimbabwe, Harare

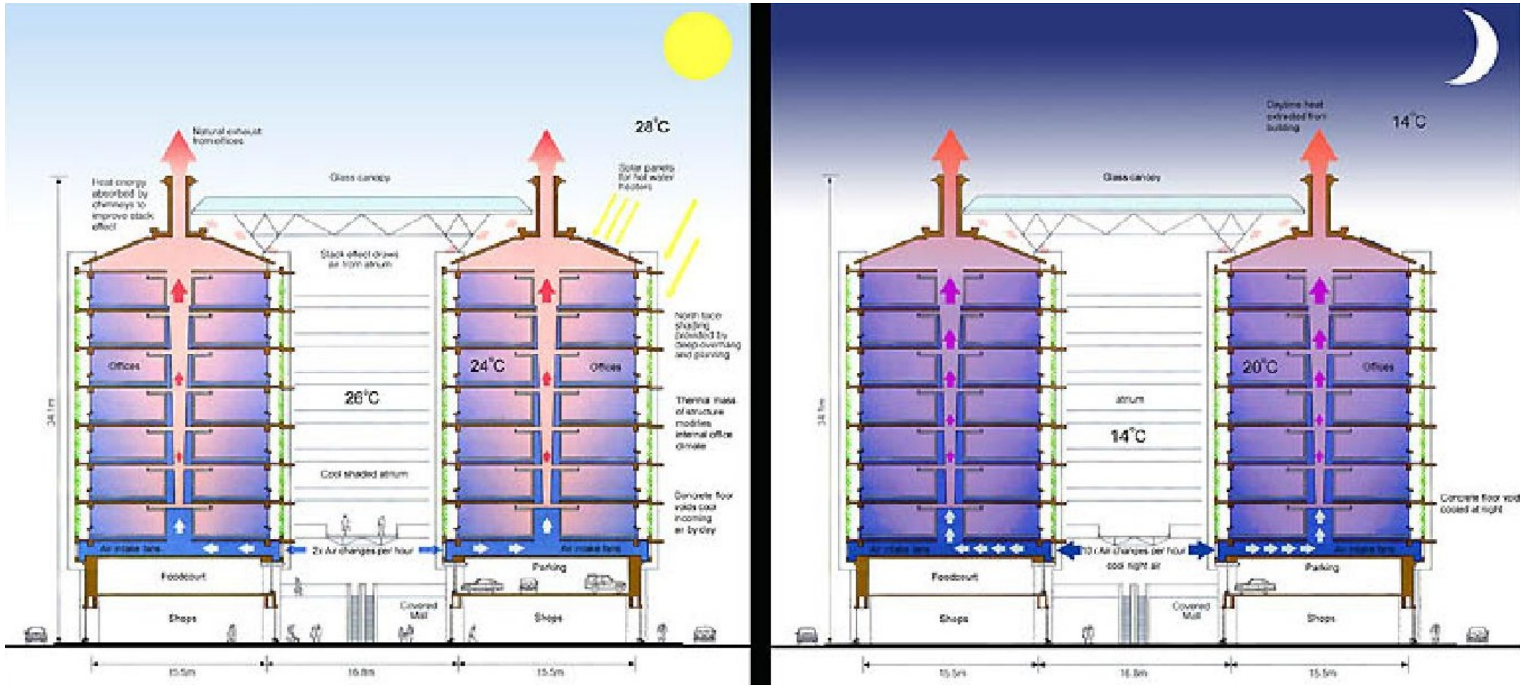
- Commercial complex that does not need any air conditioning.
- Design draws inspiration from termite mounds and local masonry skills.

Key Features

- Extensive use of ventilation stacks to promote optimal temperatures in interior spaces.
- Incorporates a series of vents to promote and regulate optimal air flow.
- External façade has a masonry screen that provides optimal shading and has a cooling effect on air flow.







Source: Mick Pearce Architecture

Key Takeaways

Learnings

- Mainstreaming passive strategies in buildings for thermal comfort can significantly reduce cooling, ventilation and lighting requirements in buildings;
- Lesser dependency on mechanical cooling/ heating approaches will decrease formation of surface ozone, hence better air quality.
- Greater awareness of the benefits of sustainable building design will spur greater demand from all strata of society
- Sensitivity in building practices will tend to decrease disparity in thermal comfort of different economic classes.
- **Make active strategies passive, and passive strategies active.**
- **70% of the buildings required in India by 2030 are yet to be built. Maintaining status quo is irrelevant, and there is a great opportunity for incorporating passive design strategies successfully across our built environment.**

Source: McKinsey

Module Anchor

Akanksha Gupta

Project Coordinator

Prayash Giria
Senior Project Associate – Urban Development, WRI India
✉ Prayash.Giria@wri.org

Project Director

Rejeet Mathews
Director – Urban Development, WRI India
✉ RMathews@wri.org

Thank you.