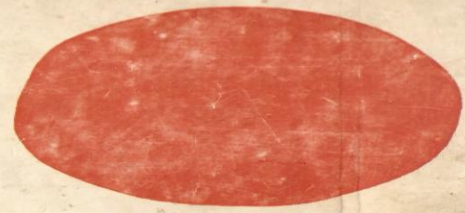


# THE RADIANT CITY

THE ORION PRESS

soleil



espace

verdure



## *Greening buildings: sustainable approach*

**Jit Kumar Gupta**

**Former Director, College of Architecture IET Bhaddal**

**jit.kumar1944@gmail.com**



- ***Context of Building In Human Living***

# **Buildings- Context, Role and Importance**

- **Buildings-- integral part of human history, growth, development**
- **Buildings --continue to define future journey of human growth**
- **Buildings-- manmade environment**
- **Buildings-- vital for human growth**
- **Buildings – are living organism**
- **Buildings – are structures catering to all human activities**
- **Buildings --valuable - 80% human life spent in buildings**
- **Buildings- full of dualities and contradictions**
- **Buildings -- largest consumers of energy**
- **Buildings - largest consumers of resources**
- **Buildings – largest generators of waste**
- **Buildings- largest polluter of environment /ecology**
- **Buildings --- responsible for largest carbon footprints**
- **Buildings -- responsible for global warming**
- **Buildings -- major determinant of global sustainability**



# **Buildings-Context, Role and Importance**

- **Buildings– provide optimum/worst living conditions**
- **Buildings -- make people healthy/sick**
- **Buildings -- vital to overcome human/ ecological concerns, global warming, reducing carbon footprints**
- **Making Buildings Sustainable-- essential to make value addition to -- resources, environment ,ecology**
- **Researches made/Studies carried out revealed —**
- **Green/sustainable buildings-- create win-win situation for owners, occupants & users**
  - A Green School-makes learning easy & more meaningful**
  - A Green House--makes people happy, healthy, productive**
  - **A Green Hospital-- cures patients quickly**
  - **A Green Shopping Mall-- increases sale / profits**



# Buildings- Built Environment

- Operational domain of Architects /Engineers revolves around:
  - -- Siting,
  - -- designing,
  - --construction,
  - --operation,
  - -- maintenance
  - --Demolition and
  - -Reconstruction
  - -creating state of art built environment.
  - Professionals-- have critical role/ responsibility to;--make value addition to resources ,environment ,ecology-- by creating sustainable built environment.
- Considering implications of Buildings-- resources, environment / ecology -- Going green-- a necessity – for sustainable tomorrow
- -Each building unique--requires different options for greening





***Buildings  
Population &  
Resources***



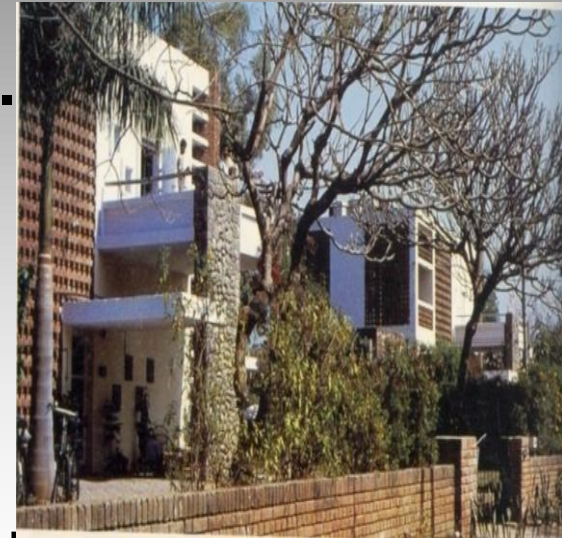
# Population Scenario- India-2011

- Population of India reached
- 1210 million in 2011
- 1420 million in 2023- to become most populated country – relegating China to p 2<sup>nd</sup> position-
- 2050- Indian population- 1600 mil.
- -- 50% in Urban India.
- During last 100 years, India witnessed—1911-2011
  - Urbanization level going up by 3 times
  - Urban settlements growing merely 4 times
  - Total Population multiplying 5 times
  - Urban population increasing 15 times
  - Rural population increasing 3.5 times
- Increased population requires;
  - More cities,
  - More housing,
  - More educational/ healthcare/ institutions
  - more Buildings– more built space to be added
- India needs 700-900msmt. Of built space annually



# **BUILDINGS --AS CONSUMERS OF RESOURCES**

- **Built environment– significantly impact environment /consumption of resources/generators of waste/climate change/rising temperature:**
  - **16% of world's fresh water withdrawal.**
  - **25% of wood harvested.**
  - **30% of consumption of raw material.**
  - **50% of global energy consumption.**
  - **35% of world's CO2 emission**
  - **40% of Municipal solid waste.**
  - **50% of Ozone depleting CFC's still in use.**
  - **30% of residents having sick building syndrome**
- **--70% of global warming outcome of ;**
- **--built environment & transportation**
- Majority of existing buildings--- low concern for energy conservation**



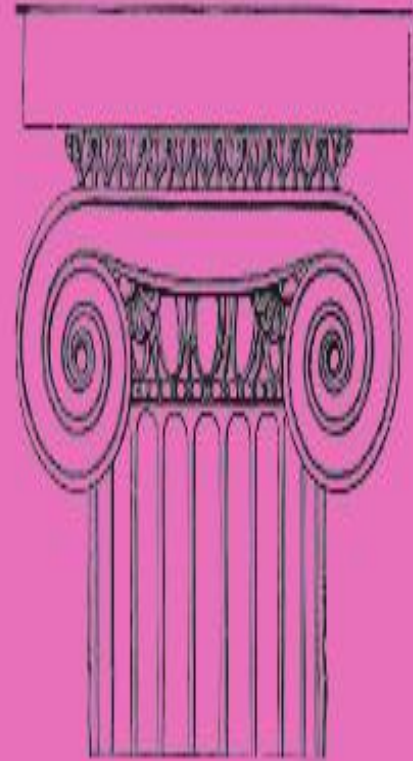


- ***Changing  
Context  
Buildings***



# Vitruvius-Three Pillars of Architecture

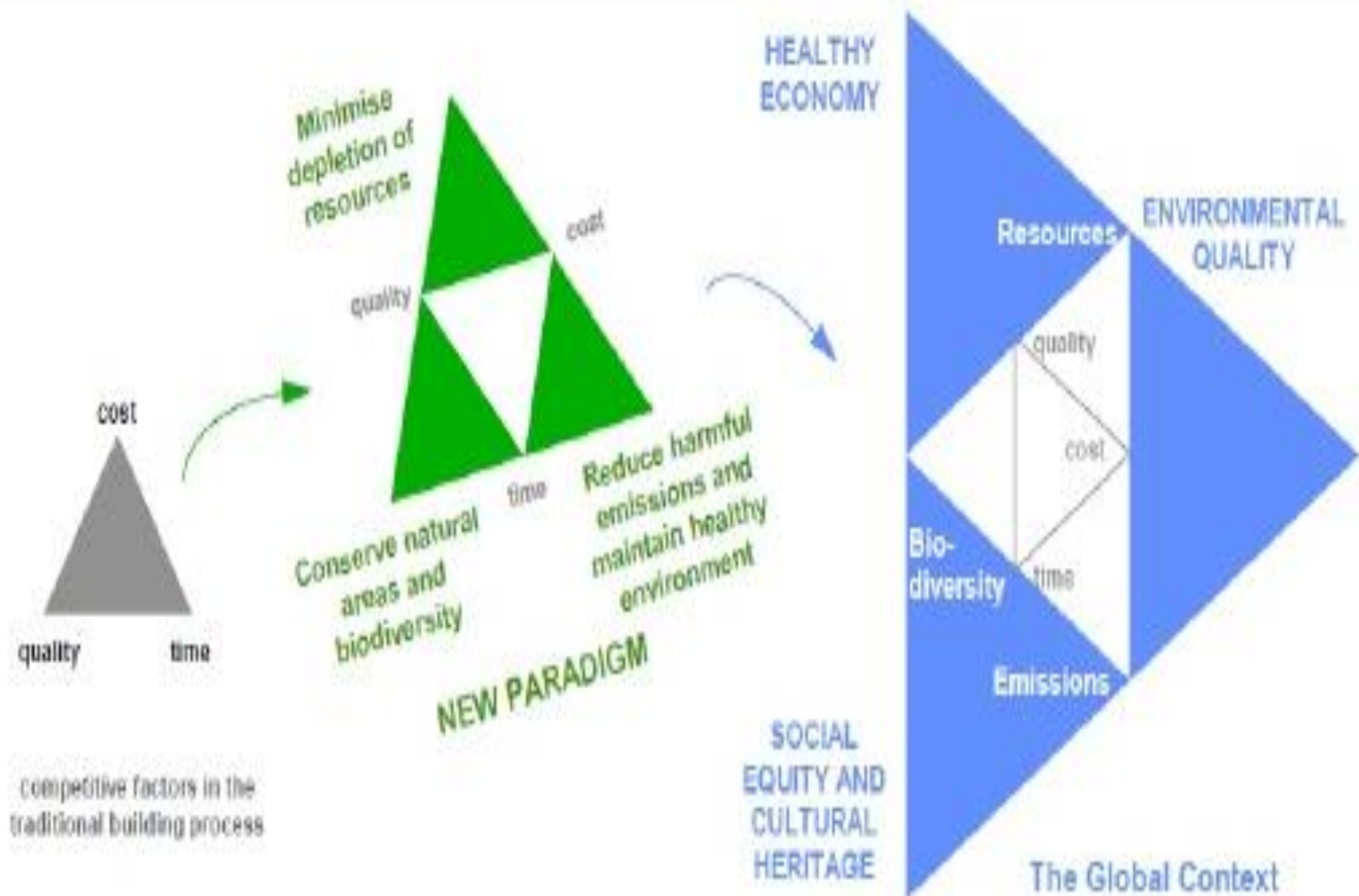
*Firmitas - Durable*



*Utilitas - Useful*

*Venustas - Beautiful*

# Changing construction perceptions



# Implications of Built Environment

| Aspects of Built Environment                                                                                                                                                             | Consumption                                                                                                              | Environmental Effects                                                                                                                                                                                   | Ultimate Effects                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Siting</li><li>• Design</li><li>• Construction</li><li>• Operation</li><li>• Maintenance</li><li>• Renovation</li><li>• Deconstruction</li></ul> | <ul style="list-style-type: none"><li>• Energy</li><li>• Water</li><li>• Materials</li><li>• Natural Resources</li></ul> | <ul style="list-style-type: none"><li>• Waste</li><li>• Air pollution</li><li>• Water pollution</li><li>• Indoor pollution</li><li>• Heat islands</li><li>• Stormwater runoff</li><li>• Noise</li></ul> | <ul style="list-style-type: none"><li>• Harm to Human Health</li><li>• Environment Degradation</li><li>• Loss of Resources</li></ul> |

- ***Green Buildings-***
- ***Need , Definition & Advantages***

# ***SDG 11- Make cities / human settlements- inclusive ,safe, resilient and sustainable***

**1** NO POVERTY



**2** ZERO HUNGER



**3** GOOD HEALTH AND WELL-BEING



**4** QUALITY EDUCATION



**5** GENDER EQUALITY



**6** CLEAN WATER AND SANITATION



**7** AFFORDABLE AND CLEAN ENERGY



**8** DECENT WORK AND ECONOMIC GROWTH



**9** INDUSTRY, INNOVATION AND INFRASTRUCTURE



**10** REDUCED INEQUALITIES



**11** SUSTAINABLE CITIES AND COMMUNITIES



**12** RESPONSIBLE CONSUMPTION AND PRODUCTION



**13** CLIMATE ACTION



**14** LIFE BELOW WATER



**15** LIFE ON LAND



**16** PEACE AND JUSTICE  
STRONG INSTITUTIONS



**17** PARTNERSHIPS FOR THE GOALS



**THE GLOBAL GOALS**  
For Sustainable Development



# Defining Green Building- WGBC

- *'Green' building is a building that;*
  - *- in its design, construction / operation,*
  - *- reduces / eliminates*
  - *– negative impacts, and*
  - *– creates positive impacts*
  - *– on our climate /natural environment.*
  - **WGBC committed -- achieving following goals by 2050:**
  - **- limiting global temperature rises to 2 degrees Celsius;**
  - **- reducing building /construction sector's  $\text{CO}_2$  emissions by 84 gigatons ;**
  - **-- ensuring all buildings made *net zero* emissions.**
  - **-- ensuring buildings /construction sector fulfill ambition of *Paris Agreement*.**
- 

# Defining- Green Buildings

## DEFINITION:

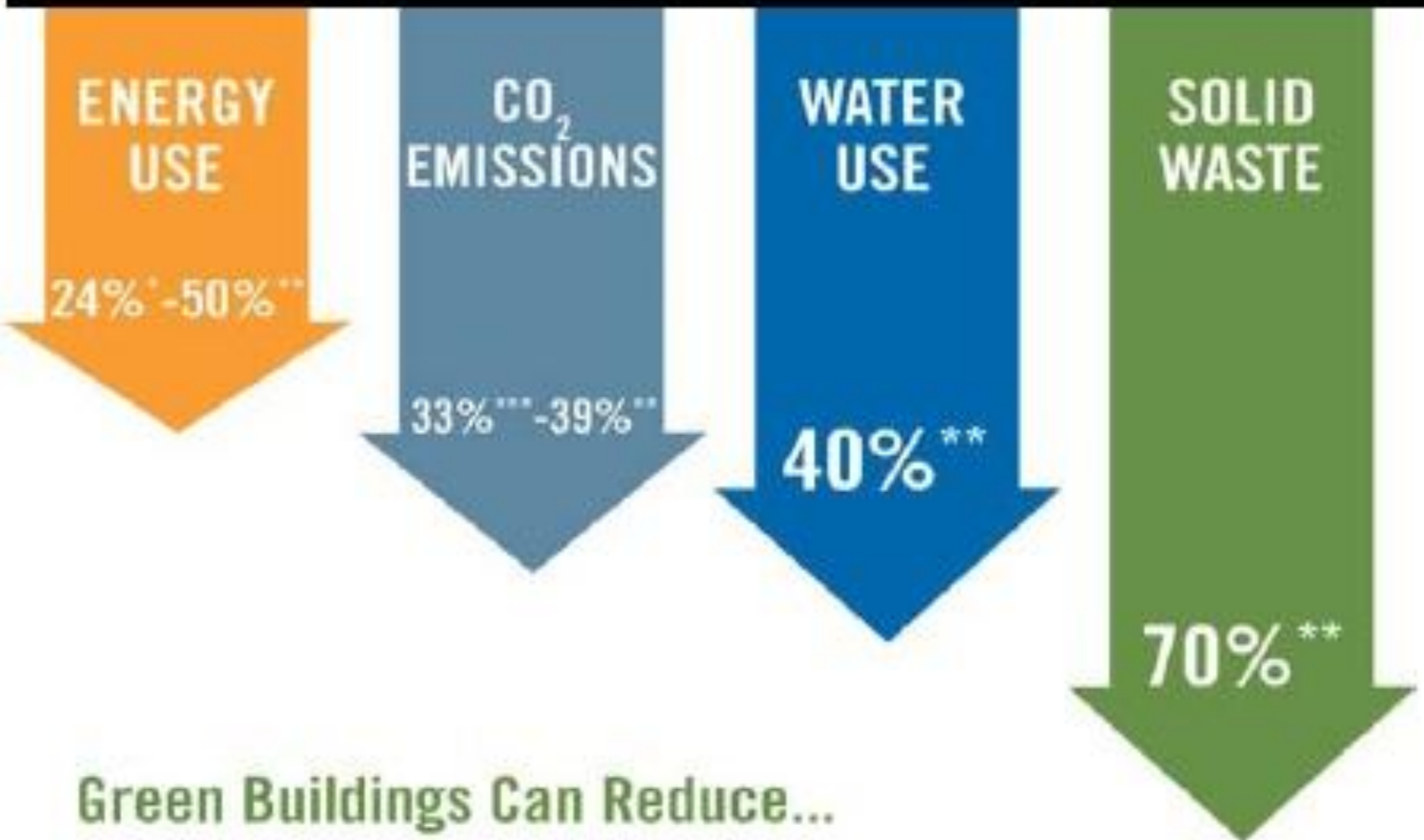
- "A green building is one which uses less water, optimises energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building."



# ***Green Building- Characteristics***

- ***Energy focused-efficiency in energy- Instead of Consuming Enrgy Buildings to produces Energy***
- ***Water focused—conservation of water***
- ***Resource focused—efficiency in using Resources***
- ***Material-focused -Using materials that minimize environmental impact .***
- ***Sustainability focused- Designing buildings Using Construction processes -- environmentally sustainable.***
- ***Designed Focused- minimizes impact on environment.***
- ***Indoor air quality focused- Provide best possible indoor air quality***
- ***Human focused- promote good health for users***
- ***Site Focused- Causing minimum site disturbance***
- ***Durability focused- Remains durable.***
- ***Land Focused-- Remains Compact-saves/conserves land***

# Advantages of Green Buildings



\* Turner, C. & Fraebel, M. (2008). Energy performance of LEED for New Construction buildings. Final report.

\*\* Kats, G. (2003). The Costs and Financial Benefits of Green Building: A Report to California's Sustainable Building Task Force.

\*\*\* GSA Public Buildings Service (2008). Assessing green building performance: A post occupancy evaluation of 12 GSA buildings.

# Tangible Benefits

- Reduce operating costs
- Optimize life cycle economic performance
  - Sustained savings



HPCL-Admin Building, Vizag

- ❖ **Energy savings: up to 50 %**
- ❖ **Water savings: up to 40 %**



# In-tangible Benefits of Green Design

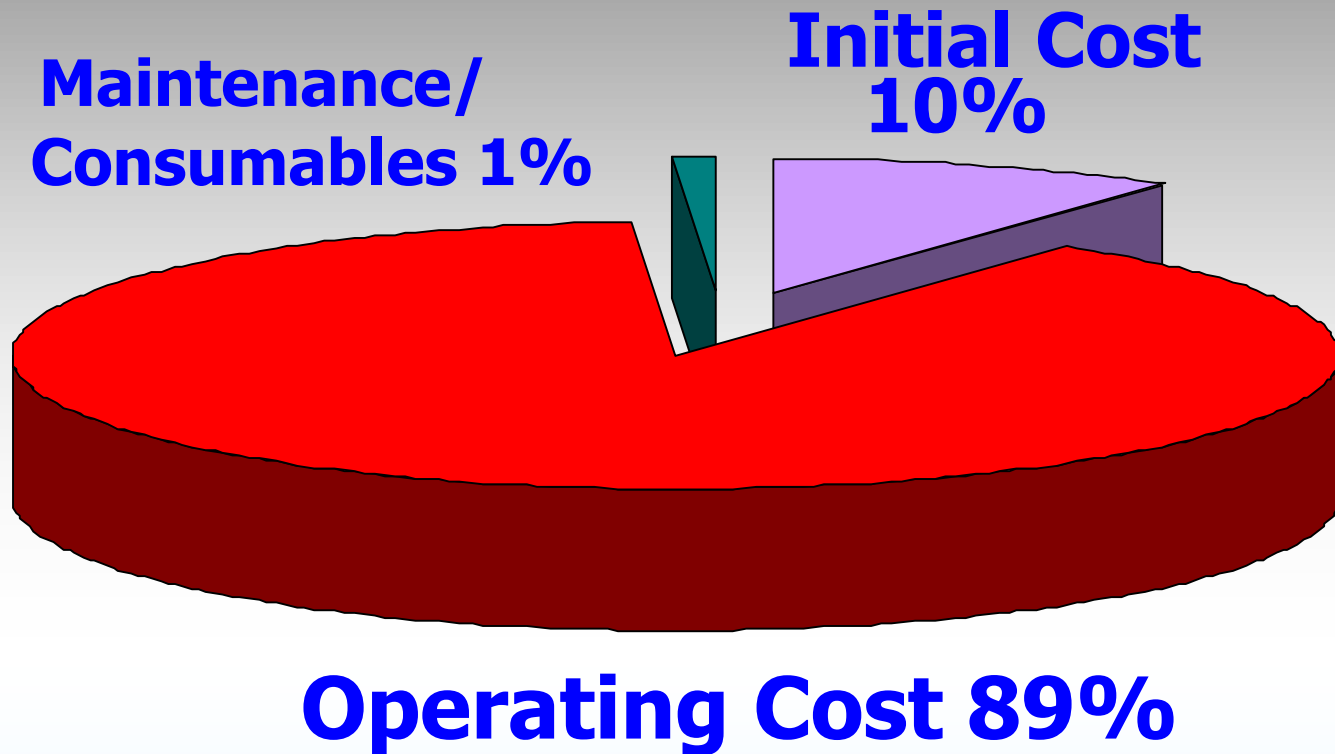
- **Environmental benefits**
  - Reduce impact on environment
- **Health and Safety benefits**
  - Enhance occupant comfort
- **Improve Productivity of occupants**



# ADVANTAGES OF GREEN BUILDINGS

- *i. Green Buildings help in :*
- ii. saving in energy consumption—up to 50%
- iii. saving in water consumption- up to 40%
- iv. Reduction in carbon emission -- 35%
- v Reduction of -- 8000-12000 Tons Co<sub>2</sub> / million Sq. ft. of built space
- vi Saving -- 3 MW in connected electric load / million Sq ft built space
- vii Reduction of- 70% waste to facilitate easy handling
- viii Reduced load- on municipal water handling plants
- ix Enhance brand image--attracting national / international companies
- x Better returns-- due to higher rents
- ***Benefits to State :***
- Reduction of electric demand– Reduced production capacity- saving 21000- 27000 MW for new construction to be added
- Reduction in solid waste- less waste to be carried/dumped
- Reduction in water requirement - using less water /less waste /smaller network –supply/waste- lower development/operational cost
- --Financial benefits, Environmental benefits, Social benefits

# Green Buildings- life cycle costs



# What constitutes -- Cost of Building

- *Initial cost (short term)& Life-cycle cost (long term)*
- *Life Cycle Cost of building depends upon:*
  - I Cost of land
  - ii Cost of construction- Initial cost
  - iii Cost of maintenance and
  - iv Cost of parts replacement cost
  - v. Disposal cost or salvage value, and
  - vi Useful life of system or building
- Building cost viewed --in both -- short term & long term
- Building cost also evaluated -- Initial Cost & Life Time Cost
- Short Time Cost includes-- Initial Cost of Construction of building
- Long Term Cost component --- whole life cost.
- -- To promote economy in building– Life cycle cost of building will be critical



# Cost of Green Buildings-Indian Experience

| Building                                    | Year awarded | Built-in Area (sq.ft) | Rating Achieved | % Increase in cost | Payback (Yrs) |
|---------------------------------------------|--------------|-----------------------|-----------------|--------------------|---------------|
| CII-Godrej GBC, Hyderabad                   | 2003         | 20,000                | Platinum        | 18 %               | 7 years       |
| ITC Green Centre, Gurgaon                   | 2004         | 1,70,000              | Platinum        | 15 %               | 6 years       |
| Wipro, Gurgaon                              | 2005         | 1,75,000              | Platinum        | 8 %                | 5 years       |
| Technopolis, Kolkata                        | 2006         | 72,000                | Gold            | 6%                 | 3 years       |
| Spectral Services Consultants Office, Noida | 2007         | 15,000                | Platinum        | 8%                 | 4 years       |
| Kalpataru Square                            | 2008         | 3,00,000              | Platinum        | 2%                 | 2 years       |
| Suzlon One Earth, Pune                      | 2010         | 8,00,000              | Platinum        | 2%                 | 2 years       |

- ❖ **Cost showing a decreasing trend over the years**
- ❖ **Incremental Cost lower-- if base design has already factored normal Green features**



# ***Traditional Buildings***

- ***Vs***
- ***Green Buildings***



# Traditional Buildings Vs Green Buildings

- TB- Limited involvement of project members- limited to their trade & specialization
- *GB- Project members involved right from beginning to help design/ planning process*
- TB- Project gets more intensive as it progresses- Less time spent in beginning
- *GB-Project starts intensively--- with more time spent in meetings/discussions*
- TB– Decisions made by few stakeholders- owners, architect, contractor
- *GB—Decisions made by team--- based on research, discussions, brainstorming sessions*



# Designing Traditional Buildings Vs Green Buildings

- TB- involves adoption of linear approach
- ***GB— adopt Integrated approach***
- TB-Focus to reduce -upfront capital cost
- ***GB- Reduces- long term O&M costs***
- TB—Systems considered in isolation --leading often to over-designing/over-sizing
- ***GB- Building performance assess impact of each system individually/collectively to create optimum design***
- TB- Project members undertake limited responsibilities
- ***GB-Members share equal responsibilities /work jointly***
- TB-Linear process ends when project is completed
- ***GB- Evaluating performance of buildings/user's satisfaction through post- evaluation surveys /energy audit***





- ***Designing Green Buildings***

# Designing Green Buildings

## i **Decision to Build Green - taken initially in design process for:**

- --Maximizing green potential
- --Minimizing re-design
- --Assured overall success and
- --Achieving economic viability of Green Building Project

## ii. **Setting Green Goals/ Objectives for:**

- -Energy Efficiency
- --Water consumption
- --On site treatment of rain/storm water
- --Material/ Resource management
- --Construction waste Management

## iii. **Building a Green Team-**

- --Hiring a design team of-- Architect, Engineers, Consultants with expertise, knowledge, experience, understanding of Green Concept

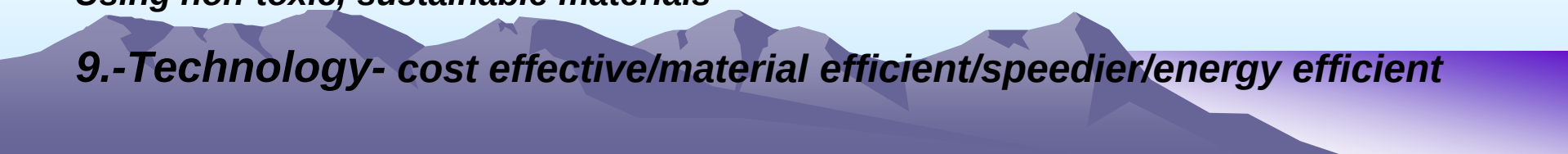
## Iv **Adopting an Integrated Approach to Design-**

## v **Key Principles /Strategies-**

- i Sustainable built environment,
- li Water/waste management ,
- lii Energy Management,
- Iv Material/ Resource Management and
- V Indoor air Quality



# Designing Green Buildings

- **1. Adopting integrated approach to building design**
  - **2. Design based on Climate**
  - **Macro Climate – Regional climate; Meso Climate– local climate**
  - **Micro Climate--Site climate -- based on site characteristics,**
  - **3. Orientation -- to optimize light , heat gain/ heat loss**
  - **4. Sun movement-- to maximizes use of free solar energy for heating /lighting**
  - **5.Wind direction---using air movement for ventilation/ cooling**
  - **6. Planning of Building-- optimize site, size, shape, planning spaces, allocating uses, placing rooms, circulation, promoting building efficiency, promoting natural sunlight, air / ventilation**
  - **7.Designing Building Envelop--- Mass – space relationships/ solids/voids, positioning –openings/projections, shading devices, height, shape of building, natural lighting and ventilations etc**
  - **8. Materials- low embodied energy; locally ; natural form, lightweight; materials-- Using non-toxic, sustainable materials**
  - **9.-Technology- cost effective/material efficient/speedier/energy efficient**
- 

# Designing Green Buildings

- 10. **Indoor Air Quality** - Creating optimum living conditions for occupants
- 11. **Nature** -- making best use of nature; natural resources ; sun/wind energy
- 12. **Site** - Optimizing use of site potential
- 13 **Loads** -- Minimising self/structural – live load
- 14 **Energy** -- Generating on-site renewable energy.
- 15 **Planning** -- with energy as focus,
- 16 **Water** -- Minimizing water consumption
- 17 **Environment** - Preserving/promoting environment in design, construction and operation
- 18 **Quality of life** -- occupants in design, construction operation
- 19 **Reuse/ Recycling** -- Promoting re-use and recycling

**Green Building practices expands/ complements**

- economy,
- utility,
- durability,
- comfort.



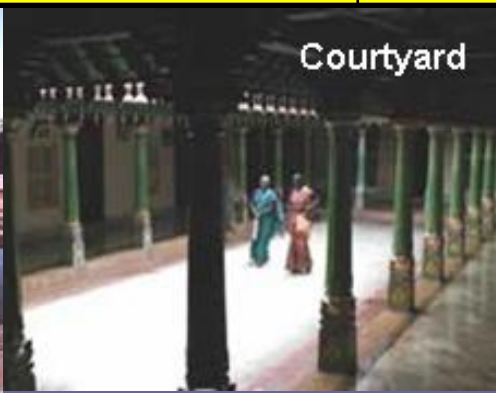
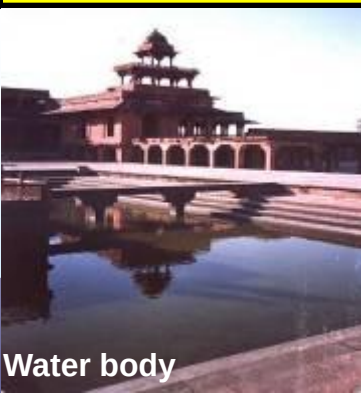
# Integrated Approach: **Green Buildings**



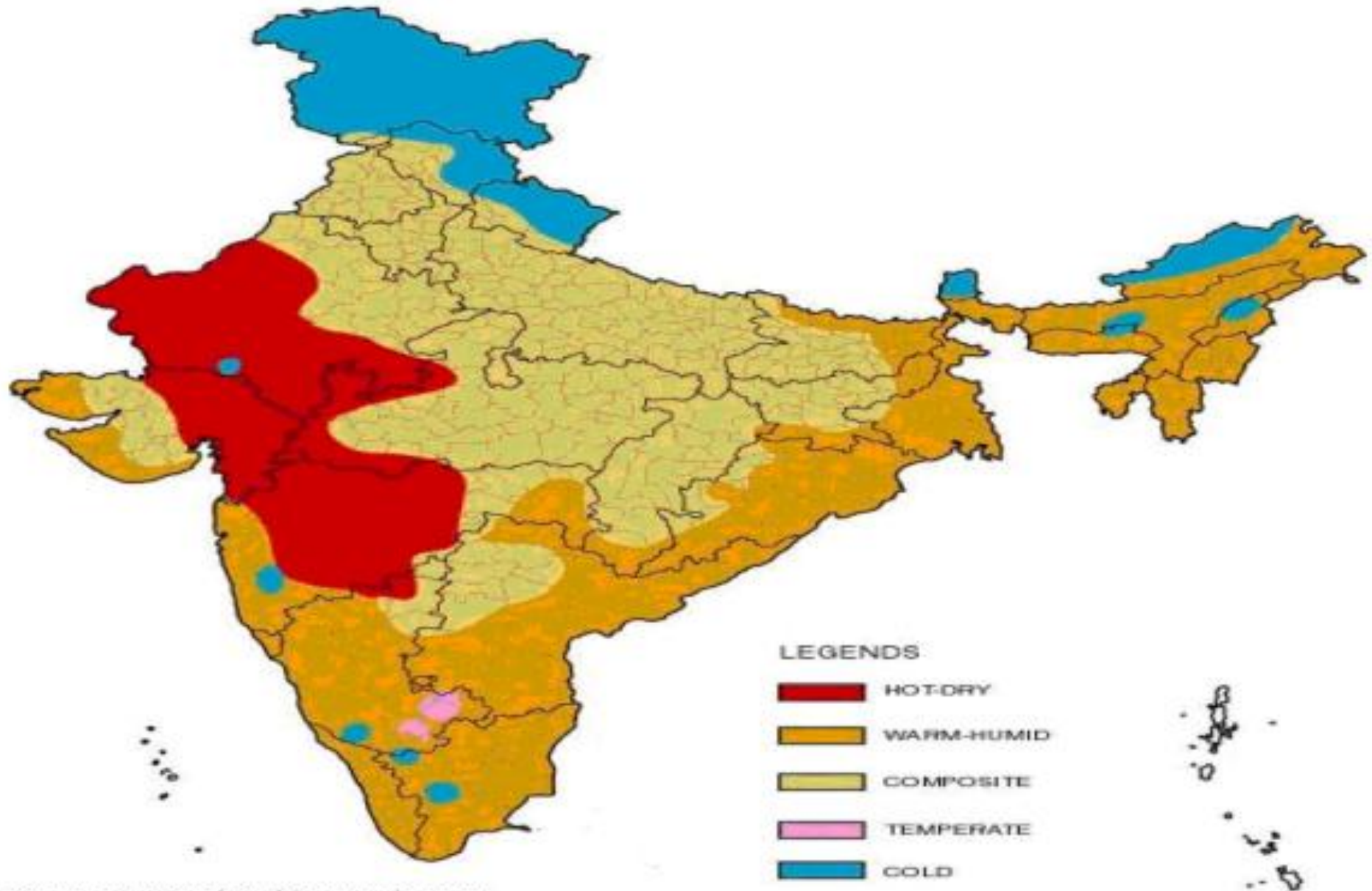
# Indian Way of approaching design

- Rediscovery Indian ethos- Making optimum use of 5 elements of Nature (Panchabhutas)

|                        |                                     |
|------------------------|-------------------------------------|
| <b>Prithvi (Earth)</b> | <b>Sustainable Sites</b>            |
| <b>Jal (Water)</b>     | <b>Water Efficiency</b>             |
| <b>Agni (Energy)</b>   | <b>Energy Efficiency</b>            |
| <b>Vayu (Air)</b>      | <b>Indoor Environmental Quality</b> |
| <b>Akash (Sky)</b>     | <b>Daylight</b>                     |



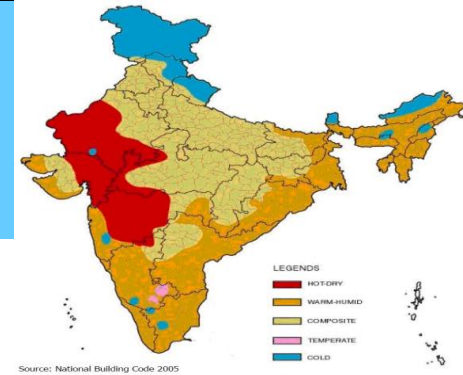
# 5 CLIMATIC ZONES IN INDIA



Source: National Building Code 2005



# CLIMATIC ZONES AND THEIR CHARACTERISTICS

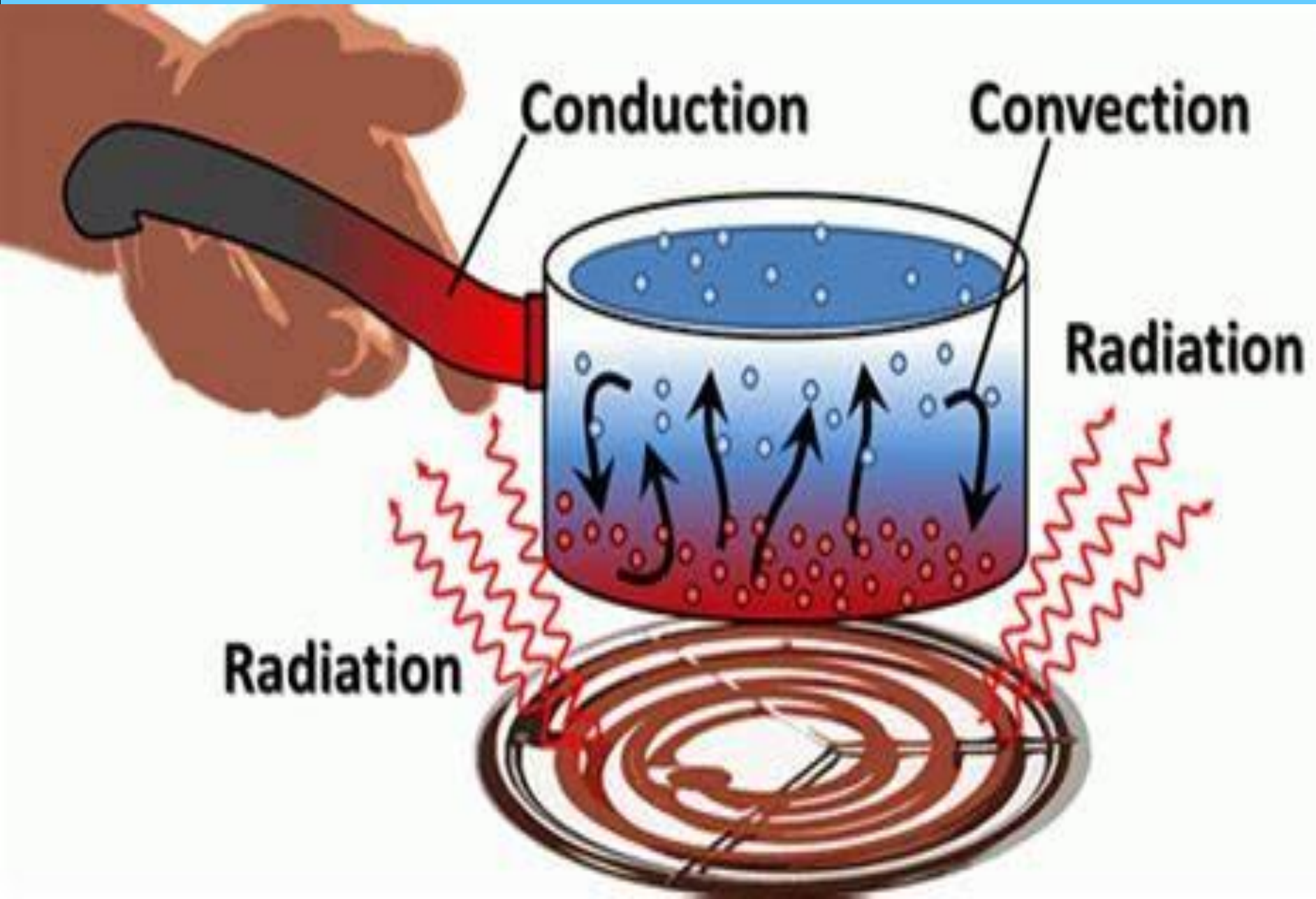


**Table 2.1 Classification of Climates**

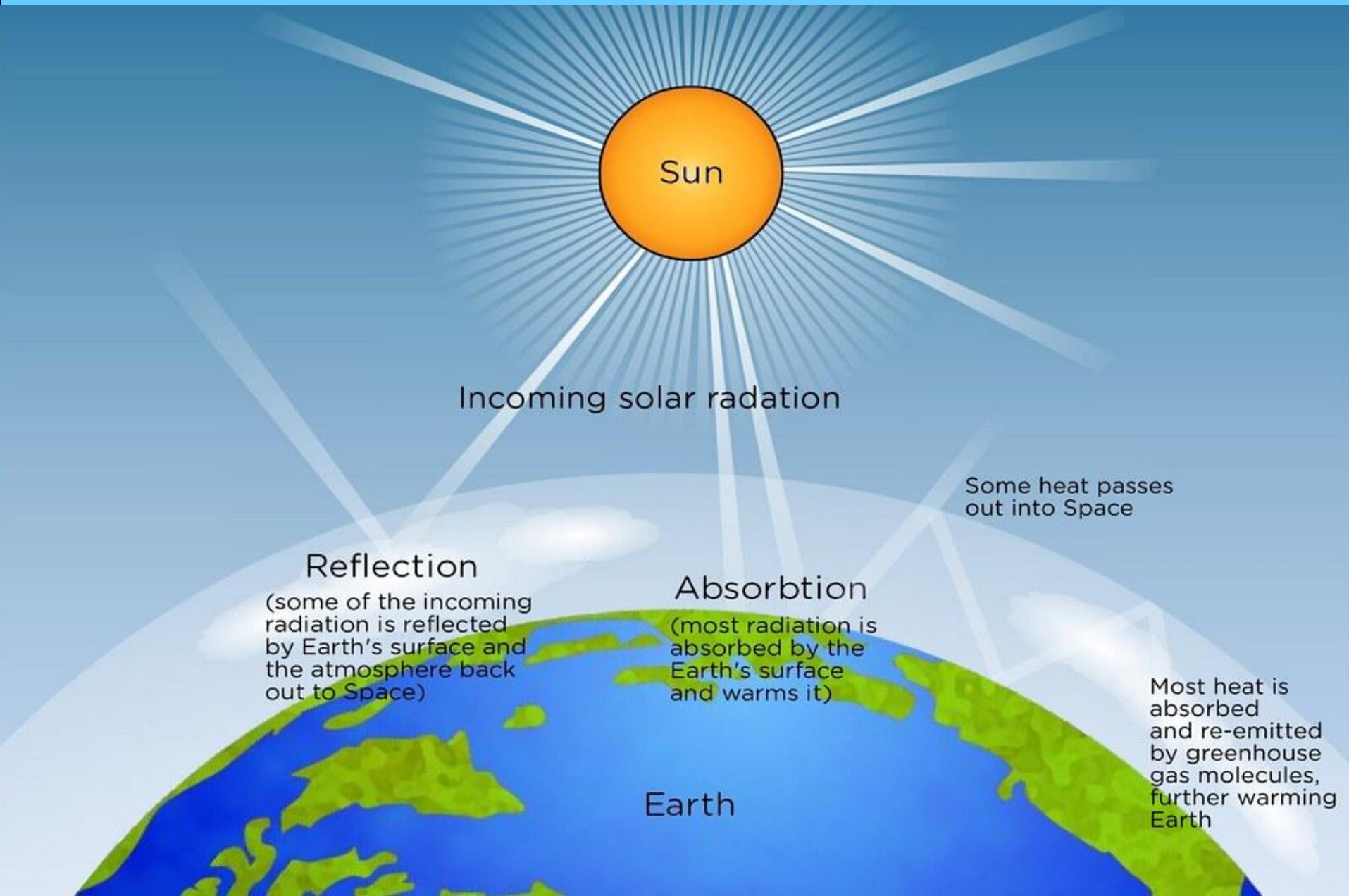
| Criteria of Bansal et al. [1] |                                                                                      |                       | Criteria of SP 7: 2005 [9] |                                                                                      |                       |
|-------------------------------|--------------------------------------------------------------------------------------|-----------------------|----------------------------|--------------------------------------------------------------------------------------|-----------------------|
| Climate                       | Mean monthly temperature (°C)                                                        | Relative humidity (%) | Climate                    | Mean monthly maximum temperature(°C)                                                 | Relative humidity (%) |
| Hot and dry                   | >30                                                                                  | <55                   | Hot and dry                | >30                                                                                  | <55                   |
| Warm and humid                | >30                                                                                  | >55                   | Warm and humid             | >30<br>>25                                                                           | >55<br>>75            |
| Moderate                      | 25-30                                                                                | <75                   | Temperate                  | 25-30                                                                                | <75                   |
| Cold and cloudy               | <25                                                                                  | >55                   | Cold                       | <25                                                                                  | All values            |
| Cold and sunny                | <25                                                                                  | <55                   |                            |                                                                                      |                       |
| Composite                     | This applies, when six months or more do not fall within any of the above categories |                       | Composite                  | This applies, when six months or more do not fall within any of the above categories |                       |



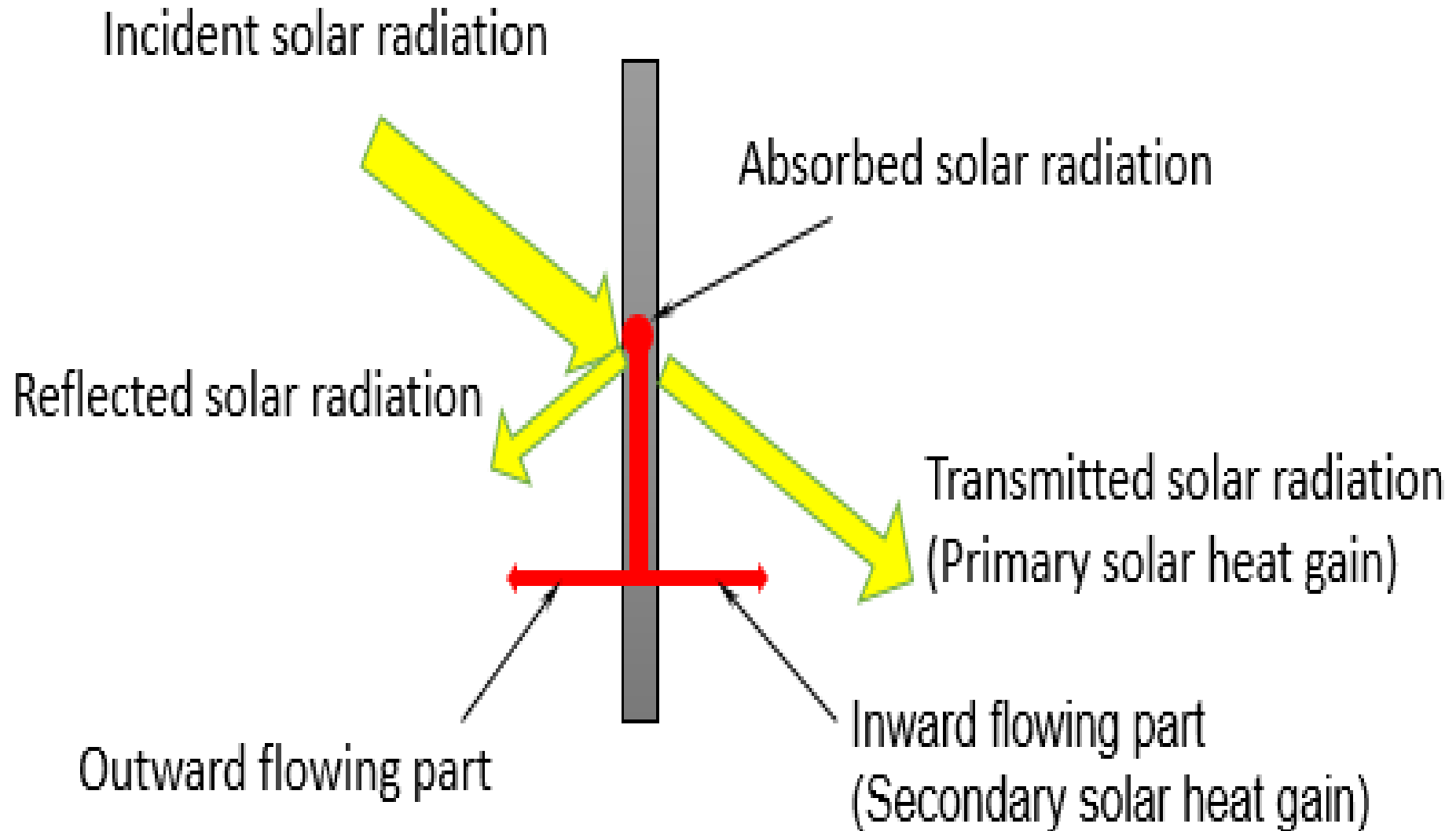
# Heat Transfer



# Heat Transfer by SUN

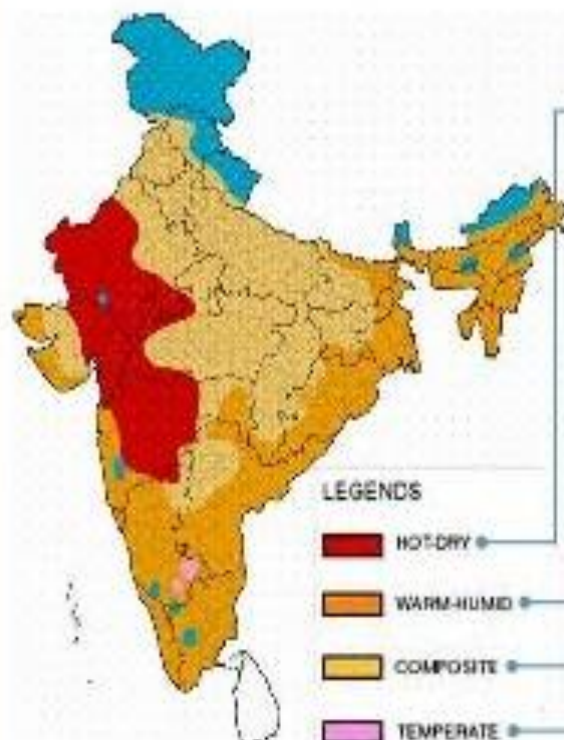


# Heat Transfer in Buildings





# Climate Zones in India



## LEGENDS

- HOT-DRY
- WARM-HUMID
- COMPOSITE
- TEMPERATE
- COLD

High temperature • Low humidity and rainfall • Intense solar radiation and a generally clear sky • Hot winds during the day and cool winds at night

Temperature is moderately high during day and night • Very high humidity and rainfall • Diffused solar radiation if cloud cover is high and intense if sky is clear • Calm to very high winds from prevailing wind directions

This applies when 6 months or more do not fall within any of the other categories • High temperature in summer and cold in winter • Low humidity in summer and high in monsoons • High direct solar radiation in all seasons except monsoons high diffused radiation • Occasional hazy sky Hot winds in summer, cold winds in winter and strong wind in monsoons

Moderate temperature • Moderate humidity and rainfall • Solar radiation same throughout the year and sky is generally clear • High winds during summer depending on topography

Moderate summer temperatures and very low in winter • Low humidity in cold/sunny and high humidity in cold/cloudy • Low precipitation in cold/sunny and high in cold/cloudy • High solar radiation in cold/sunny and low in cold/cloudy • Cold winds in winter

SOURCE: Bureau of Indian Standards, National Building Code of India 2016, Part 3 Building Services, Section 3 Air Conditioning, Heating and Mechanical Ventilation; Barua, N. K. & G. Moha (2010), Climatic Zones and Rural Housing in India; Mishra, A., N. Y. Bhat & S. V. Sivakrishna (2011), Climate Responsive Architecture: A Design Handbook for Energy Efficient Buildings, Tata McGraw-Hill



**USAID** | **INDIA**  
FROM THE AMERICAN PEOPLE



# ***Integrated Design Process***

- **Five Climatic Zones In India-**

- *Hot and Dry*
- *Warm and Humid*
- *Moderate / Temperate*
- *Cold (Cloudy/Sunny)*
- *Composite*

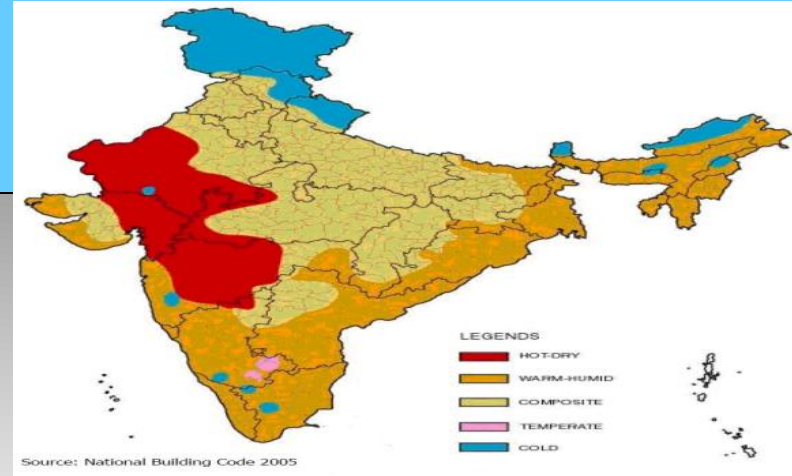
- All green buildings need not-- to be same

**All zones have specific requirements regarding:**

- light,
- heat,
- ventilation and
- thermal comfort

**Different zones require different design strategies regarding -- building envelop,**

- *--HVAC,*
- *-- Lighting ,*
- *-- Fenestration,*
- *-- Performance standards*





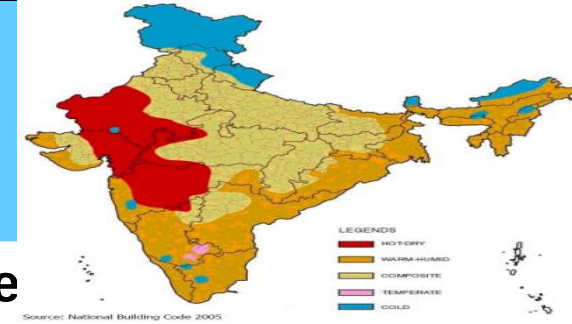
# Hot and dry climate



- ❑ This zone lies in western and central part of India, jaisalmer, jodhpur, etc.
- ❑ This region is usually flat, sandy, rocky ground with spares vegetation of cacti thorny bushes.
- ❑ Water level is very low here.
- ❑ The diurnal variation in temperature is quite high more than  $10^{\circ}\text{C}$ .

# Hot and Dry Climate Zone-

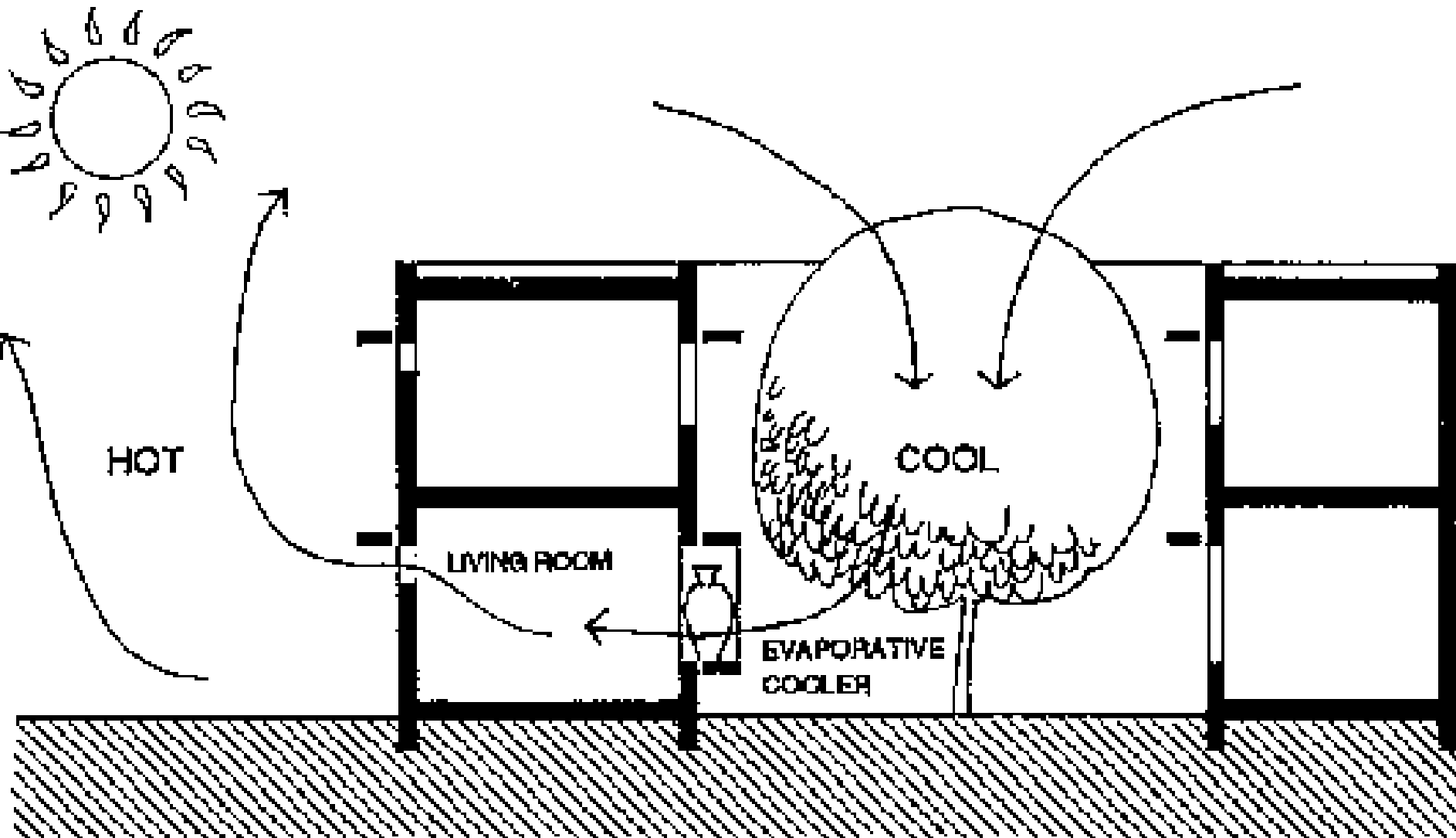
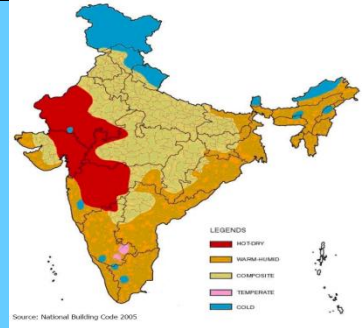
## Comfort requirements and Physical manifestations in Buildings



| Thermal Requirements                                          | Physical Manifestations                                                                                                     |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| <b>Reduce Heat Gain</b>                                       |                                                                                                                             |
| Decrease exposed surface area                                 | Orientation and shape of building                                                                                           |
| Increase thermal resistance                                   | Insulation of building envelope/roof/walls                                                                                  |
| Increase thermal capacity (Time lag)                          | Massive structure                                                                                                           |
| Decrease air exchange rate<br>(ventilation during the day)    | Smaller windows openings, night ventilation                                                                                 |
| Increase buffer spaces                                        | Air locks/lobbies/balconies/verandahs                                                                                       |
| Increase shading                                              | External surfaces protected-overhangs, fins, trees                                                                          |
| Increase surface reflectivity                                 | Pale color, glazed China mosaic tiles etc.                                                                                  |
| Reduce solar heat gain                                        | Use glazing with lower Solar Heat Gain Co-efficient-SHGC and provide shading for windows. Minimize glazing in East and West |
| <b>Promote Heat Loss</b>                                      |                                                                                                                             |
| Increase air exchange rate<br>(ventilation during night-time) | Courtyards/wind tower/arrangement of openings                                                                               |
| Increase humidity levels                                      | Trees, water ponds, evaporative cooling                                                                                     |

# Hot and Dry Climate Zone-

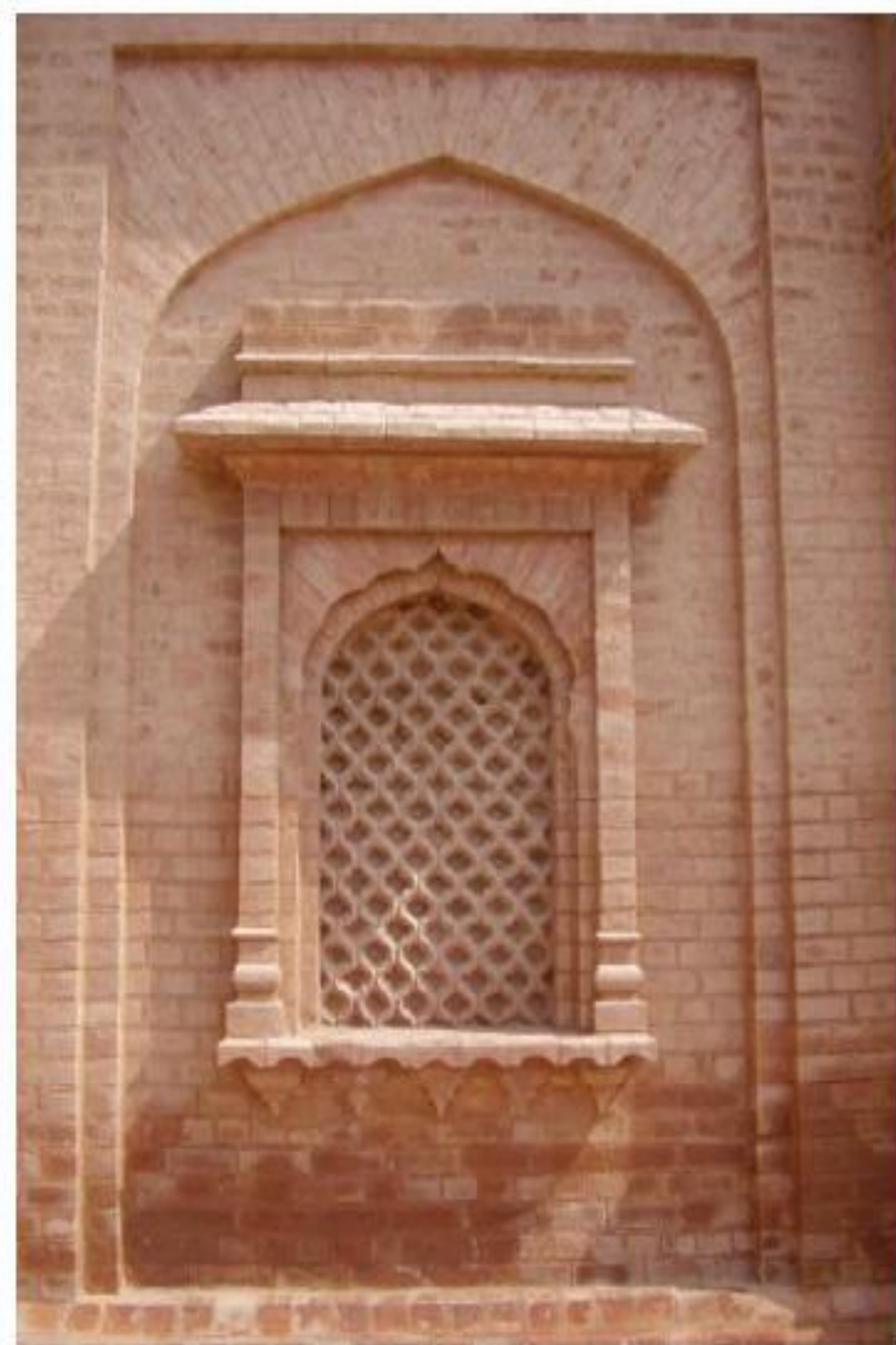
Comfort requirements and Physical manifestations in Buildings



# Cavity Walls





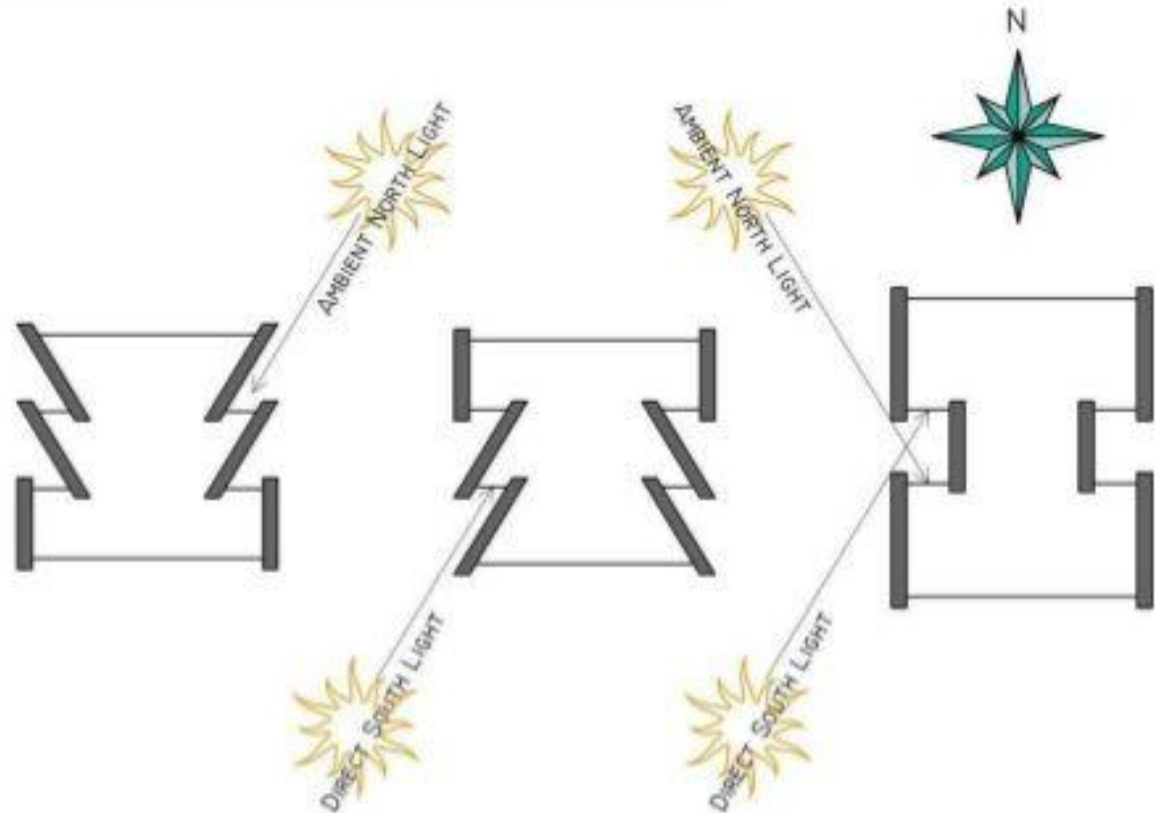




# Shading Strategies for East and West Elevations

AVOID WINDOWS ON THE EAST & WEST FACADE  
BY SHIFTING THE WINDOWS TO FACE NORTH OR SOUTH:

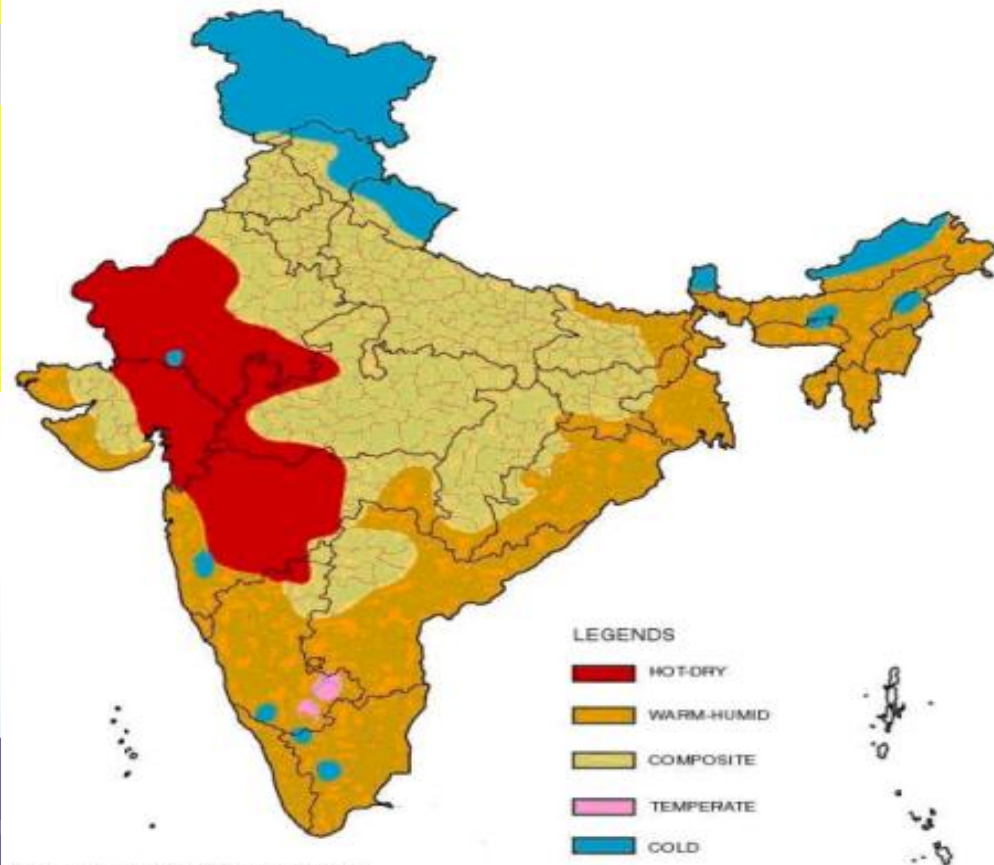
**1. The best solution**  
by far is to limit using  
east and especially  
west windows (as  
much as possible in  
hot climates)



**2. Next best** solution is to have windows on the east and west façades face north or south

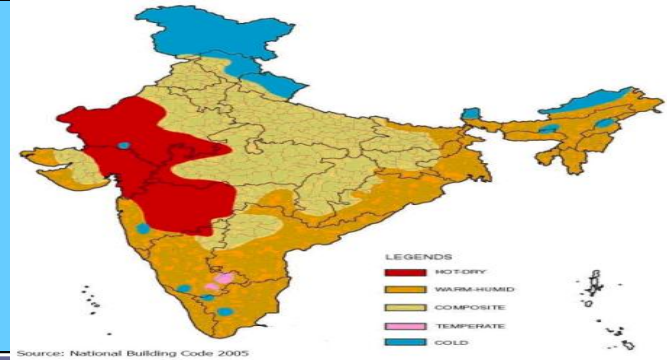
• ***HOT & HUMID***

• ***ZONE***



Source: National Building Code 2005

# Warm and Humid Climate Zone



| Thermal Requirements                                       | Physical Manifestation                                                                         |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| <b>Reduce Heat Gain</b>                                    |                                                                                                |
| Decrease exposed surface area                              | Orientation and shape of building                                                              |
| Increase thermal resistance                                | insulation of Roof and wall                                                                    |
|                                                            | Reflective surface of roof                                                                     |
| Increase buffer spaces                                     | Balconies and verandahs                                                                        |
| Increase shading                                           | Walls, glass surfaces protected by overhangs, fins and trees                                   |
| Increase surface reflectivity                              | Pale colour, glazed china mosaic tiles etc.                                                    |
| Reduce solar heat gain                                     | Use glazing with lower SHGC and provide shading for windows. Minimize glazing in East and West |
| <b>Promote Heat Loss</b>                                   |                                                                                                |
| Increase air exchange rate (ventilation during night-time) | Ventilated roof construction, courtyards/ wind tower and arrangement of openings               |
| Decrease humidity levels                                   | Dehumidifiers/desiccant cooling                                                                |

# BUILDING DESIGN IN WARM-HUMID ZONES

Provide maximum ventilation and free air movement by large openings.

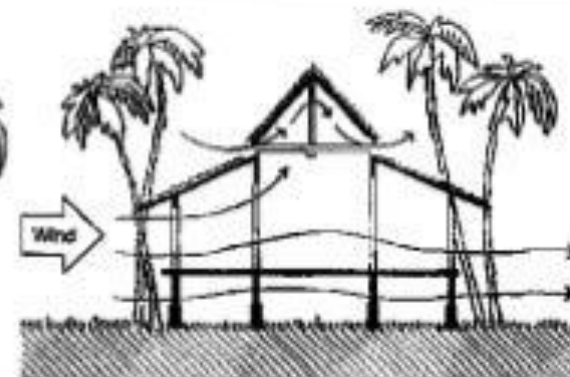
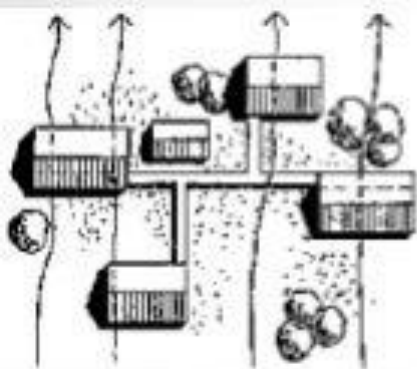
Provide maximum shading of direct and diffuse solar radiation.

Avoid heat storage.

Use reflective outer surfaces.

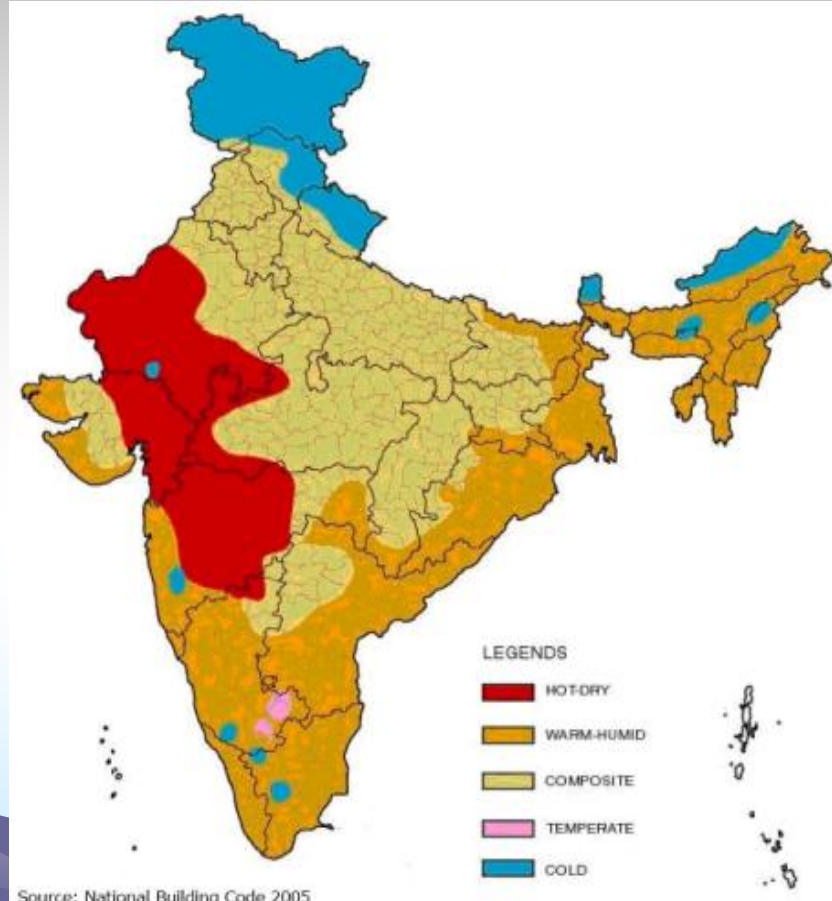
Use ventilated double roofs.

Use vegetation to moderate the solar impact



- *Moderate*

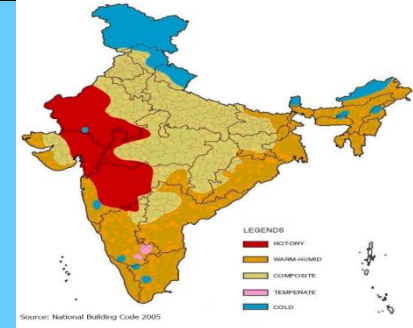
- *Climate*





# Moderate/Temperate Climate Zone

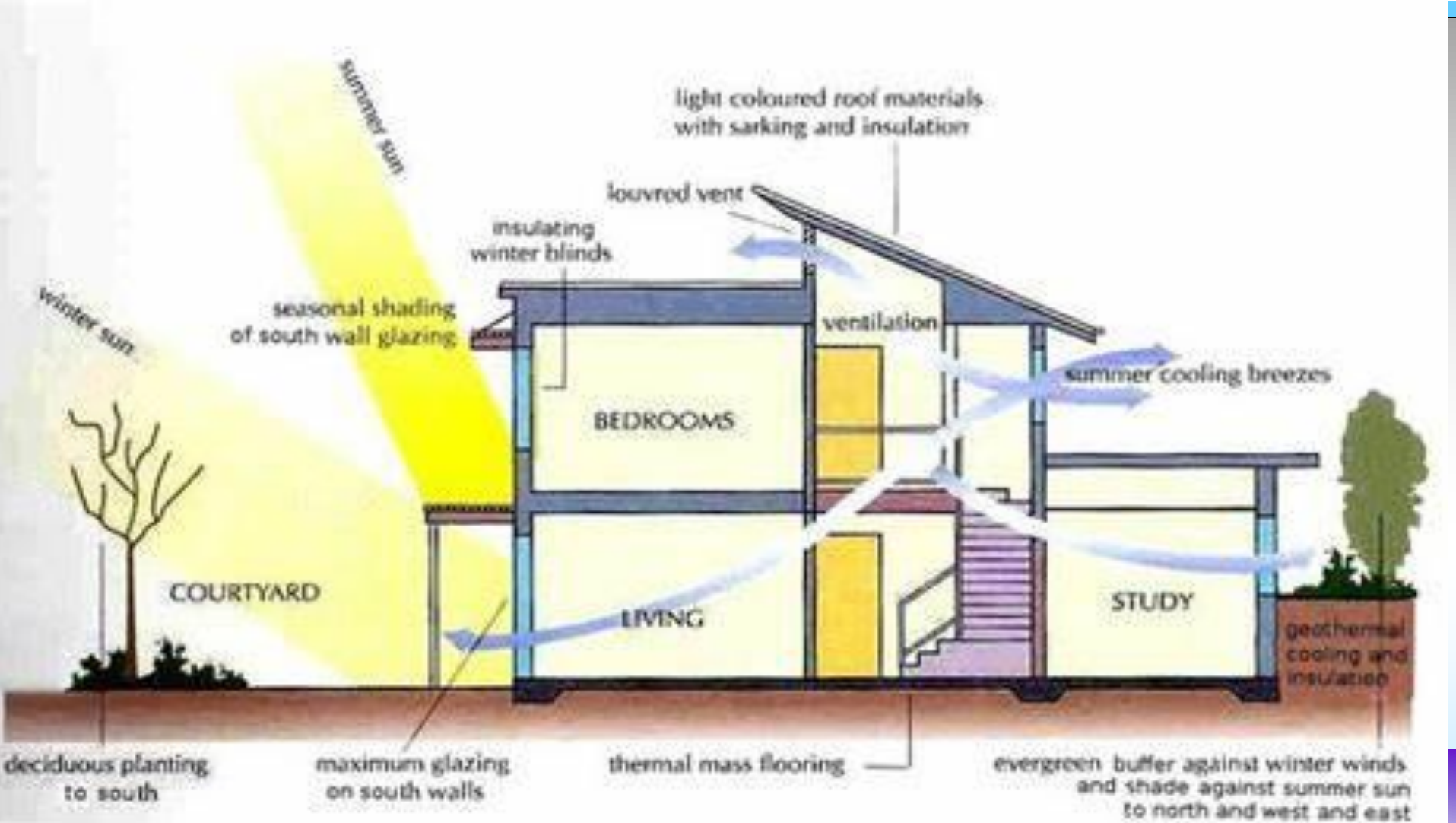
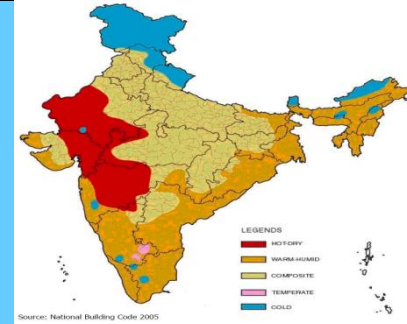
## Comfort requirements and Physical manifestations in Buildings



| Thermal Requirements                     | Physical Manifestation                                                     |
|------------------------------------------|----------------------------------------------------------------------------|
| <b>Reduce Heat Gain</b>                  |                                                                            |
| Decrease exposed surface area            | Orientation and shape of building                                          |
| Increase thermal resistance              | Roof insulation and East and West wall insulation                          |
| Increase shading                         | East and West Walls, glass surfaces protected by overhangs, fins and trees |
| Increase surface reflectivity            | Pale colour, glazed china mosaic tiles etc.                                |
| <b>Promote Heat Loss</b>                 |                                                                            |
| Increase air exchange rate (ventilation) | Courtyards and arrangement of openings                                     |

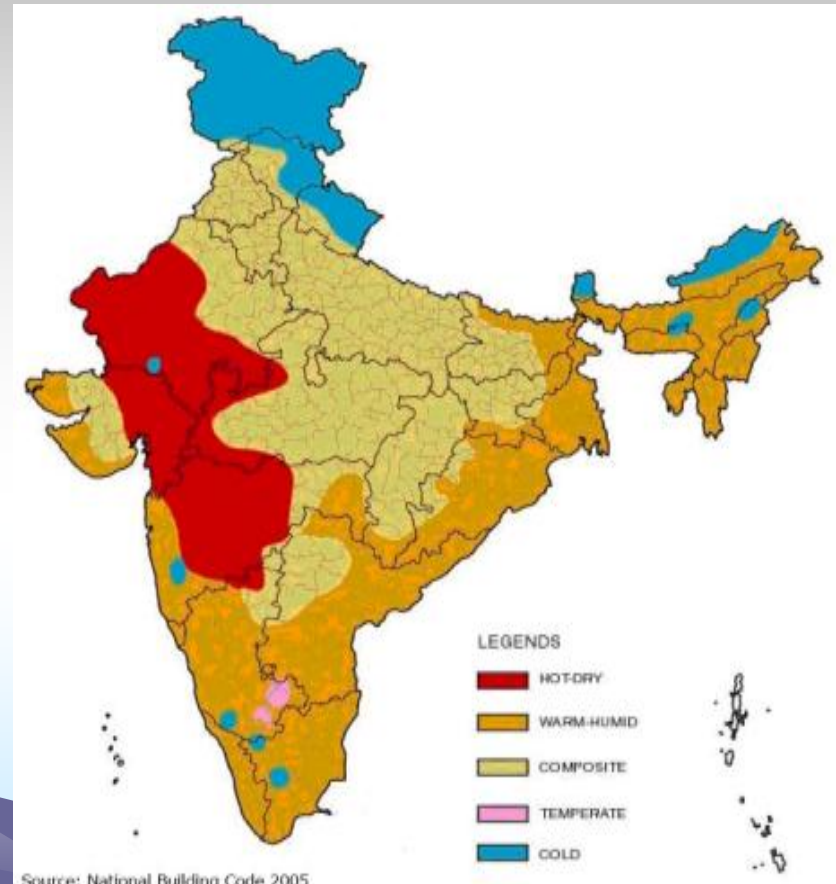
# Moderate/Temperate Climate Zone

## Comfort requirements and Physical manifestations in Buildings



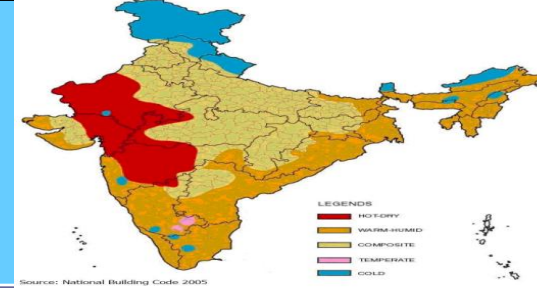
- *Composite*

- *Climate*



# Composite Climate Zone-

## Comfort requirements and Physical manifestations in Buildings

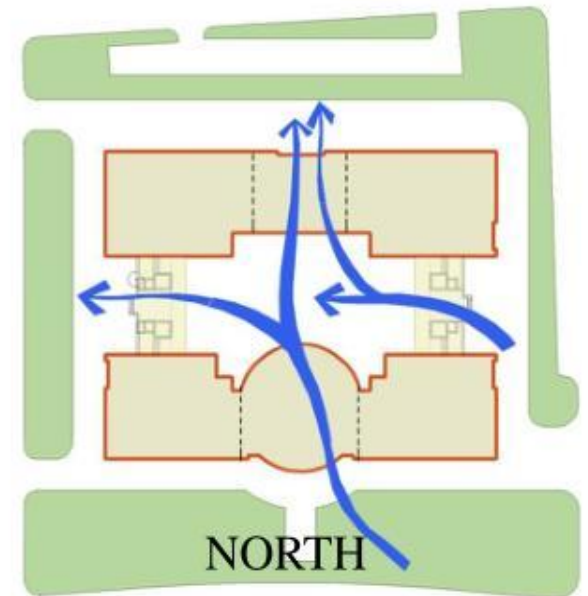


| Thermal Requirements                                             | Physical Manifestation                                                                         |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| <b>Reduce Heat Gain in Summer and Reduce Heat Loss in Winter</b> |                                                                                                |
| Decrease exposed surface area                                    | Orientation and shape of building. Use of trees as wind barriers.                              |
| Increase thermal resistance                                      | Roof insulation, wall insulation                                                               |
| Increase thermal capacity (Time Lag)                             | Thicker walls                                                                                  |
| Increase buffer spaces                                           | Air locks/Balconies                                                                            |
| Decrease air exchange rate                                       | Weather stripping (                                                                            |
| Increase shading                                                 | Walls, glass surfaces protected by overhangs, fins and trees                                   |
| Increase surface reflectivity                                    | Pale color, glazed chins mosaic tiles, etc.                                                    |
| Reduce solar heat gain                                           | Use glazing with lower SHGC and provide shading for windows. Minimize glazing in East and West |
| <b>Promote Heat Loss in Summer/Monsoon</b>                       |                                                                                                |
| Increase air exchange rate (Ventilation)                         | Courtyards/wind towers/arrangement of openings                                                 |
| Increase humidity levels in dry summer                           | Trees and water ponds for evaporative cooling                                                  |
| Decrease humidity in monsoon                                     | Dehumidifiers/desiccant cooling                                                                |



# Design Strategies in Composite Climate

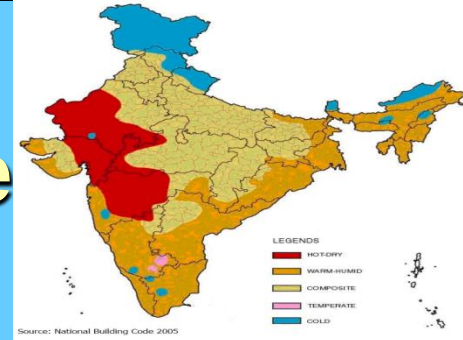
- Plan the building around the courtyard.
- Reduce heat gain in the building through building envelope.
- Plan water bodies
- cavity walls, terrace gardens, light shelves.



CROSS VENTILATION AT THE MICRO LEVEL THROUGH OPENINGS

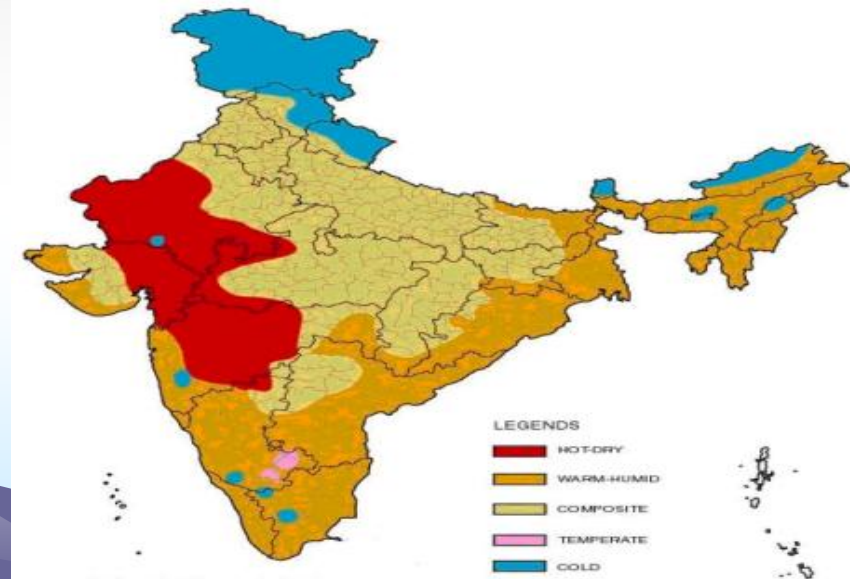


# Composite Climate Zone



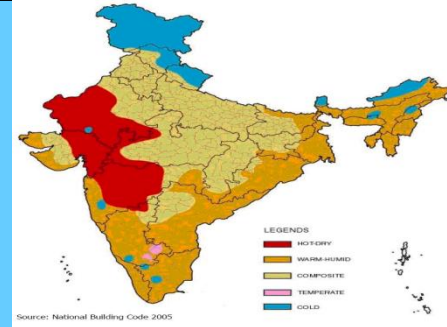
# *Cold- Cloudy/Sunny*

- *Climate*



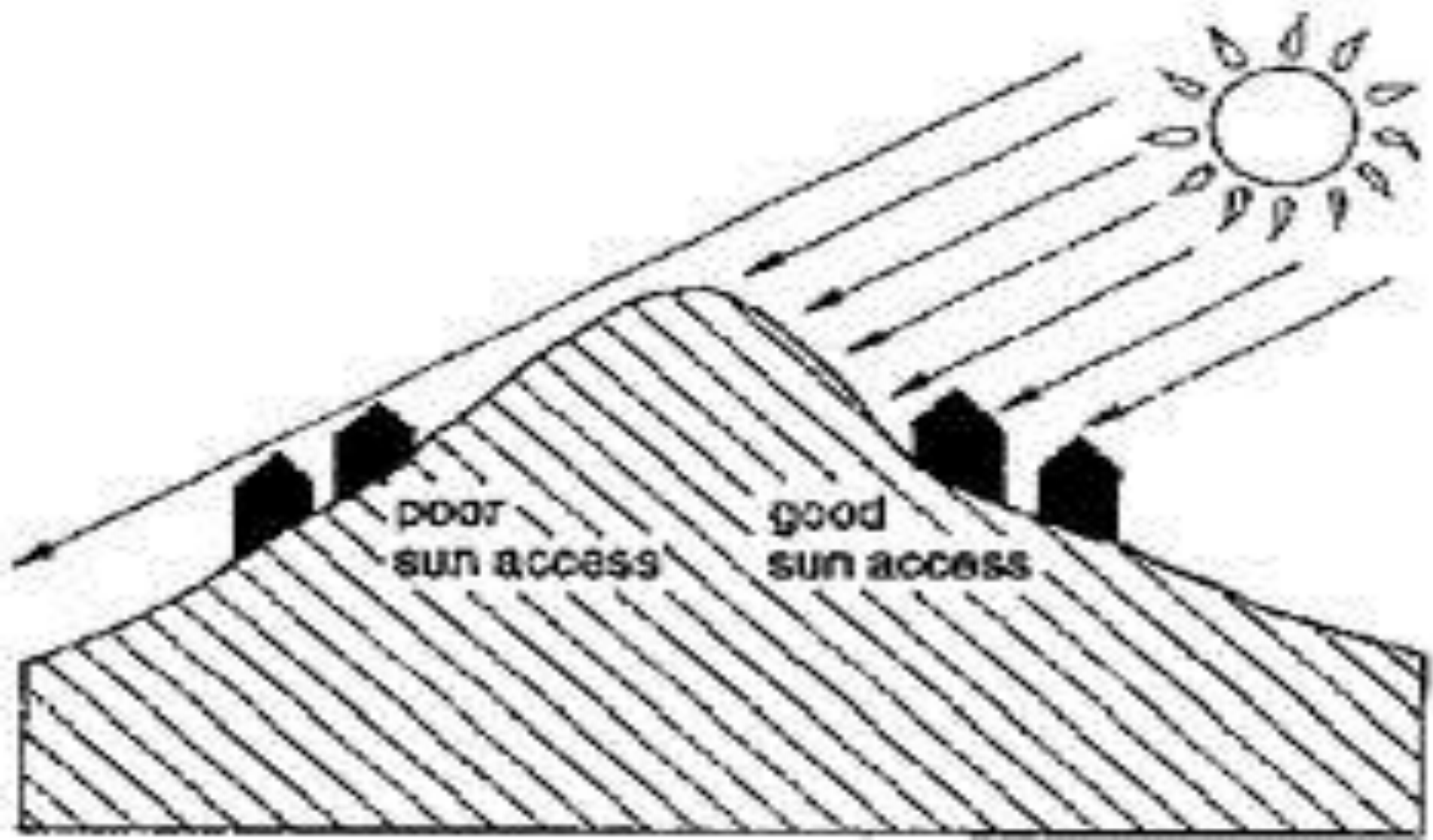
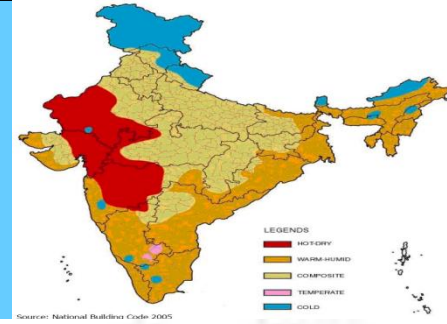
# Cold (Cloudy/Sunny) Climate

## Zone- Comfort requirements and Physical manifestations in Buildings



| Thermal Requirements                 | Physical Manifestation                                            |
|--------------------------------------|-------------------------------------------------------------------|
| <b>Reduce Heat Loss</b>              |                                                                   |
| Decrease exposed surface area        | Orientation and shape of building. Use of trees as wind barriers. |
| Increase thermal resistance          | Roof insulation, wall insulation and double glazing               |
| Increase thermal capacity (Time Lag) | Thicker walls                                                     |
| Increase buffer spaces               | Air locks/Lobbies                                                 |
| Decrease air exchange rate           | Weather stripping and reducing air leakage.                       |
| Increase surface absorption          | Darker colours                                                    |
| <b>Promote Heat Gain</b>             |                                                                   |
| Reduce shading                       | Wall and glass surfaces                                           |
| Trapping heat                        | Sun spaces/green houses/trombe walls etc.                         |

# Cold (Cloudy/Sunny) Climate Zone- Comfort requirements and Physical manifestations in Buildings





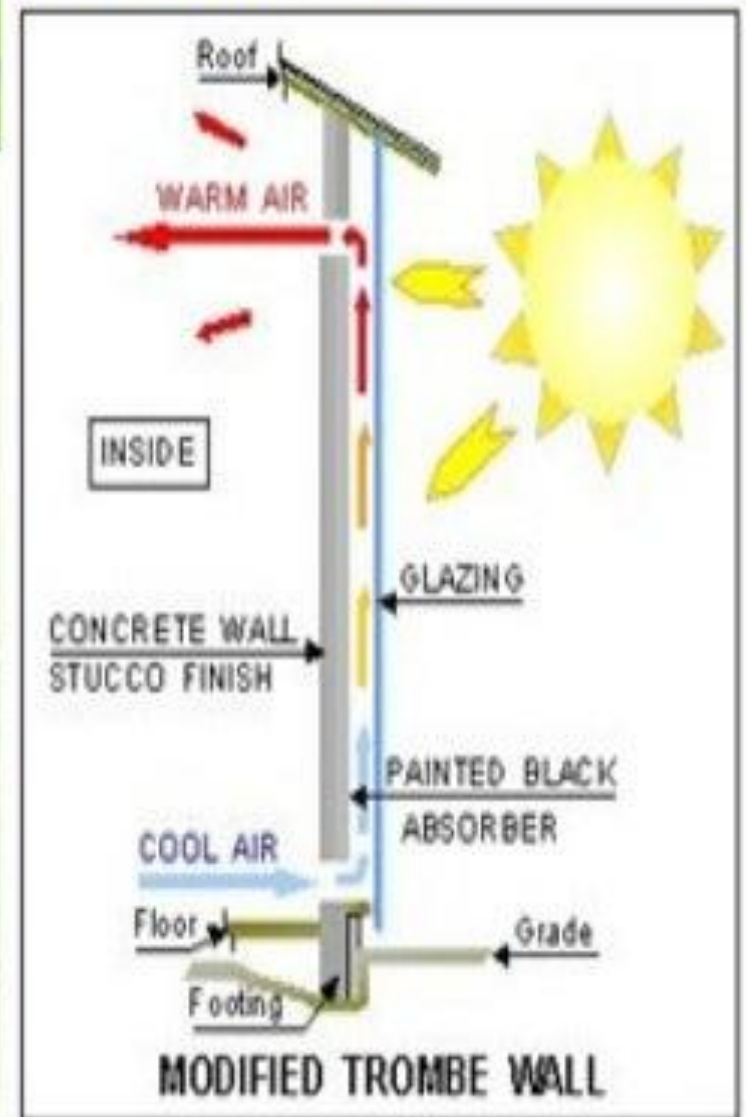
# SOLARIUM





# Design Strategies in Cold Climate

- Glazing windows up to 25% floor area
- Double glazing to avoid heat losses during winter nights.
- Adopt Trombe walls.
- Sunspaces



# Cold (Cloudy/Sunny) Climate Zone





# LOCATION OF CITY





# ***Understanding Site, & Site Analysis***



## SWOT

## STRENGTH

- The site is near to the business and agriculture land of the place.
- It has good condition of accessibility through road.
- The area has enough water supply, power lines, telephones and communication lines are available.

## WEAKNESSES

- There is a possible to deal with noise pollution.
- There are problems in heavy traffic during weekdays.

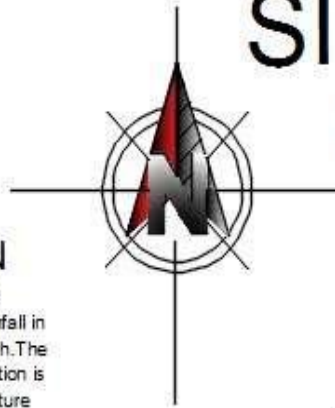
## OPPORTUNITIES

- It can also provide job opportunities to the locals.
- The rich and the poor have the opportunity to socialize with one another.
- Can also provide opportunities for families with no sufficient income for the facilities to be built.
- All families have the opportunity to choose their residence to the best of their income.
- This project can also add to the development increase of the city.

## THREATS

# SITE ANALYSIS

## STRENGTH, WEAKNESSES, OPPORTUNITIES, THREATS



## INTRODUCTION

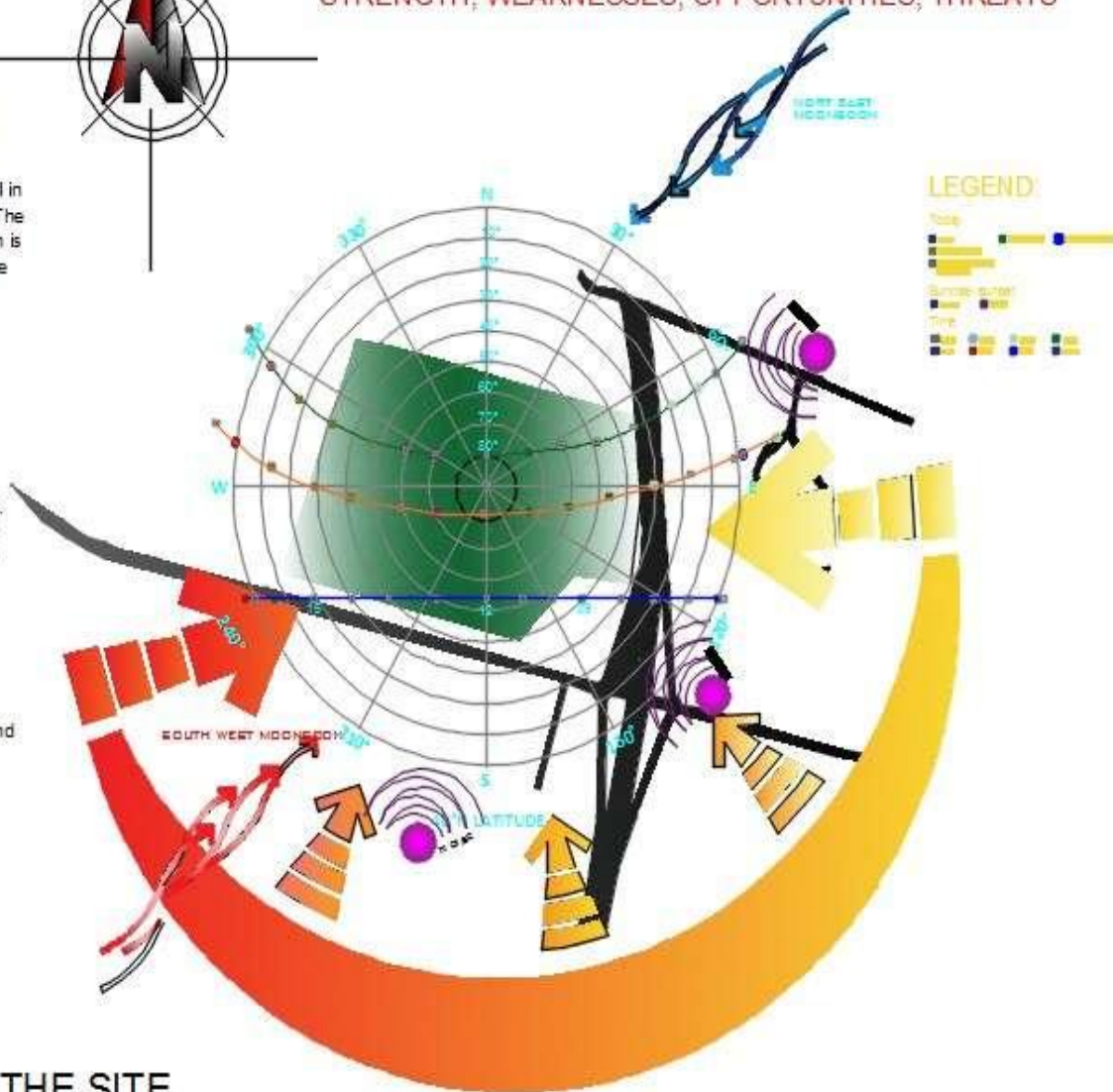
Tanauan, Batangas has a tropical climate. There is a great deal of rainfall in Tanauan, even in the driest month. The Koppen-Geiger climate classification is Af. The average annual temperature is 27.0 °C in Tanauan. The average annual rainfall is 2459 mm.

## CLIMATOLOGY

The temperatures are highest on average in August, at around  $27.8^{\circ}\text{C}$ . The lowest average temperatures in the year occur in January, when it is around  $25.9^{\circ}\text{C}$ .

## TOPOGRAPHY

The city of Tanauan covers a total land area of 10,716 hectares which represents 3.38% of the total land area of the province (316,581 ha). Majority of the areas in Tanauan City belong to 0 to 15 percent slope that are undulating to rolling.



## VIEWS FROM THE SITE

# Site Analysis- Factors To be considered for Evaluating site

- i) Understanding Site
  - ii) Location
  - iii) Orientation- *rising sun- position of a building in relation to an east-west axis.*
  - iv) Wind direction
  - v) Soil conditions
  - vi) Topography
  - vii) Vegetation and Natural Features
  - viii) Hydrology and Precipitation
  - ix) Infrastructures
  - x) Surrounding Land uses & Buildings
  - xi) Vision / Visual Linkages
- 

# Site Analysis- Location

## i) ***Understanding Site –***

- Most critical in design process
- Detailed site analysis needed to--
  - Recording elements existing at site
  - understand various features
- Evaluate information on site/ its surroundings
- Use of Site as per Master Plan

## ***ii)Location***

First aspect that one needs to be looked at----

- Where site is located?
- How site is approached?
- Name of street/ road etc-- on which site is located?
- How far away is major junction- major land mark

# Site Analysis- Orientation

iii) **Orientation** -- position/positioning of site with relation to points of the compass or other specific directions

- Orientation of site plays important **role in siting of building.**

**When combined with:**

- wind direction and
  - sun path
- would give a good idea as to how building / design should be oriented to :
- optimize design.
- Orientation /sun path will also determine
  - **placement of rooms** inside buildings.



# Site Analysis- Wind Direction

#### ***iv) Wind Direction***

- **Most locations will have a general major direction from which wind comes.**

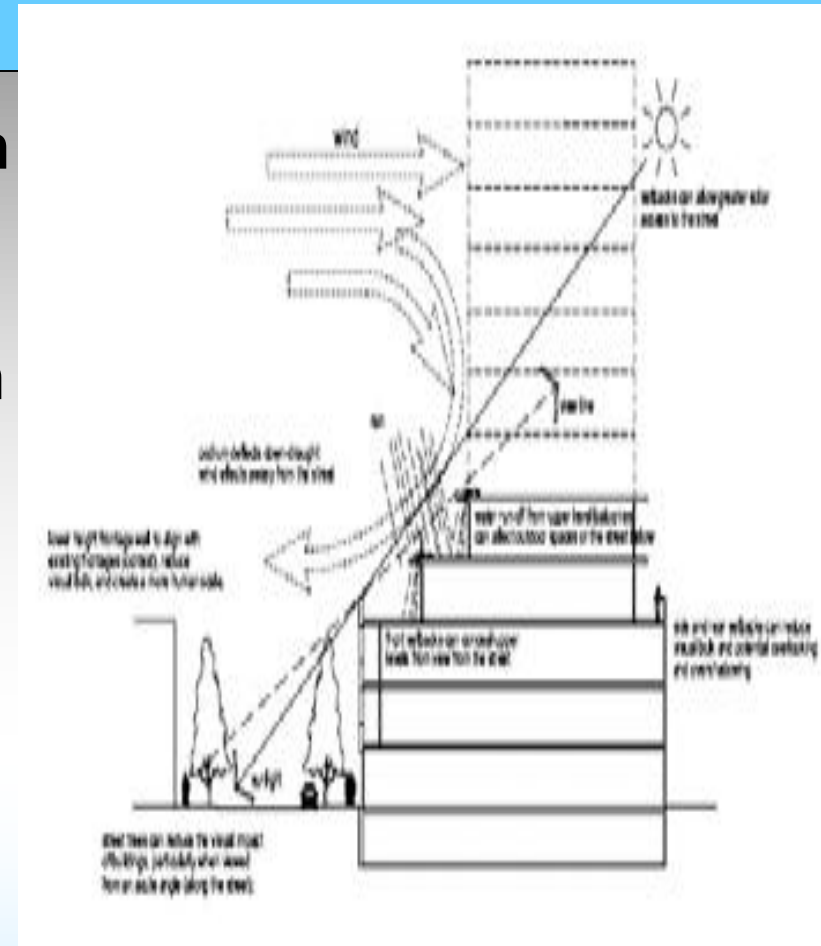
- However, this will not always hold true and will vary from location to location.

- For designing a climatologically responsive building----

## important to consider

## --direction of wind

--so that it can be channelized through interiors.--



# Site Analysis-Soil Conditions

## **vi) SOIL**

**Soils vary from place to place.**

- **with Properties also varying according to type of soil.**
  - Sandy soil,
  - clayey soil,
  - laterite etc
- all have different properties**
  - load bearing, water retentivity /absorption, homogeneity
  - which impact design of building.
- Soil conditions -- important from structural point of view while designing High Rise buildings.**

# Site Analysis-Topography

## *vii) Topography* –

--refers to slope & level of land whether

--- land is flat/plain or

--- sloping/ undulating

- Designing--a sloping site will be more challenging.

- In sloping, sites-- exact slope can be interpreted from a detailed Contour map.

- Locations/ spacing of contour-- play a big role in siting of building.

- Always better to design buildings along contours,

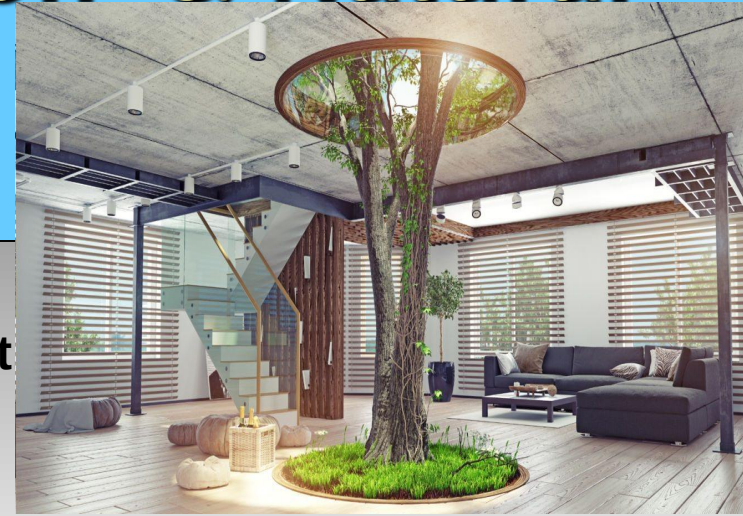
- integrating contours into design reduces unnecessary cutting / filling of soil.



# Site Analysis-Vegetation & Natural Features

## •*Viii) Vegetation and Natural Features*

- Natural vegetation present on site very important
- Every good design will
  - integrate
  - highlight &
  - accentuate
  - in design Natural vegetation to create perfect harmony.
- Vegetation comprises of
  - trees, flora / fauna present on site.
- These should be marked on site plan
  - so that it will assist during design stage along with ;
  - location, ---
  - type ,
  - size ,
  - diameter or
  - spread of branches/ heights etc







# ***Site Analysis-Precipitation & Hydrology***

## ***ix) Hydrology and Precipitation:***

- Amount of rainfall
- Time period during which rainfall occurs/ site receives
- -are to be mapped/ found out.
  
- Relative Humidity found out to --determine moisture content in atmosphere.
  
- Higher relative humidity suggests a humid climate,-- cross circulation of wind at body level is must for comfort.
- A lower relative humidity suggests a dry climate
- Great rainfall/ Snow– Roof to be sloping
- - Draining of water to be ensured
- - Large proportion of site to be kept landscaped /open





# Site Analysis- Infrastructure Facilities

## **x) Infrastructure**

- Infrastructure facilities-- refer to services present in vicinity of Site.
- Major facilities to be considered are :
  - water supply,
  - Storm water drainage ,
  - Waste disposal,
  - Electricity supply
  - Roads
  - Communication network etc.
- important while planning / zoning in site for :
  - promoting economy and
  - making optimum use of services





# ***Site Analysis-Land Use/Visual Linkages***

## ***xi) Surrounding land uses & buildings –***

. For optimum design solution —

--surrounding land uses and

--buildings

.need close focus and consideration

- Incompatible land-uses lead to creation of issues in design.

- Height /setbacks of adjoining buildings important in ensuring

- flow of air

- sunlight.

## ***xii) Prominent Vision lines / Visual linkages –***

- Important element in design process.

- Views to site as well as

- views from site

- -- need careful consideration, while designing.







# ***Principles of Site Planning***





# Site Planning Principles

- i) **Neighbourhood Character**
- ii) **Physical Characteristics**
- iii) **Site and Slopes**
- iv) **Minimum Fingerprints of Building**
- v) **Minimum damage to site**
- vi) **Design with Nature and local Culture**
- vii) **Promoting Pedestrianization**
- viii) **Using hierarchy of**
  - **Preservation,**
  - **Conservation and**
  - **Regeneration**





# Site Planning Principles

***Site planning / design---*** Architect to consider broad range of concerns before evolving design concept.:

- physical aspects of site
- vision/ program of client,
- designer's own creative inclination,
- concerns of community
- interests of end user.
- zoning /bye-laws requirements -- to regulate density / geometry of development, road widths ,parking and drainage requirements,
- natural resource( protection ) areas.

## ***ii) Neighbourhood Character***

## ***iii) Physical Characteristics***

Site planning incorporate an accurate description of:

- Shape, size, orientation of site and easements.
  - Levels /contours of site & difference in levels between site / surrounding properties.
  - Location /height of existing buildings on site & surrounding properties.
- Use of surrounding buildings, including location of habitable rooms.

# Site Planning Principles

## *iv) Site and Slopes*

- Good designing follow grades and runs along ridge lines.
- Steep site slopes often require increased cut and fill-- if building are sited using conventional methods of designing
- If incorporated into initial subdivision/layout process-slope can be an asset to the development..
- Avoiding Northern slope in cold climate

## *v) Use Minimum Site Finger-printing*

- Site finger-printing (minimal disturbance techniques) can be used to:
  - further reduce limits of clearing /grading
  - minimizing hydrologic impacts.

Site fingerprinting includes:

- restricting ground disturbance by
- identifying smallest possible area
- clearly delineating on site.
- Reduce paving and compaction of highly permeable soils.
- Reusing the existing areas

# Building Designing Principles

- **Minimizing damage/harm**

- Making minimum changes to site-- which will degrade surrounding environment.

- Promote projects on sites

- where previous disturbance /development presents

- an opportunity to regenerate ecosystem services through sustainable design.

- **Design with nature and culture**

Create designs that are responsive to :

- economic,

- environmental, and cultural conditions with respect to :

- local, regional, and global context.

- **Planning New Pedestrian Links**

- to promote Pedestrianization /minimising vehicular traffic

- **Use hierarchy of preservation, conservation, and regeneration**

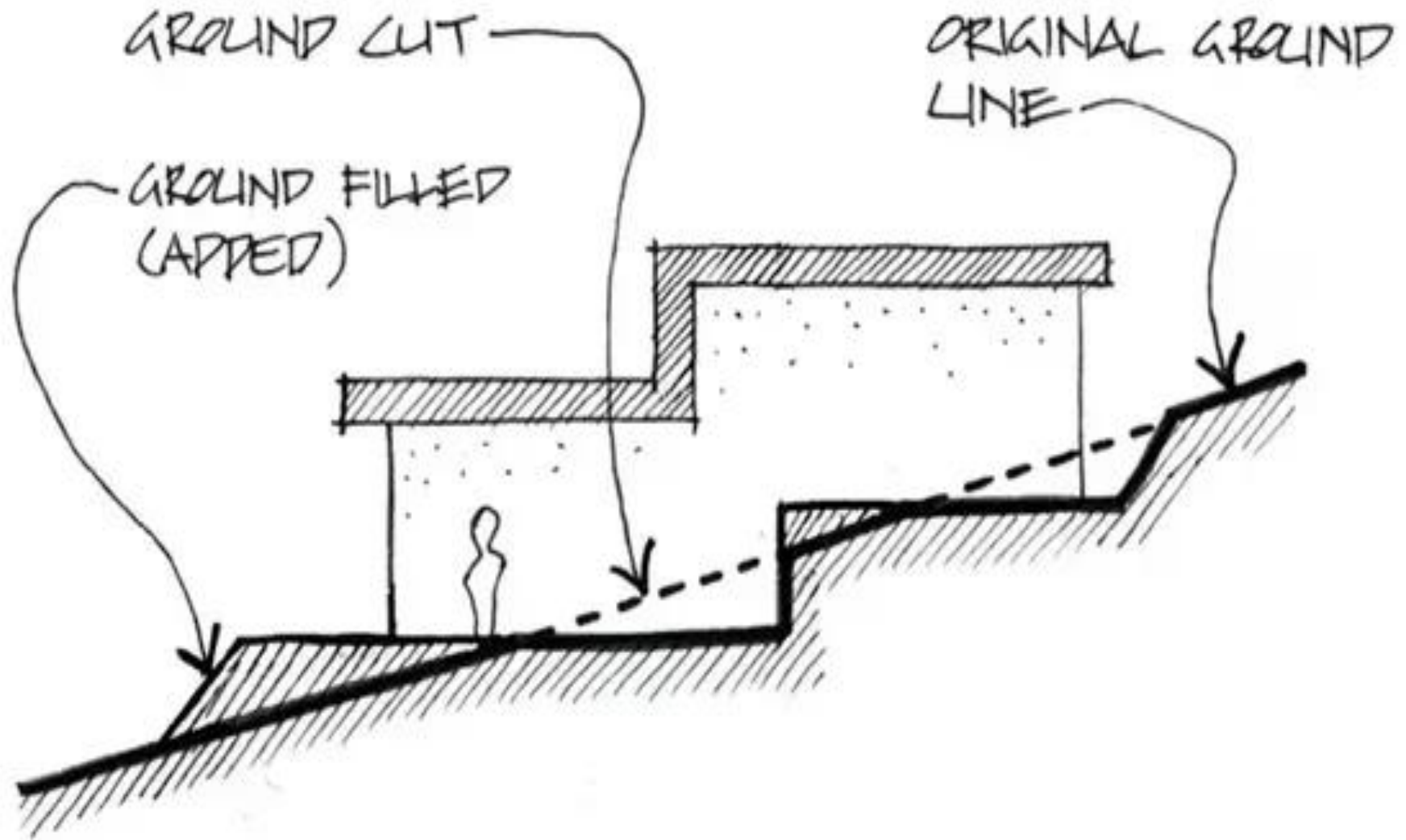
Maximise benefits of ecosystem by :

- preserving existing environmental features

- conserving resources in a sustainable manner, and

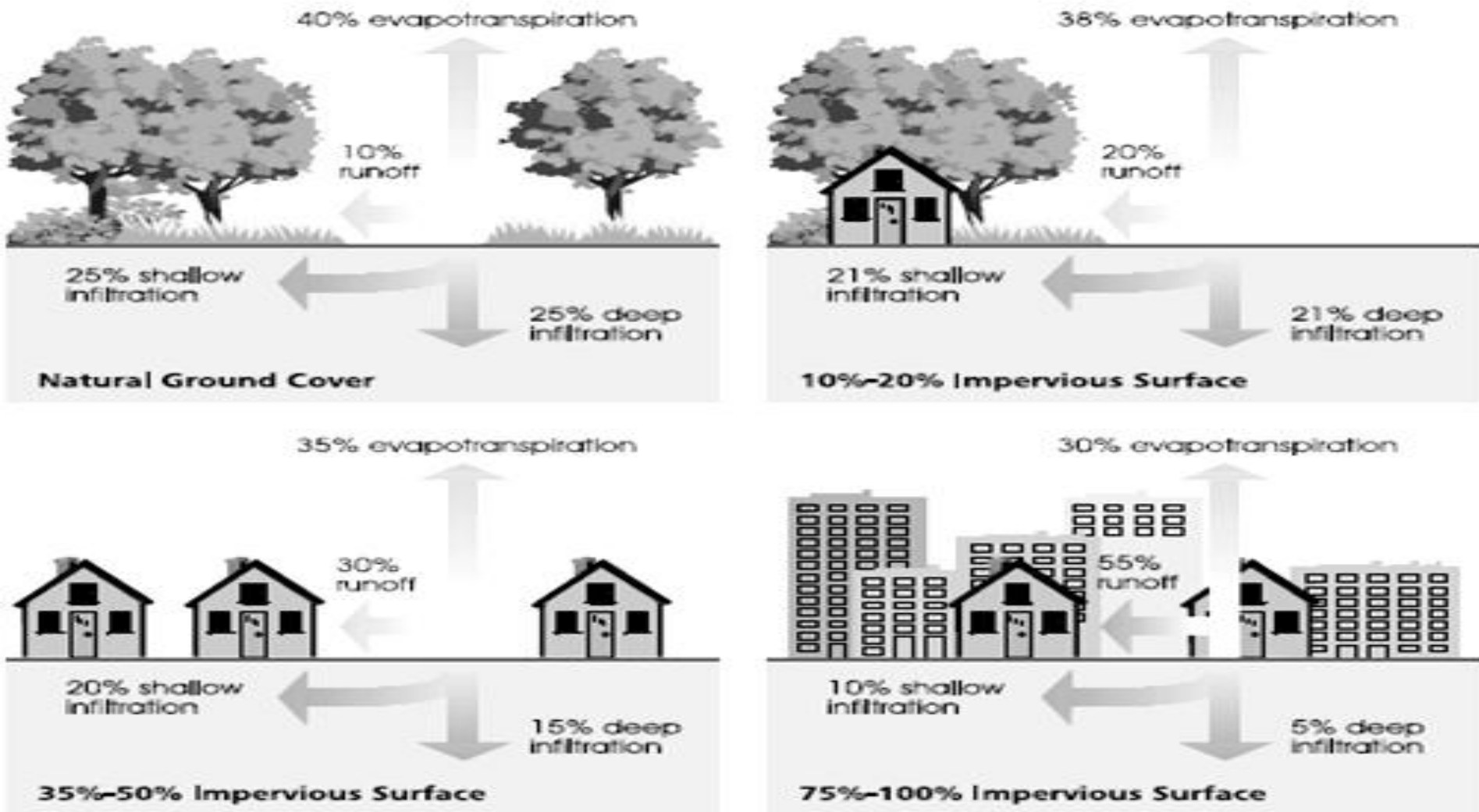
- regenerating lost or damaged ecosystem services.

# MANAGING SITE- MIN. CUTTING & FILLING

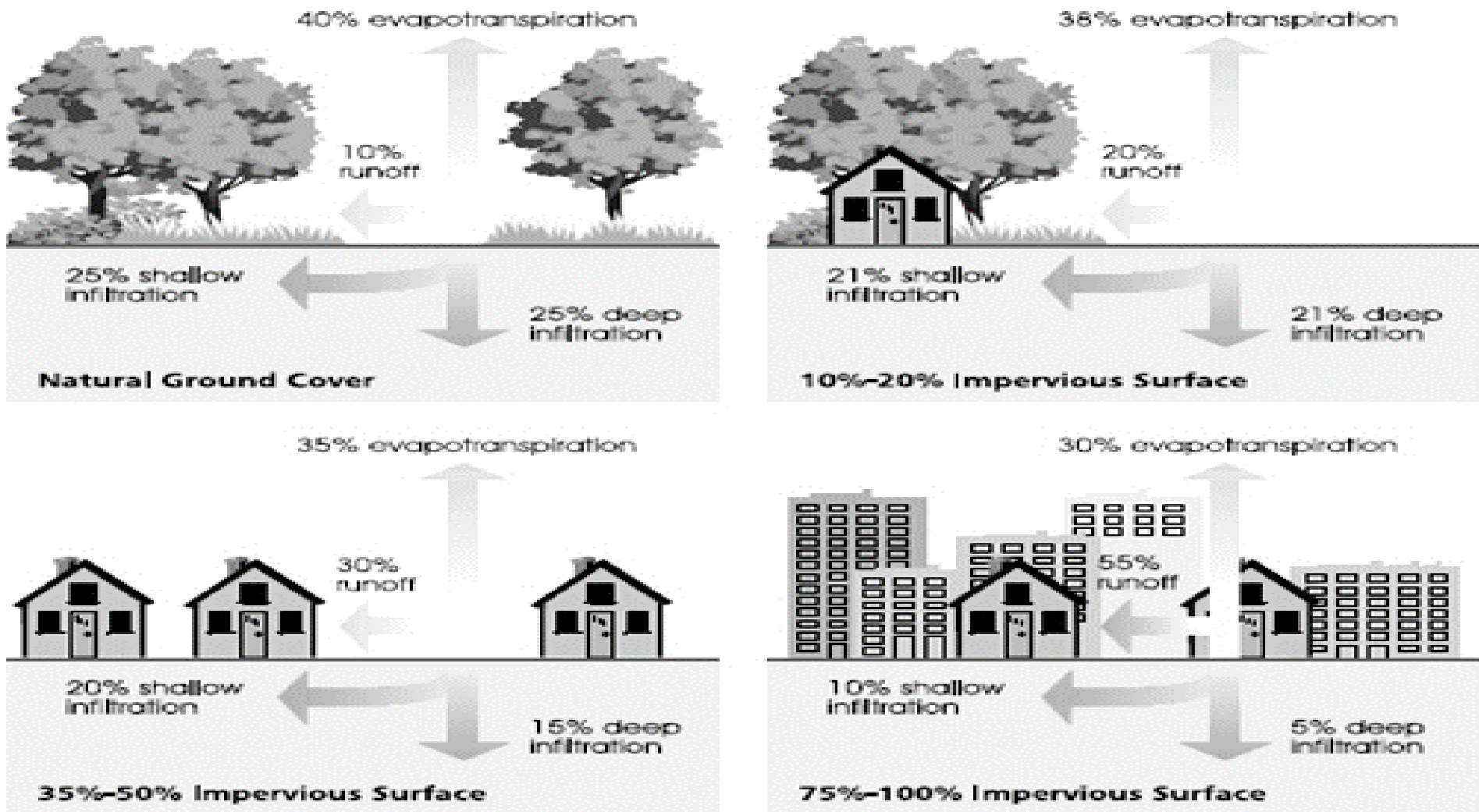




# Impact of Buildings- minimising Building Footprints



# Impact of Buildings- minimising Building Footprints



***Understanding  
Orientation;  
Planning of Spaces;  
Building Envelop***



# *Understanding/Valuing Sun*

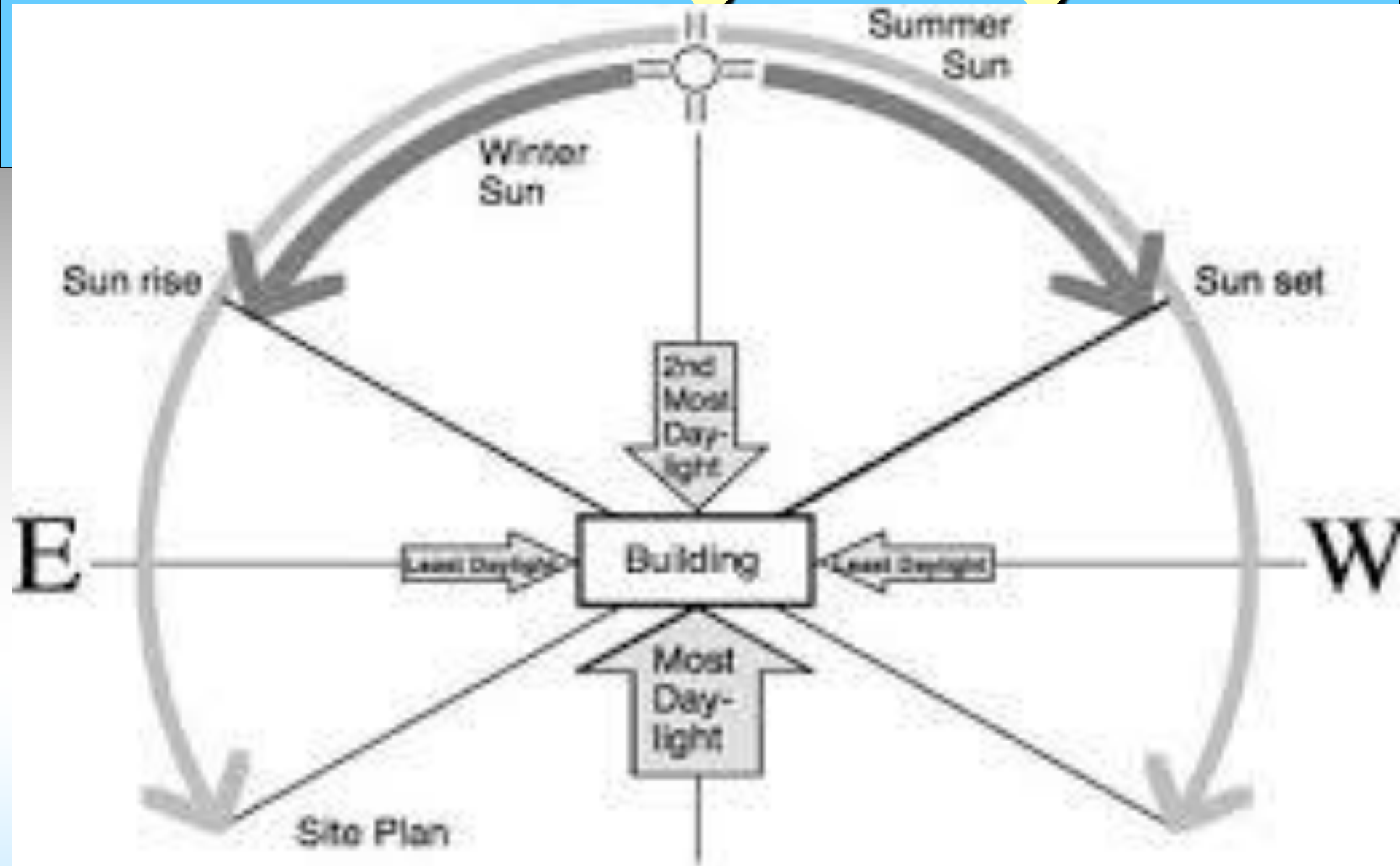


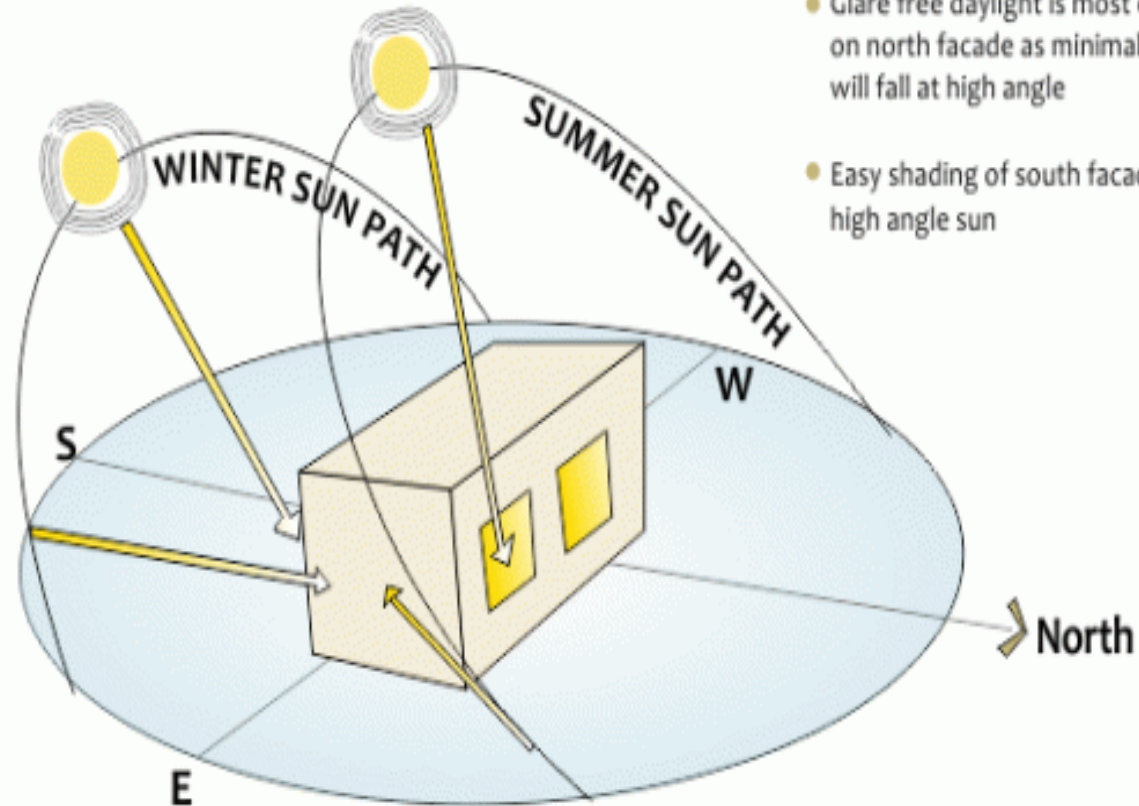
Figure 1



# ORIENTATION

## WINTER SUN

- Sun path at a low angle, south to E-W axis
- Solar radiation will penetrate south facing facades at a low angle during winter



## SUMMER SUN

- Sun path at a high angle sun, north to E-W axis
- Glare free daylight is most easily available on north facade as minimal solar radiation will fall at high angle
- Easy shading of south facade from high angle sun

East and west facades continue to receive uniform, strong solar radiation at a low angle through the year.

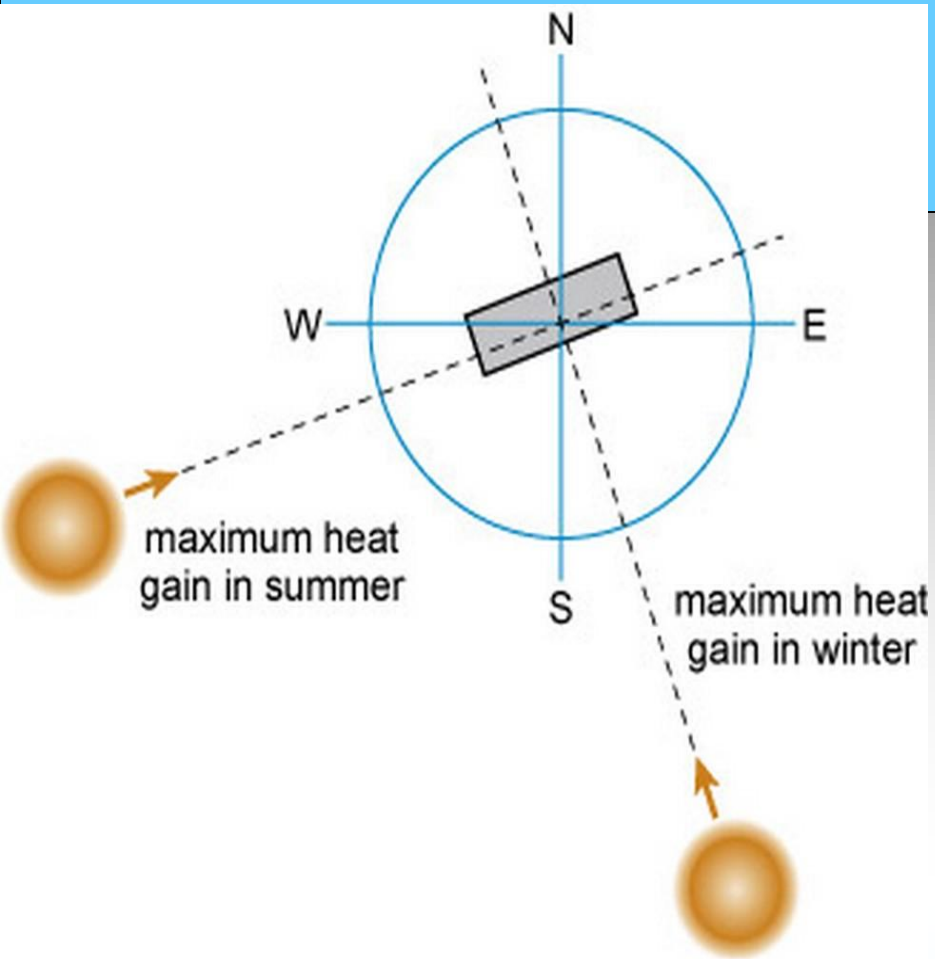
**Orientation-**  
building's positioning  
relation to

-sun --wind patterns.

Techniques- for improving  
thermal comfort inside  
building.

Orientation- critical for  
planning /Designing  
Buildings

-Optimizes heating /  
cooling needs throughout  
building.

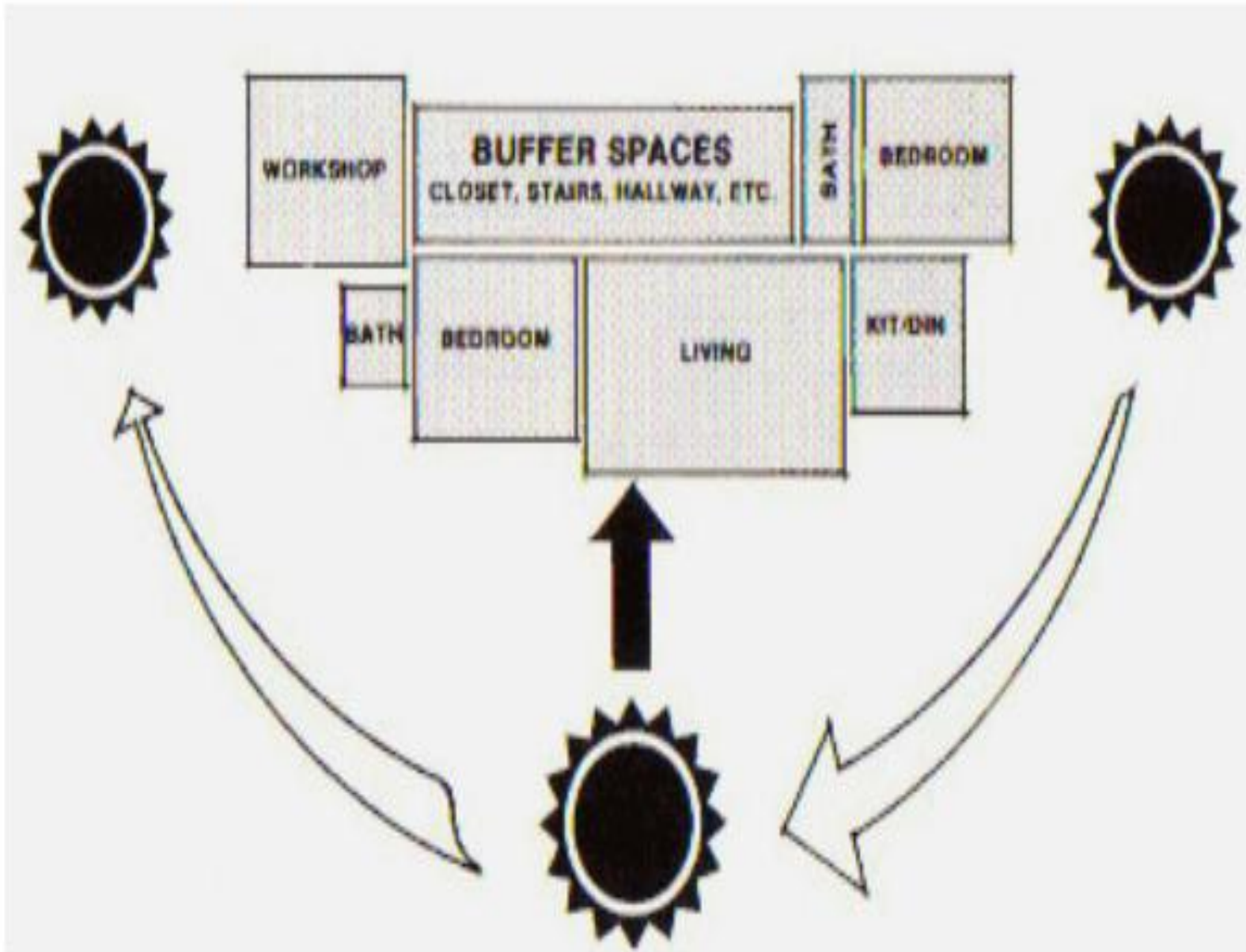


# Tower of Shadow- Sun Temple;Chhd





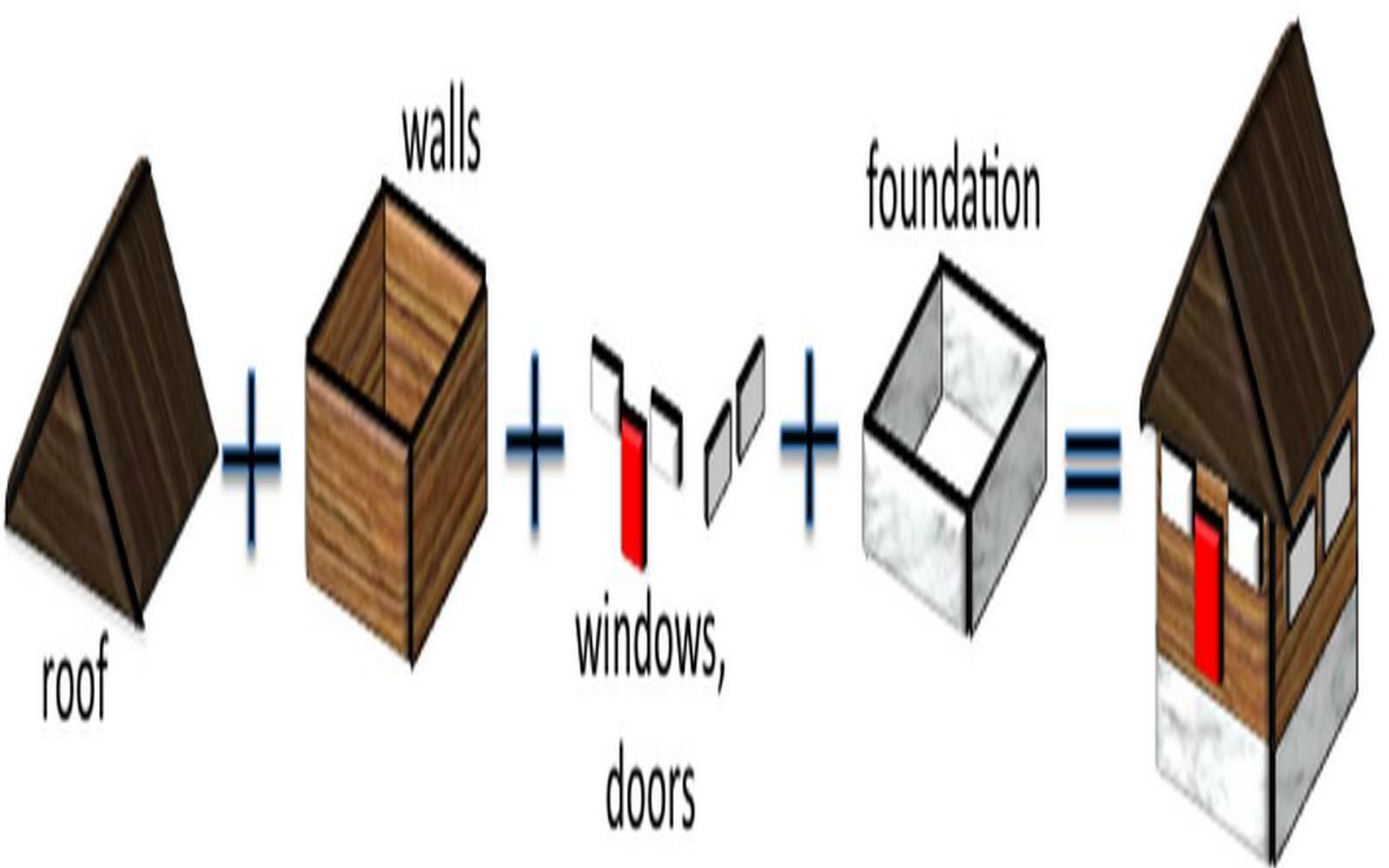
# Planning for spaces in buildings





# ***Building Envelope***

- ***Building envelope;***
- ***-Divides – natural / Manmade Environment***
- ***-First line of defense- against natural forces – rain , heat, cold, storm***
- ***Barrier-- between interior/exterior of a building***
- ***Controls-- exchange of air/water/heating/ cooling in interior.***
- ***Components constituting Envelope;-- Roof, Walls, Doors, Windows, Foundations, Projections, Recesses, Louvers; shading devices***
- ***Envelop- Involves structural loads , air, heat, moisture loads.***
- ***Colour/texture- contributes to heat gain/loss within***



# Making Roof White





# Making Roof Green



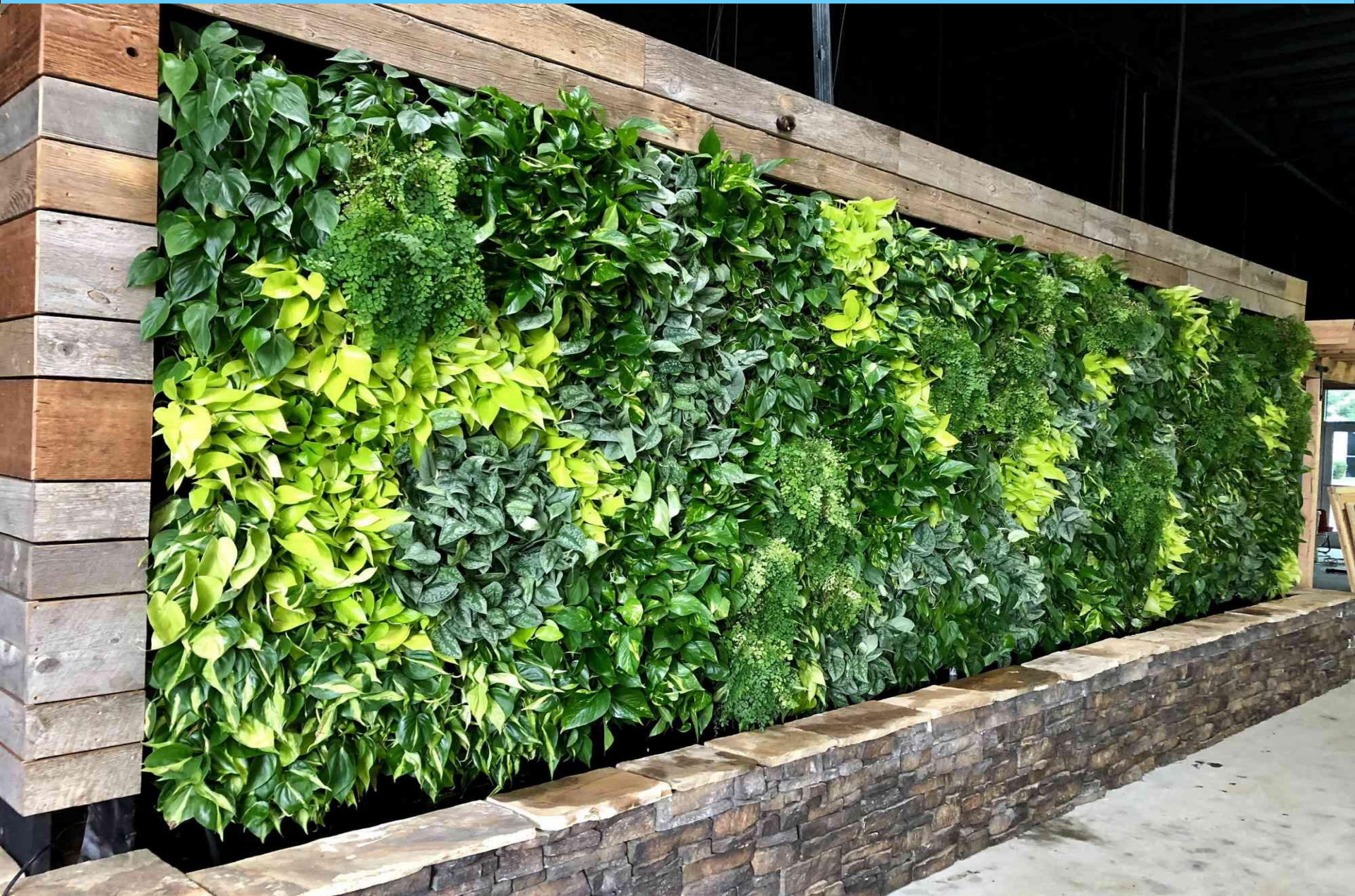


# Making Roof Garden



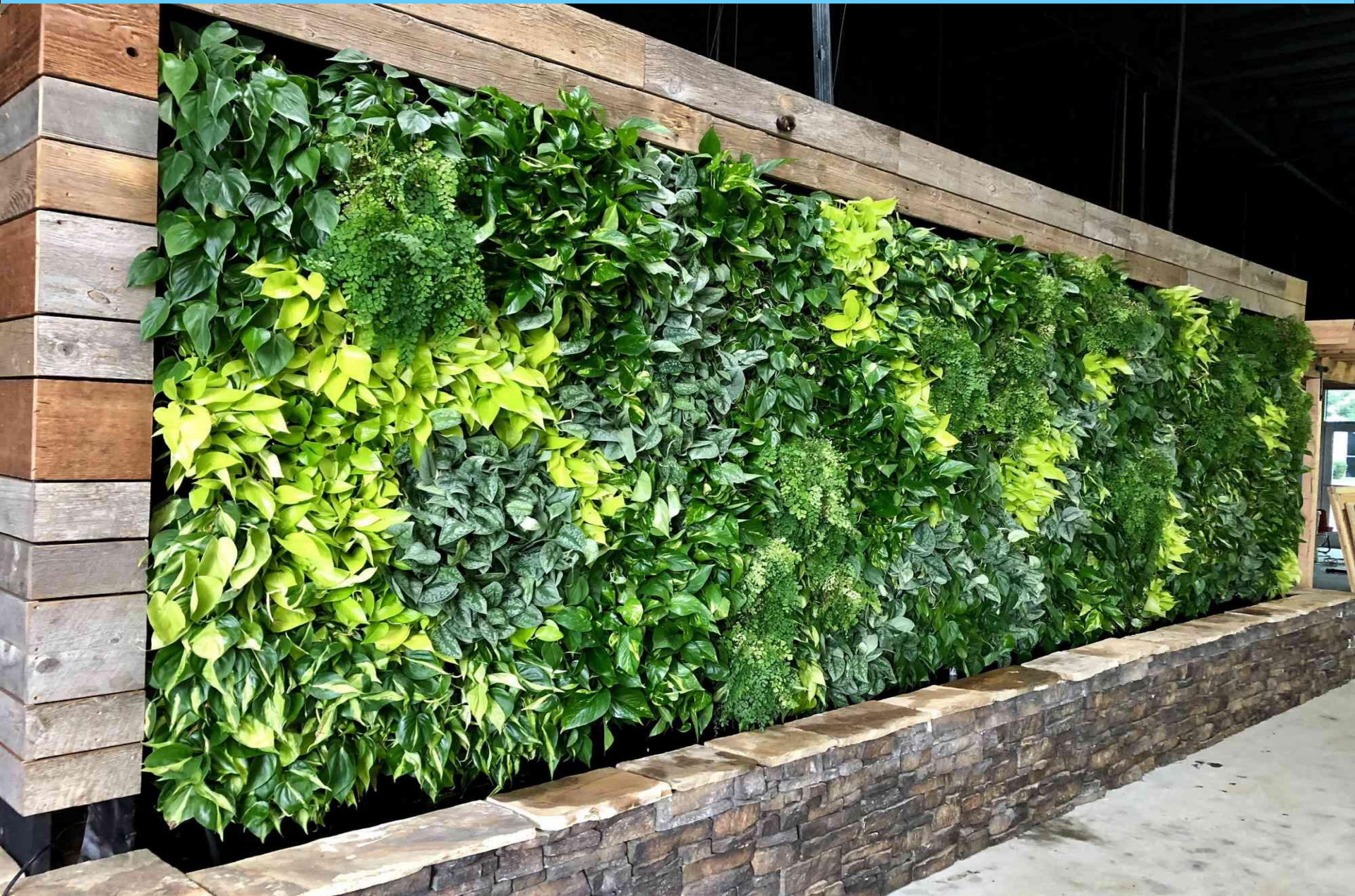


# Making Walls Green





# Making Walls Green





# Landscaping- Interiors/Exteriors

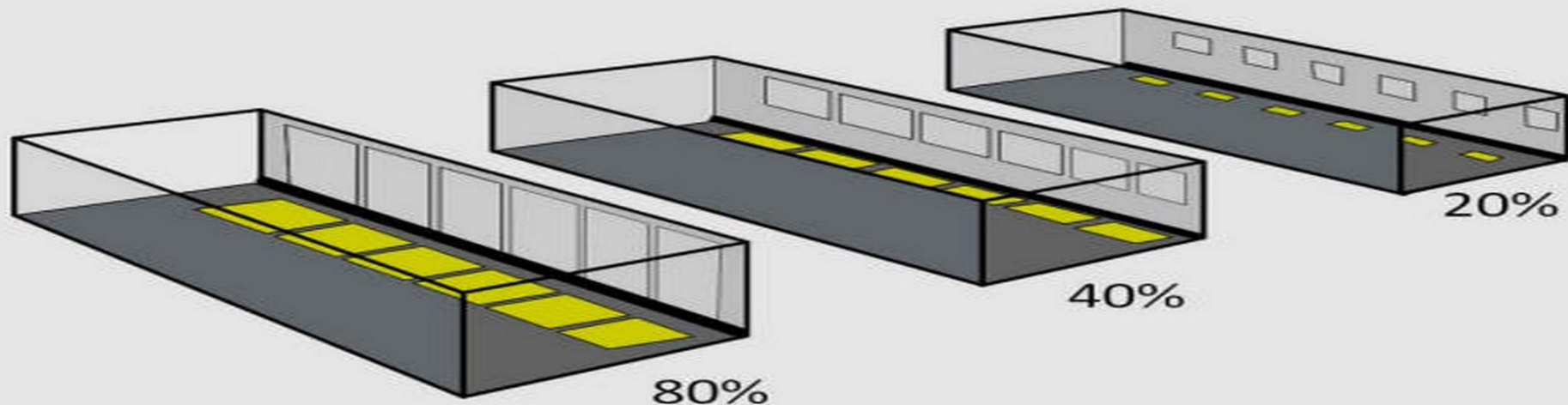




# Window-wall ratio (WWR)

Window-wall ratio;-- ratio of window area to exterior wall -- important for determining energy performance of building.-- Windows -cause energy loss twice more the wall

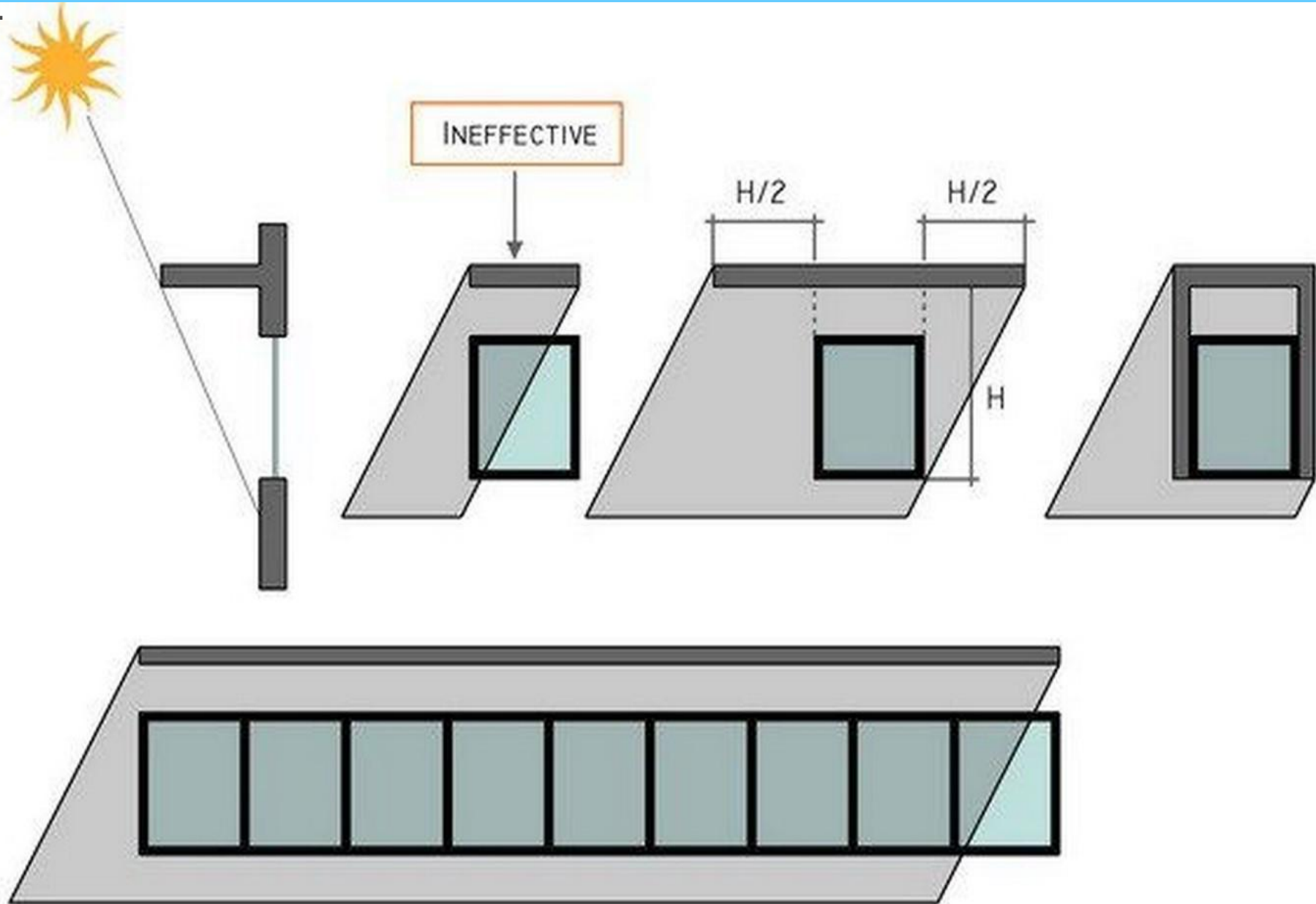
-impact heating, cooling, lighting, ventilation.-  
Size/number of windows - designed according to climatic conditions.



# Solar Shading

- *Solar control / shading --directly impact -- energy efficiency*
- *--cooling load minimized to one-fourth of building's load.*
- *-Shading devices – fins/ chajjas (overhangs) designed*
- *--to get a minimum exposure of sun in summer*
- *-- while allowing winter sun inside the space.*
- *-- helps in regulating /reducing electrical load on building.*
- *-- Solar orientation important*
- *-- while designing an effective shading device.*
- *-- Some solar shading elements -- trees, hedges, overhangs, vertical fins, low-shading coefficient glass, blinds, and louvers*

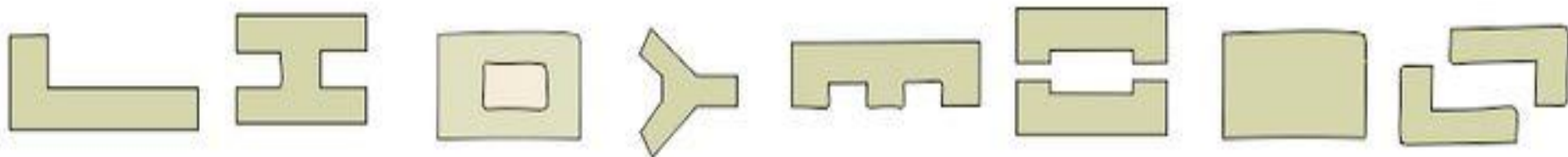
# Solar shading



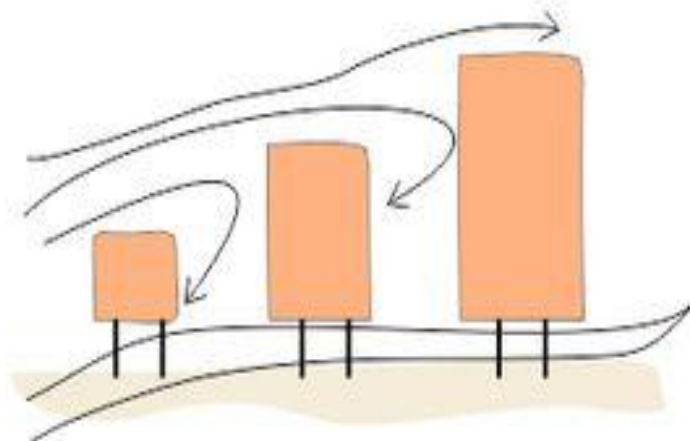
# ***Planning with Air- Cross-ventilation***



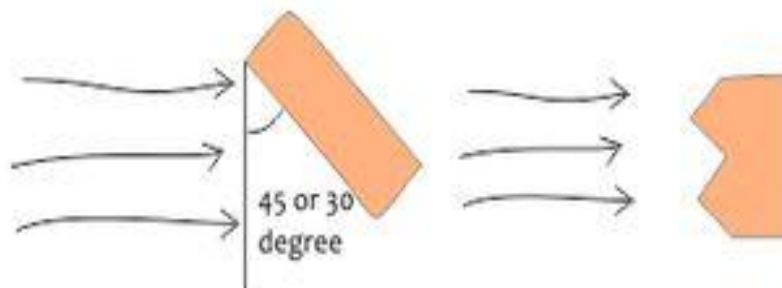




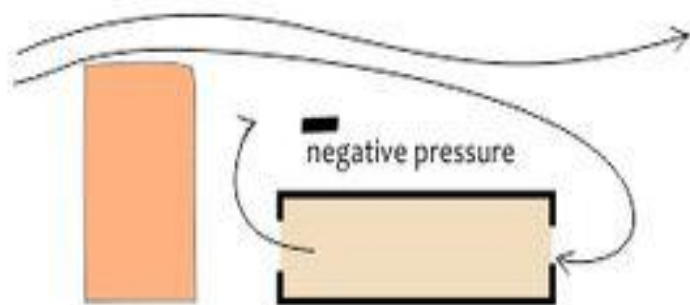
Orient longer facades along the north. This will provide glare free light in summer from north without shading and winter sun penetration from the south.



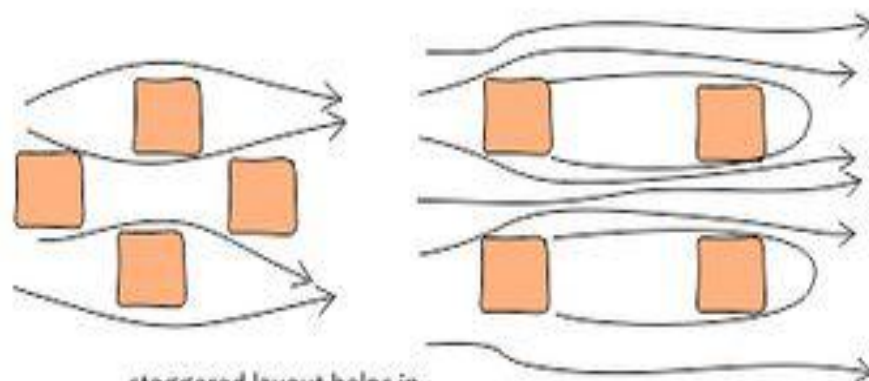
If a site has multiple buildings, they should be arranged in ascending order of their heights and be built on stilts to allow ventilation



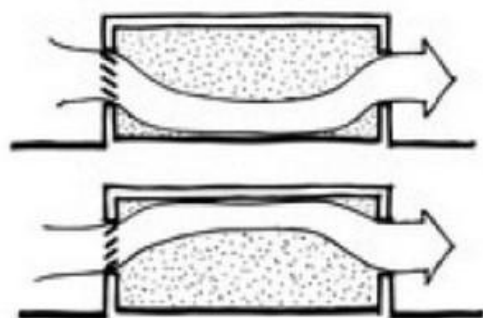
Place buildings at a 30 or 45 degree angle to the direction of wind for enhanced ventilation. Form can be staggered in the wind facing direction also to achieve the same result.



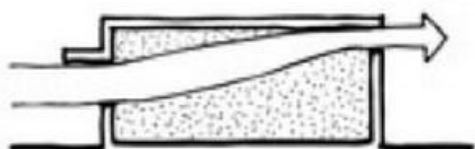
Taller forms in the wind direction of prevailing wind can alter the wind movement pattern for low lying buildings behind them



staggered layout helps in accentuating wind movement



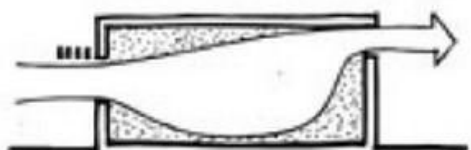
Louvres can direct airflow upward or downward.



A canopy over a window tends to direct air upward.

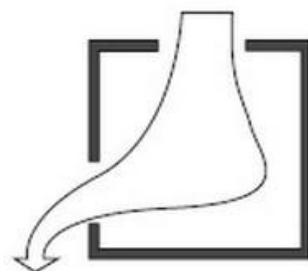


A gap between canopy and wall ensures a downward pressure.



Downward pressure is improved further in the case of a louvered sunshade.

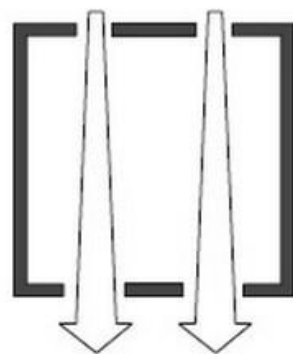
\_cross-ventilation



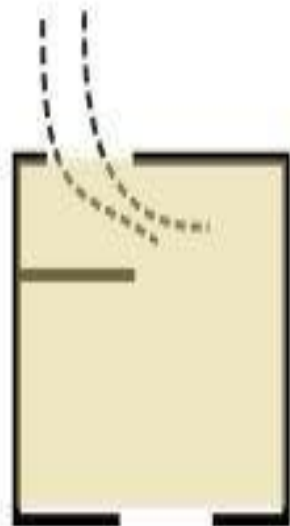
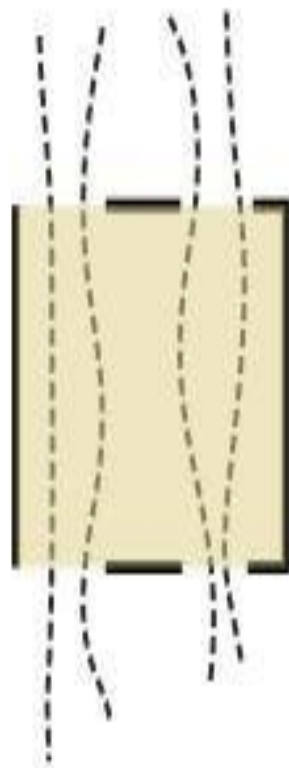
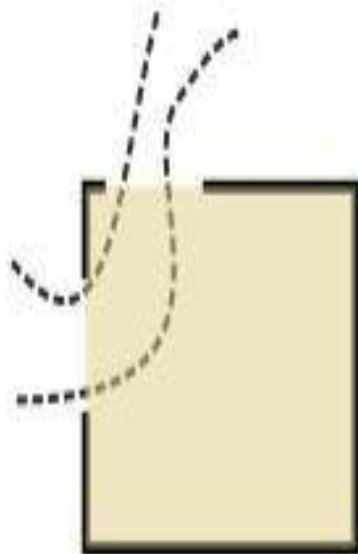
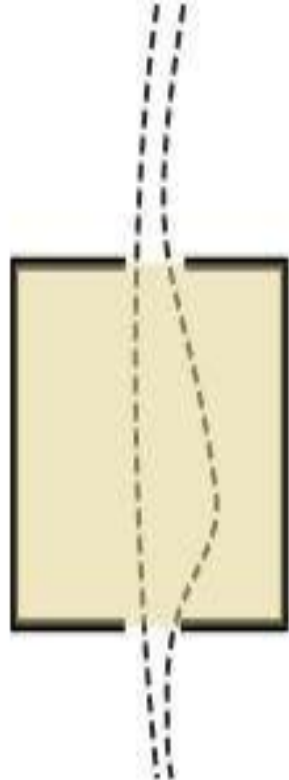
\_higher up windows to allow hot air to escape



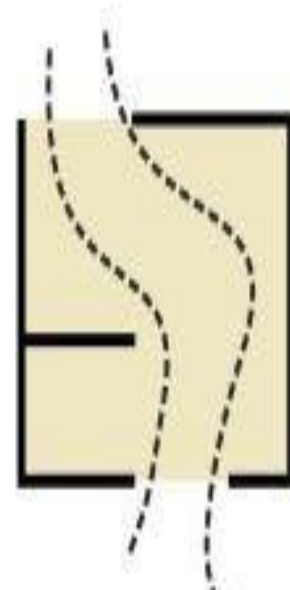
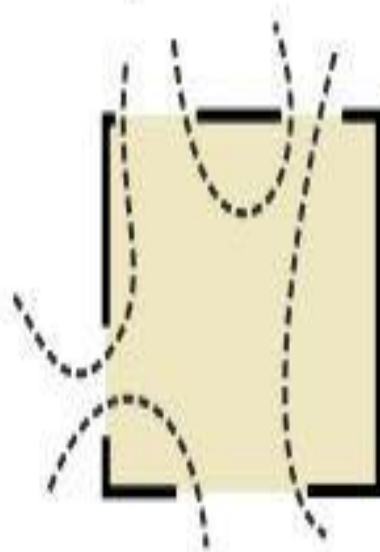
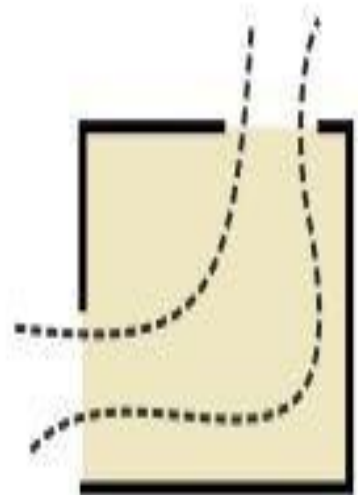
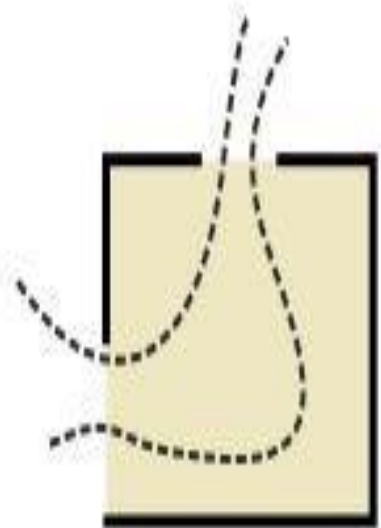
\_smaller inlet windows facing prevailing winds and larger outlet windows on opposite side

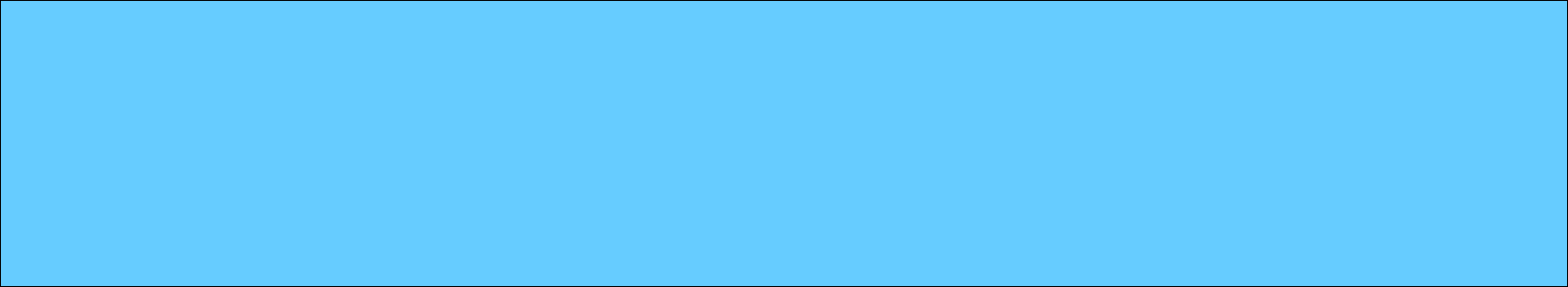


✗ Don't



✓ Do





# ***Understanding Energy, Energy Efficiency***

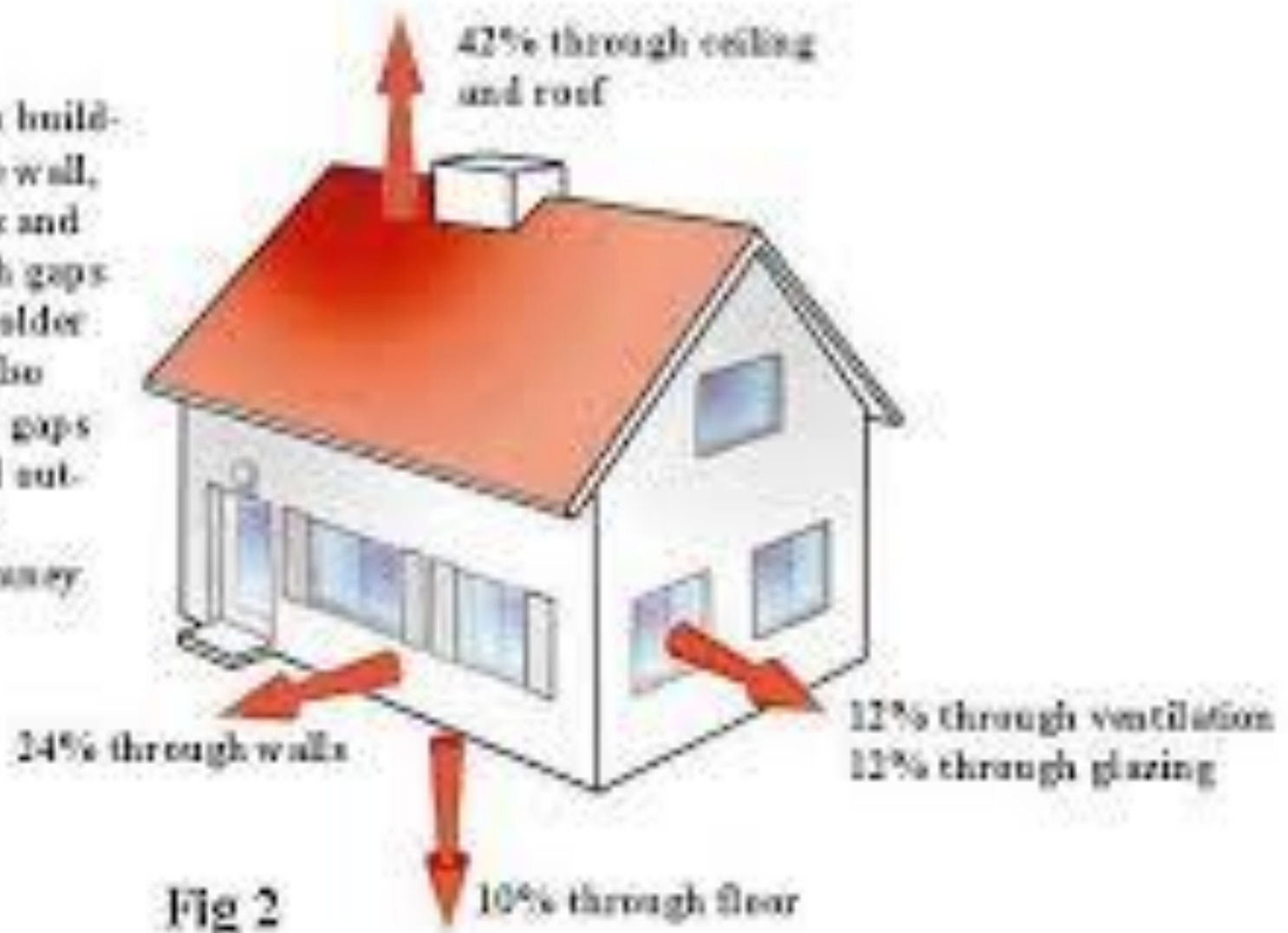




# Efficiency of Building Envelope

## HOW HEAT IS LOST FROM AN UNINSULATED HOME

Heat is lost from buildings through the wall, ceiling, windows and doors or through gaps and crevices, in older buildings heat also escapes through gaps in the lining and outside cladding or through the chimney.



# Energy Efficiency

- **Green buildings reduce energy consumption in two ways-**
  - i. **Embodied energy-** extract, process, transport and install building materials and
  - ii. **Operating energy--** to provide services to make buildings operational-- such as heating, lighting, air conditioning, ventilation and power for equipment.
- High-performance buildings use less operating energy,
- **Embodied Energy importance** – upto 15.7 % of total energy consumption.
- Use local materials/ materials which consume less energy for manufacturing
  - --buildings made of wood have lower embodied energy than steel/concrete
- **To reduce Operating energy –**
  - --reduce air leakage through building envelop
  - --Specify high-performance windows
  - --Provide extra insulation in walls, ceilings, and floors.
  - -- use Passive solar building design
  - -- Orient windows and walls rationally ,
  - -- Use trees shade windows /roofs during summer for cutting sun- in hot areas/zones
  - - while ensuring maximizing solar gain in winter- in cold areas
  - -- effective window placement (day lighting)-- to provide more natural light /reduce need for electric lighting during day.
  - -- Solar water heating reduces energy costs.
  - --Onsite generation of renewable energy through solar power wind power, hydro power or biomass significantly reduce environmental impact Of building

# Energy efficiency- Embodied energy

## What is embodied energy?

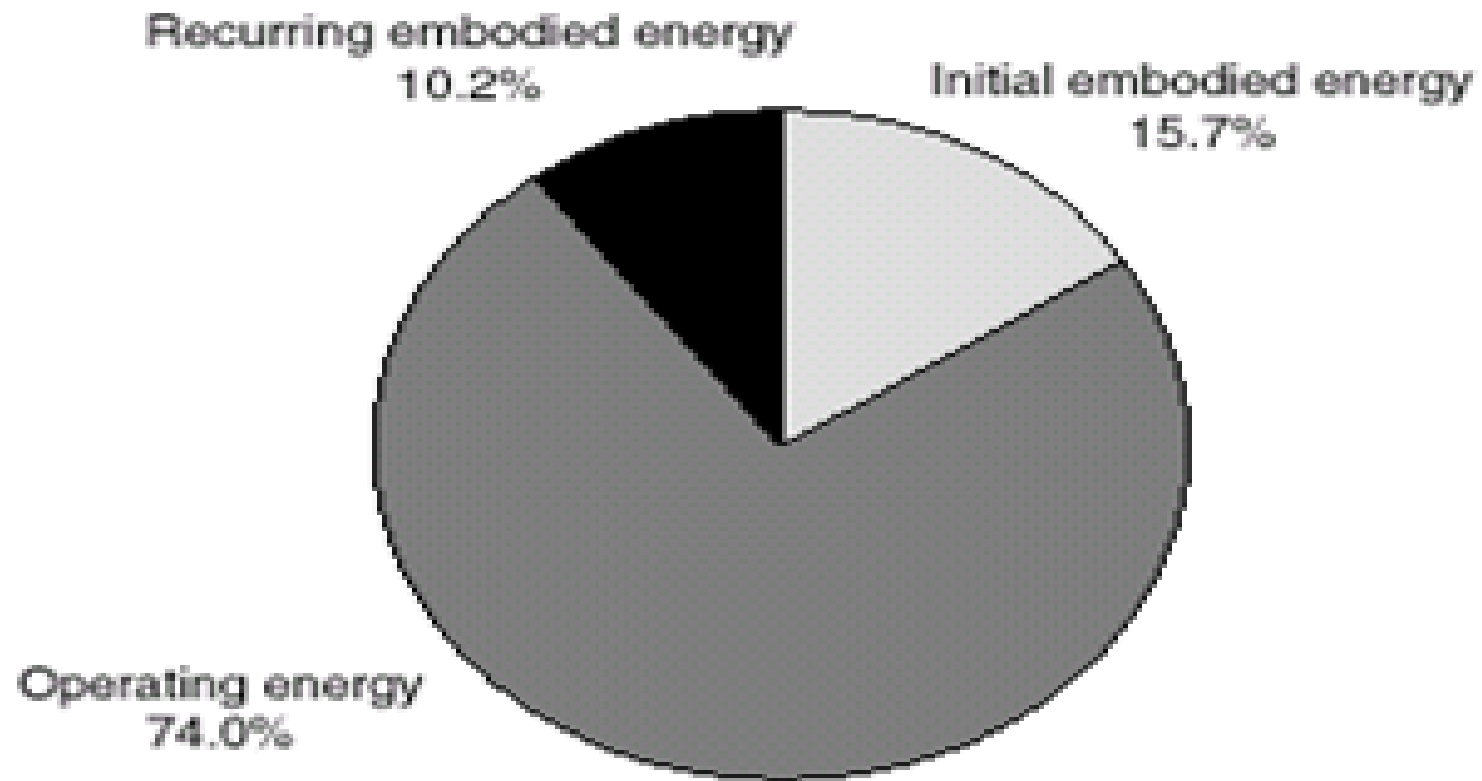
The quantity of energy required to manufacture, and supply to the point of use including:



- Extraction
- Transportation
- Manufacturing

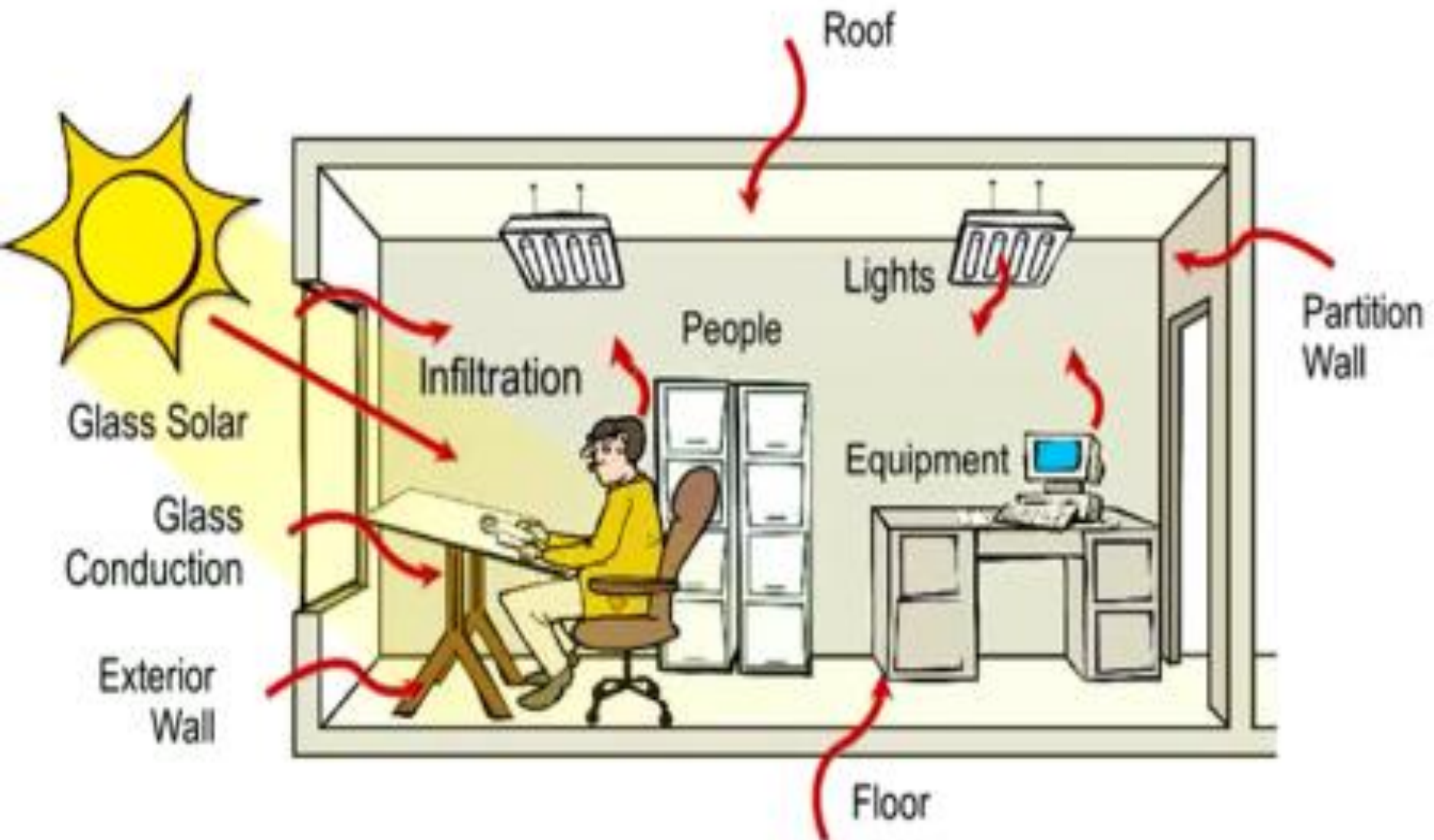
- Assembly
- Installation
- Some definitions also include:  
Disassembly & Removal

**Figure 3: Distribution of Life-cycle Energy Consumption.**





# Heat Transfer in a Building

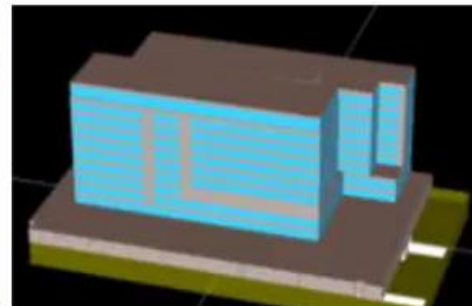
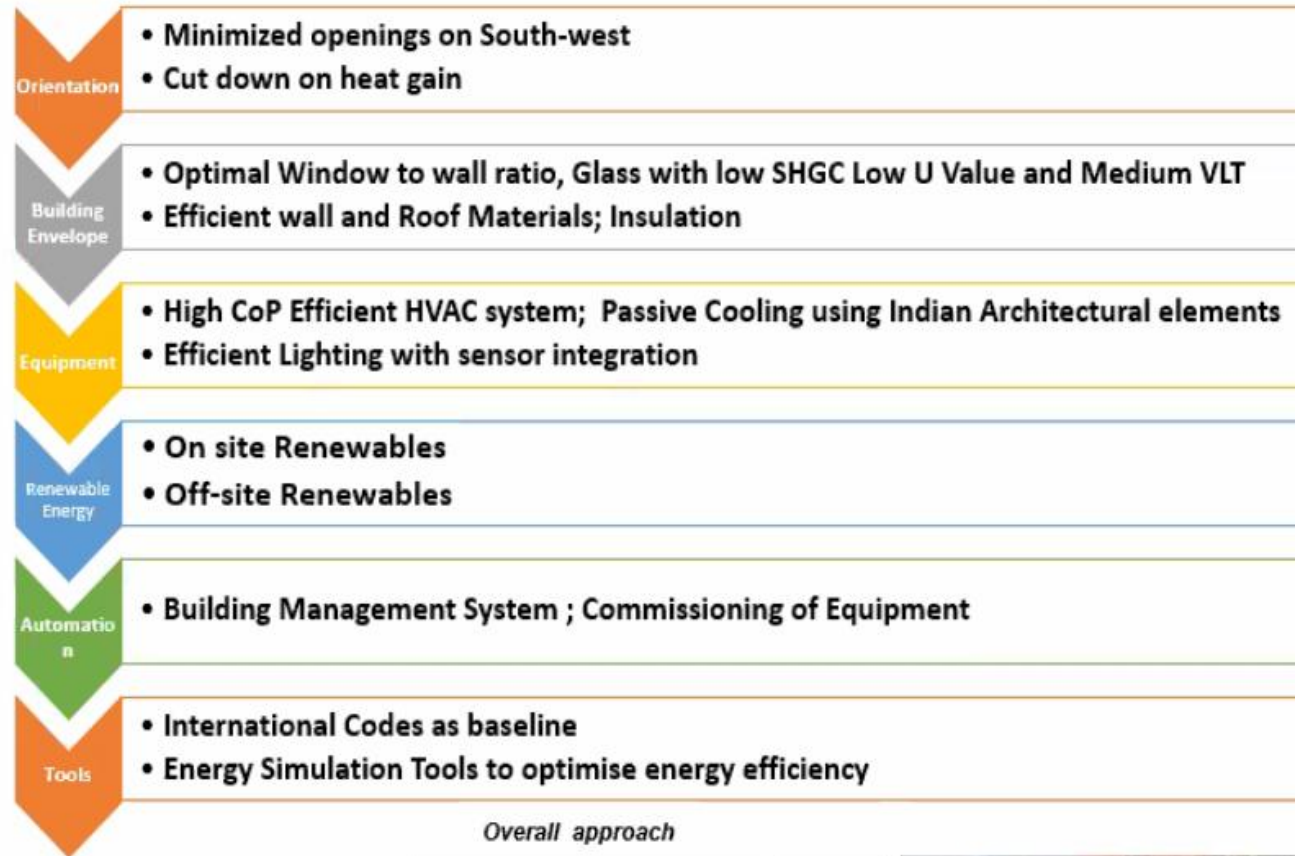


# Energy Efficiency

## ❖ Present Issues

- 35-40% of Country's energy consumption from buildings
  - ❑ 55% of power supply from Thermal power plants
- Focus on Initial Investment, rather than life cycle cost
  - ❑ HVAC systems

## Efforts to Address the issues through the rating systems



# High Performance Envelope

**Cavity Walls, Double Glazed Units, & Roof insulation**

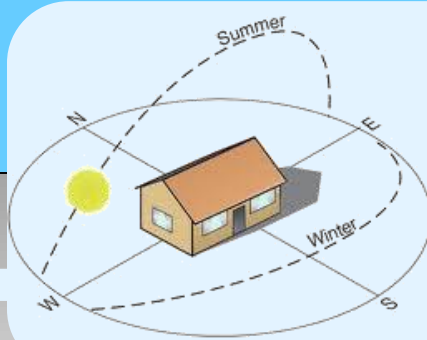
- ❖ **Reduced heat gain by design**
- ❖ **Significant energy savings**





# Cost effective strategy for energy efficiency

Reduce energy demand by **passive measures**



- Climate responsive architectural design
- Efficient building envelope
- Daylight harvesting
- Integration of natural sources for cooling & heating in building design.

Reduce energy demand by **active measures**

- Energy efficient equipment
  - Lights
  - Fans
  - Air- conditioners
- Efficient building Operation & Maintenance through BMS (Building Management System) & Smart Metering



Integration of **renewable energy**



Offset energy demand from the grid by installing on-site renewable energy

Least cost impact

Some cost impact

Highest cost impact



# Energy Efficiency

- Energy efficiency achieved through ;
  - *Adopting Passive design strategies* -- through building shape , orientation, passive solar design, use of natural lighting.
  - *Planning and Designing Spaces*- differentiating habitation/non-habitation
  - *Using natural light*- positively impact on productivity /well being.
  - *Installing high-efficiency lighting systems*-- with advanced lighting controls-- motion sensors / dimmable lighting controls.
  - *Using properly sized* / energy-efficient heat/cooling system in a thermally efficient building shell.
- 

# Energy Efficiency

- **Maximize- light/dark colours** for roofing / wall finish materials in hot/cold regions;
- -- **install high R-value** wall/ ceiling insulation;
- **R-value** -- measure of how well a two-dimensional barrier- layer of insulation/window/ complete wall/ceiling, resists conductive flow of heat
- **U-Value** -- measure of overall rate of heat transfer, by all mechanisms under standard conditions, through a particular section of construction.
- **R and U are inversely related** -- Higher R value and Low U value are good for managing heat transfer in hot areas
- -- **using minimal glass** on east/ west exposures.
- -- **Minimizing electric loads** from lighting, equipment, appliances.
- -- **Involving alternative energy sources** -- photovoltaic /fuel cells
- **Computer modelling** -- for optimizing design of electrical and mechanical systems and building shell.

# Energy efficiency- Day Lighting

*Rules of thumb to maximize day lighting without compromising thermal performance shall be:*

- Mark true north on all drawings.
- building placed with long axis running east-west.
- Minimize apertures on east and especially west
- Low sun angles for these orientations makes shading difficult without blocking entire window.
- Keep window-to-wall ratio between 0.30 and 0.40.
- Higher Window to Wall Ratio will require careful handling.



# Day Lighting

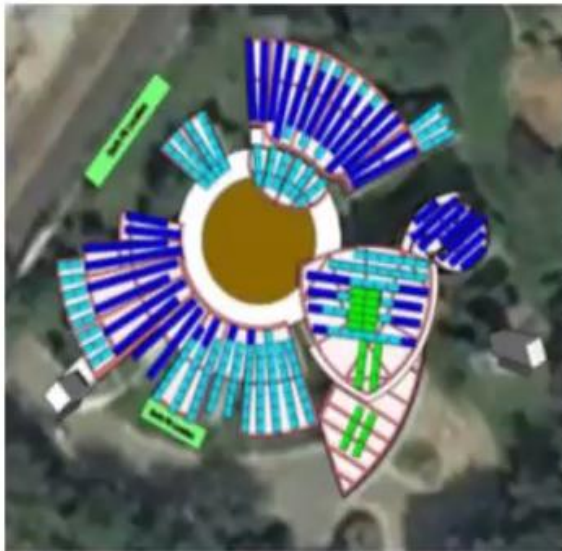


**Reduced lighting energy consumption through efficient use of skylight and light pipes**



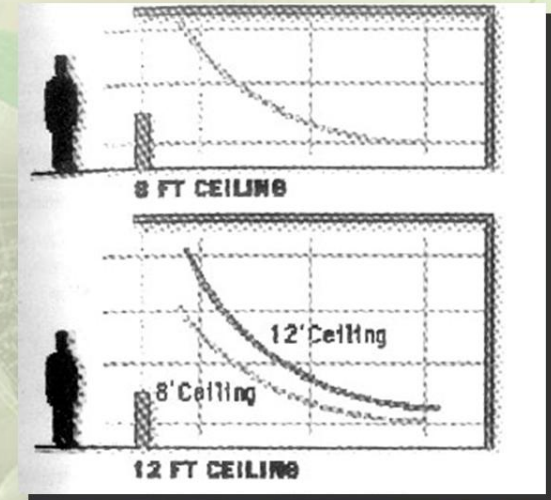
# Bifacial Solar PV Modules

- ❖ Transparent & frameless
- ❖ Energy yield enhanced with higher reflectivity
  - PV module with all-round & undisturbed reflection will have potential of higher energy yield
  - 20-30% with an elevation of 1.5 m

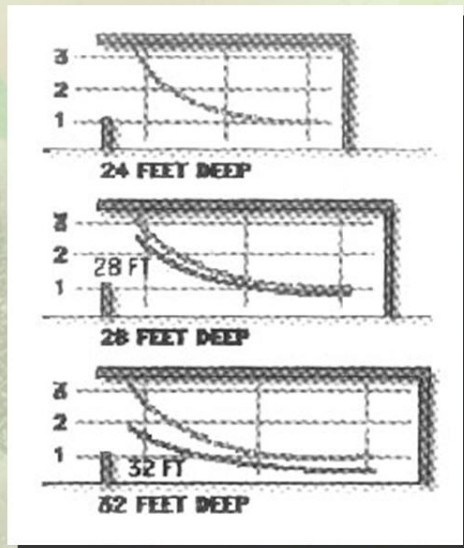


## EFFECT OF CEILING HEIGHT

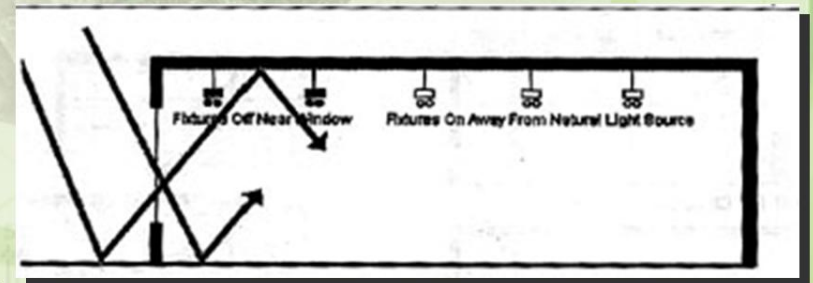
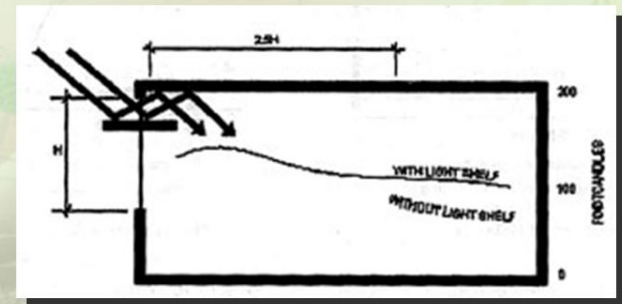
## DAY LIGHTING



## EFFECT OF ROOM DEPTH



## INTELLIGENT LIGHTING CONTROLE



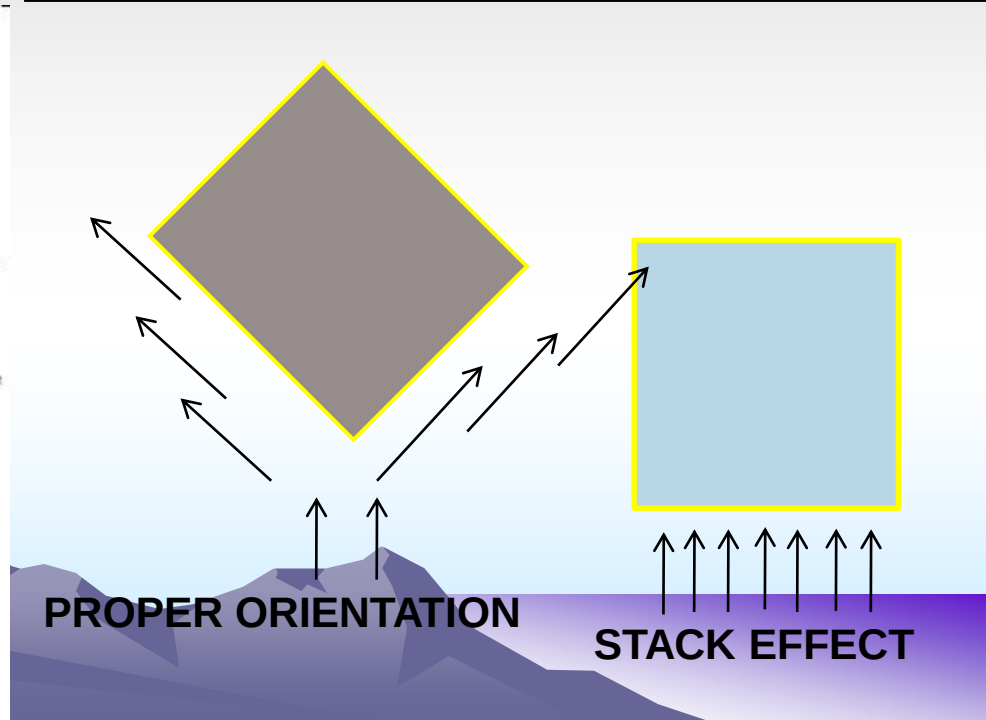
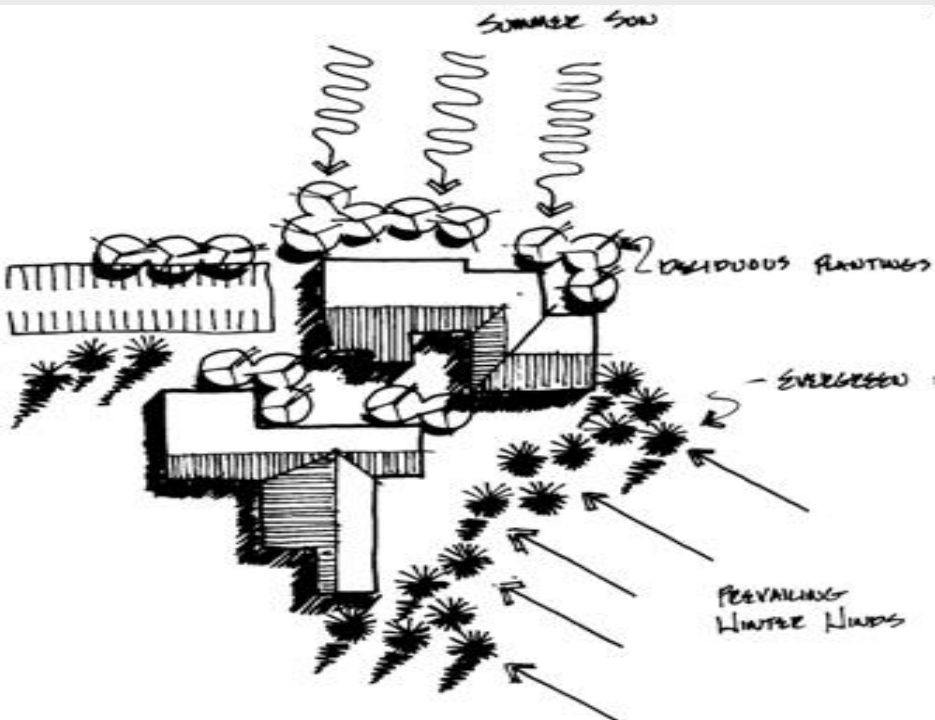
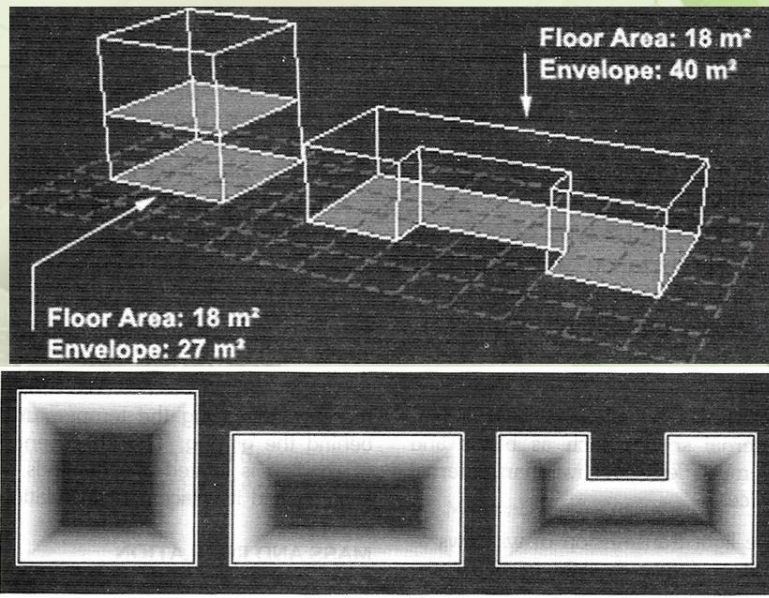
# Sun pipe- Day Light Harvesting



Sun Pipes used to lit basement,  
Avani Residences

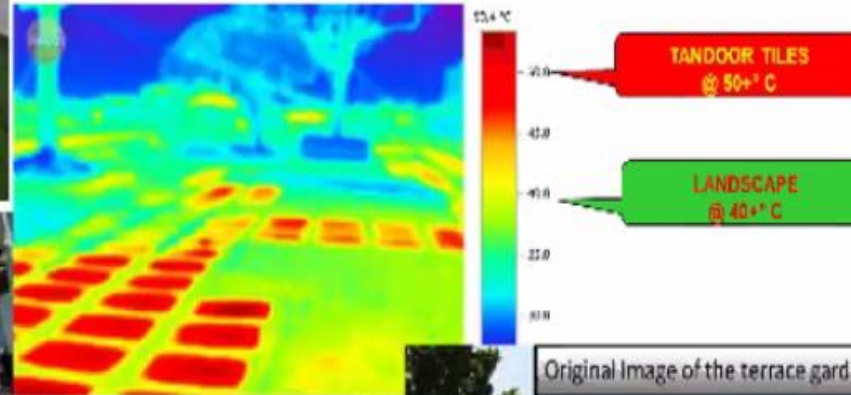


# Shape





# What Green Buildings did differently?



Thermal Image of the terrace garden

Thermal Image of Terrace Garden.

Vegetated Landscape helps in reducing the Heat Island effect.



Original Image of the terrace garden

# ***Water Efficiency***

Please

**USE WATER  
WISELY**

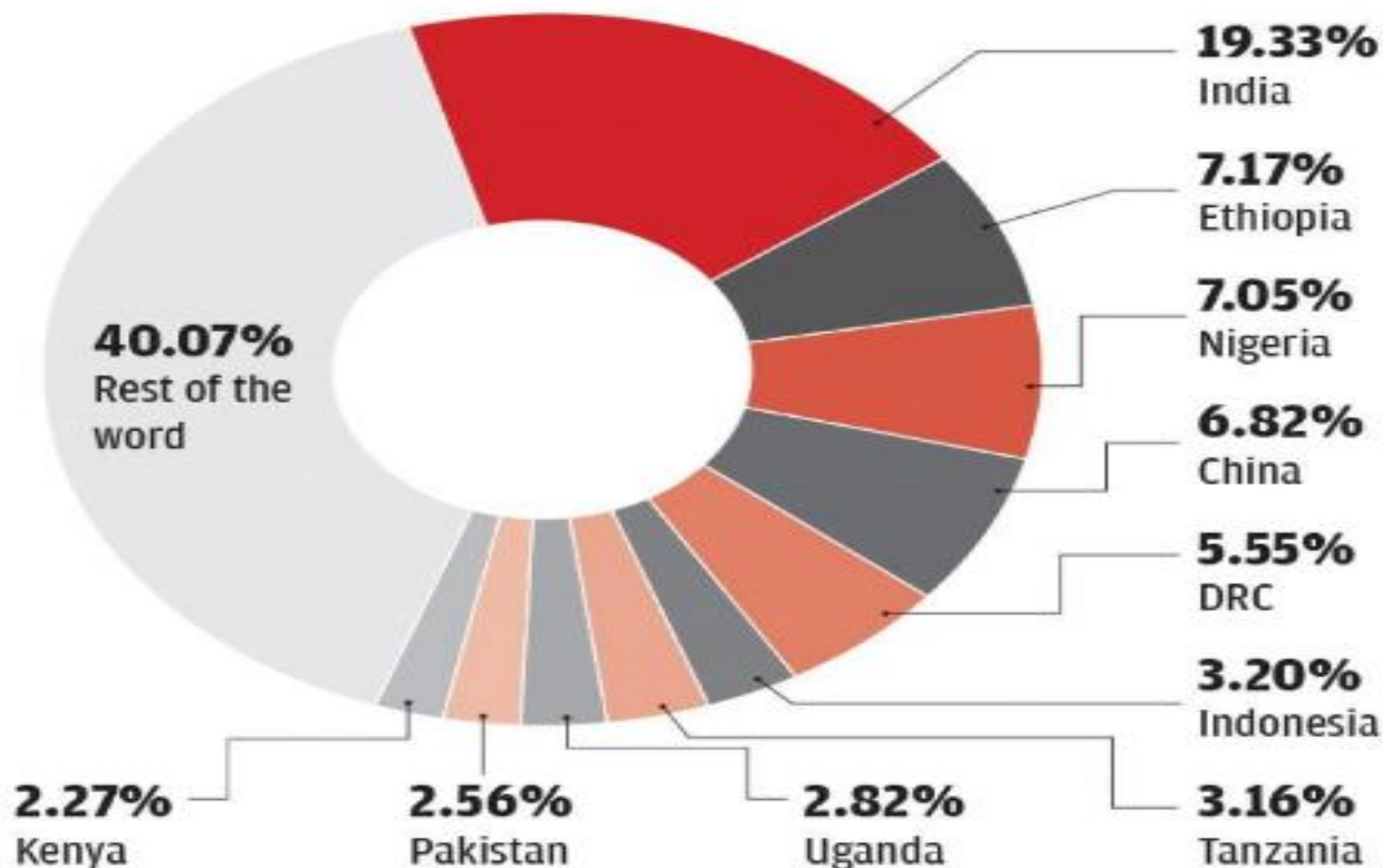


**EVERY  
DROP  
COUNTS**



# Waterless countries

Just 10 countries account for 60% of the world population without access to clean water



Source: The water gap—The State of the World's Water 2018 report by WaterAid

# Water Consumption

## Key drivers of water demand / consumption:

- Rapid growth of population- 17.7 % pop Vs 4% water
- -- Increased Urbanization
- -- Increased per capita income
- --- high consumption life style
- --- Industrialization
- -- Water intensive fixtures
- --Water intensive agriculture crop
- --Inefficient Water based Sanitation system
- --Large Misuse /wastage of water
- - Poor water management
- - ***Critical issue of water consumption --***
- ----demands on supplying aquifer/sources
- -- exceeding its ability to replenish itself



# Water Conservation

## ❖ Present Issues

### ➤ Water Management

- ❑ 3.7% of world's water resources, 17% of world's population

### ➤ Depleting Ground water

- ❑ 21 Cities in India may run out of ground water by 2022

### ➤ Stress on Municipalities

- ❑ Rapid Urbanization leads to stress on water supply
- ❑ Treatment of Waste Water

## Efforts to Address the issues through the rating systems



Overall approach



Rainwater Harvesting Pits



Rainwater Harvesting Ponds



Water Efficient Plumbing Fixtures with Aerators



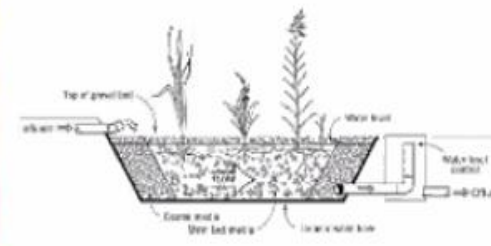
Waterless Urinals



Dual Flush system with Low Flush rates

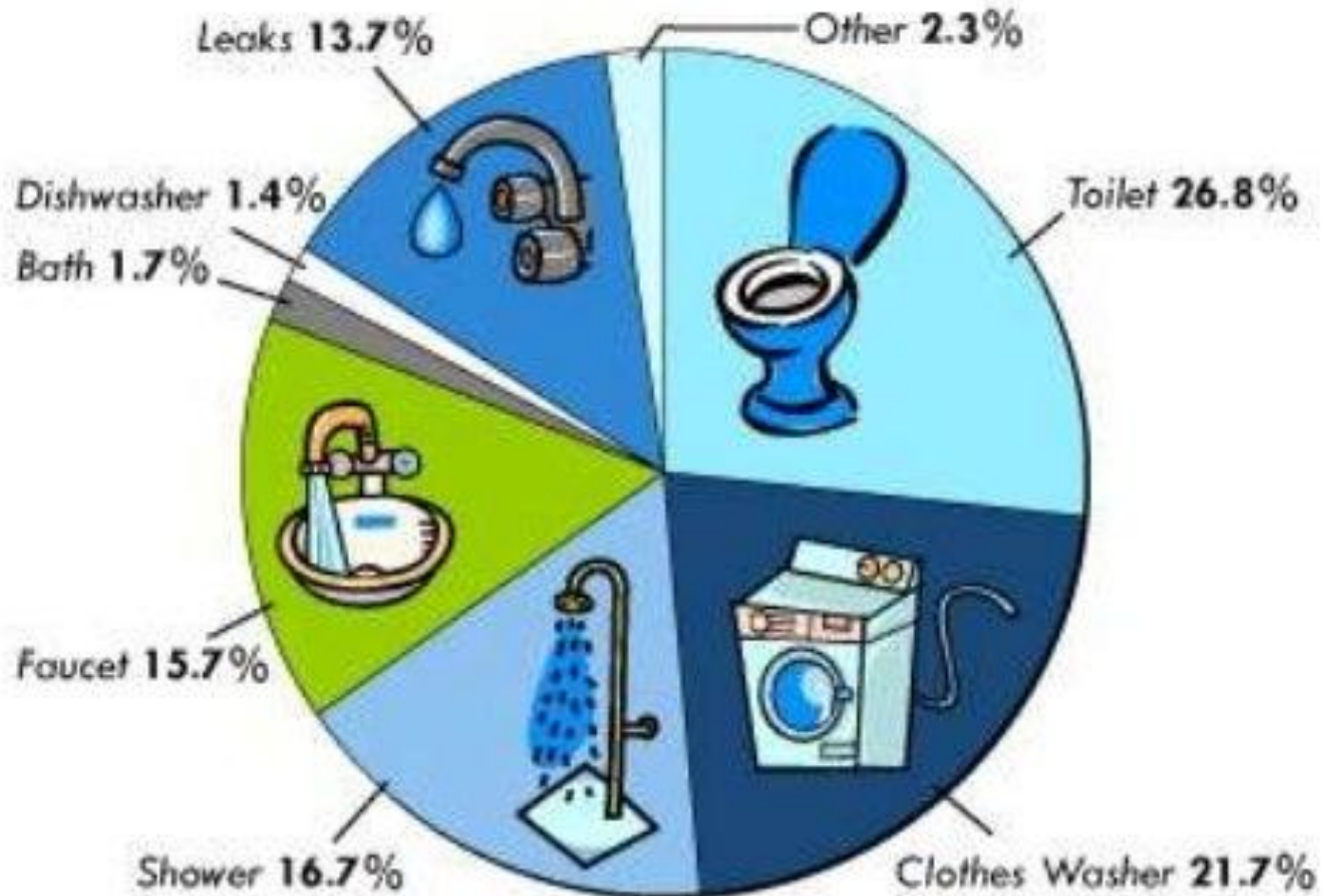


Efficient Irrigation System



# Domestic use of water

## Indoor Household Water Use

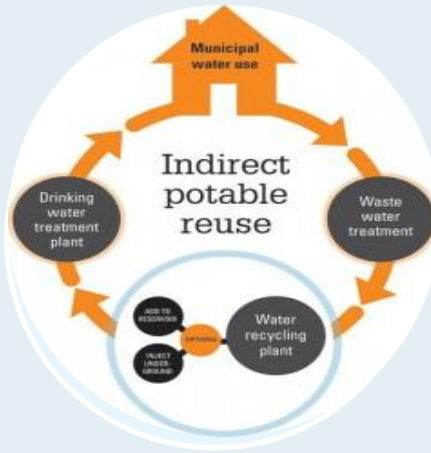


Source: Awwa Research Foundation (1999)

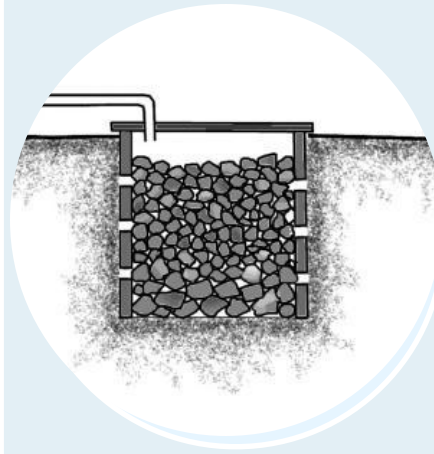
# Approach



**Reduce**



**Recycle/  
Reuse**



**Recharge**



**Refuse**



# **Water Management**

- **Key objectives of water sustainability-**
  - **i Value water**
  - **ii Protect water sources**
  - **iii. Conserve water;**
  - **iv. Protect water quality**
  - **v. Reduce consumption; Regulate water consumption -slow the flow; Use Dual Plumbing**
  - **vi Source water from rain**
  - **vii. Recharging Ground water**
  - **viii. Minimise use of water in agriculture**
  - **viii. Integrate the urban and rural water planning**



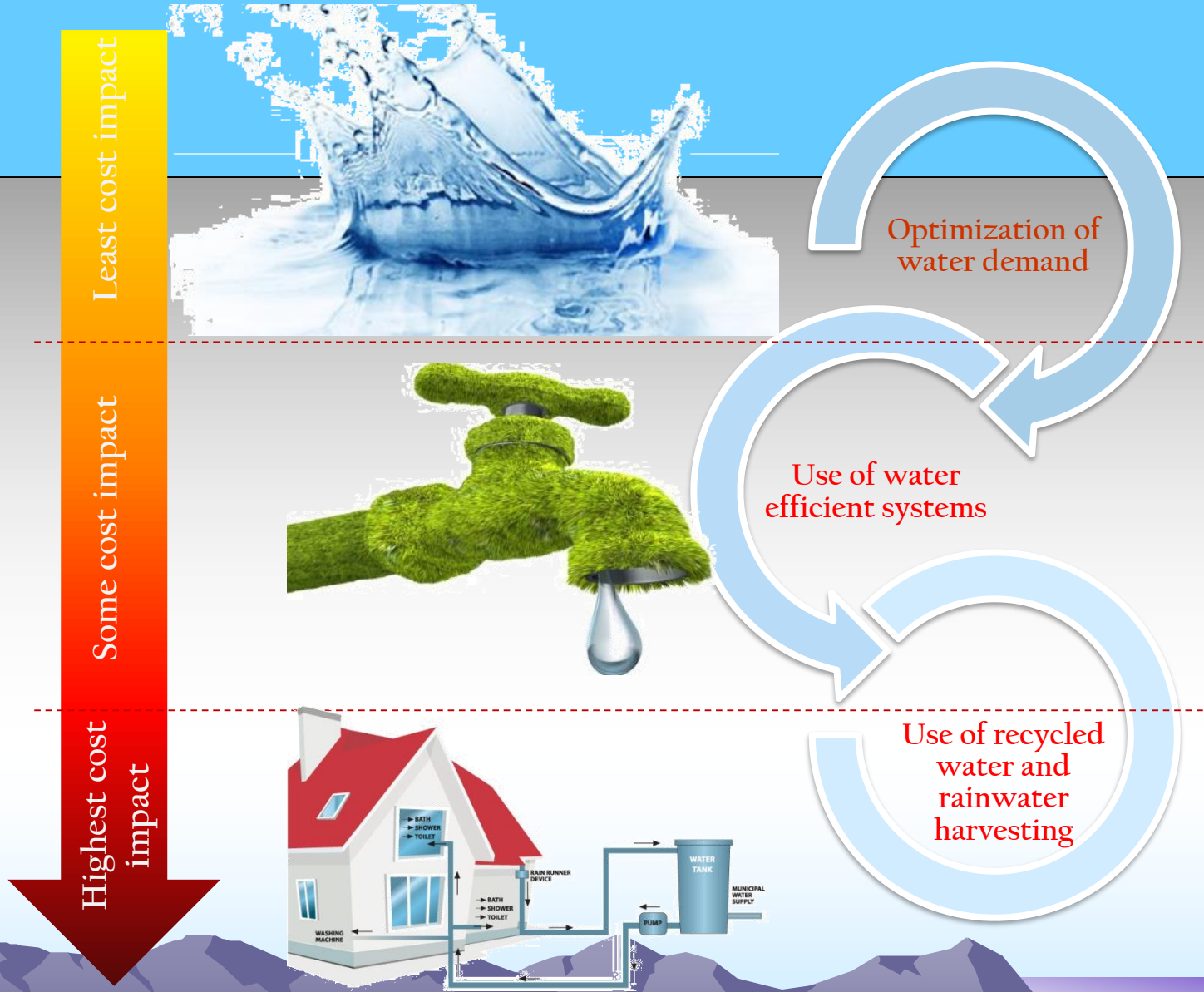
# Water Efficiency

- **Adopt Strategies for** - Slow the flow/ breaking water /water conservation/RW Harvesting/Ground water charging/ multiple use of water
- **Design for dual plumbing--** using recycled water for toilet flushing / gray water system that recovers rainwater or other non-potable water for site irrigation.
- **Minimize wastewater--** use ultra low-flush toilets, low-flow shower heads/ water conserving fixtures.
- **Use Re-circulating systems** for centralized hot water distribution.
- **Installing point-of-use hot water** heating systems-- for more distant locations.
- **Metering water use** – both for domestic/ landscape separately
- **-- Promote micro-irrigation** /sprinklers / high-pressure sprayer-- to supply water in non-turf areas.
- **Involving communities** --Through education /incentives
- **Promoting Green Buildings as a Brand**

# Water Management

- Optimizing water usage :
- Water efficient fixtures
  - i) W Cs-- *conventional system use- 13.5 liters/flush whereas*
    - *low flush uses 6 liters and*
    - *latest ultra low flush uses 3 liters-saving of 40-50%*
    - *Aim is to create waterless toilets*
  - ii) Urinal
    - *Conventional urinals use 7.5-11 liters/flush,*
    - innovated flush system reduce water to 0.4 liters or more*
    - Zero water urinals/ waterless urinals,*
    - *Timed flush system ,*
    - Sensor controlled automated system,*
  - iii) Faucets-
    - Conventional faucet uses 15 liters of water/ minute*
    - *low flow faucets use --2 liters/minute*
  - iv) Shower Heads–
    - *conventional showerheads use 11-26 liters/minute*
    - *replaced by low flow shower heads using 9 liters/min or even less-*
    - use narrow sprayer and effective mix of air and water*

# Cost effective strategy for water efficiency



# XERI-SCAPING





# Landscape Design



**Azadirakta Indica**

***Native***



**Cactus Family**



**Palm Family**

***Drought  
Tolerant***



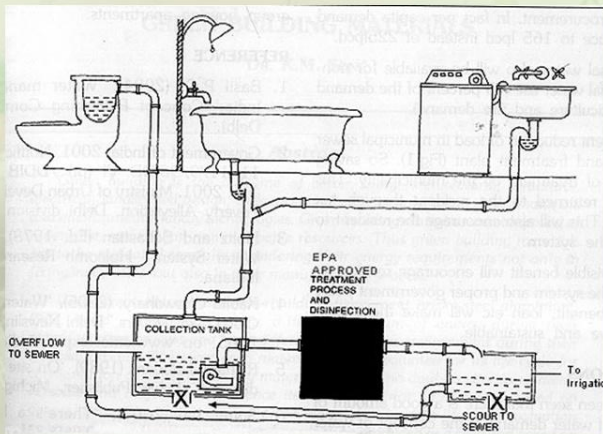
**Pinus**

***Adaptive***

## Water Efficiency

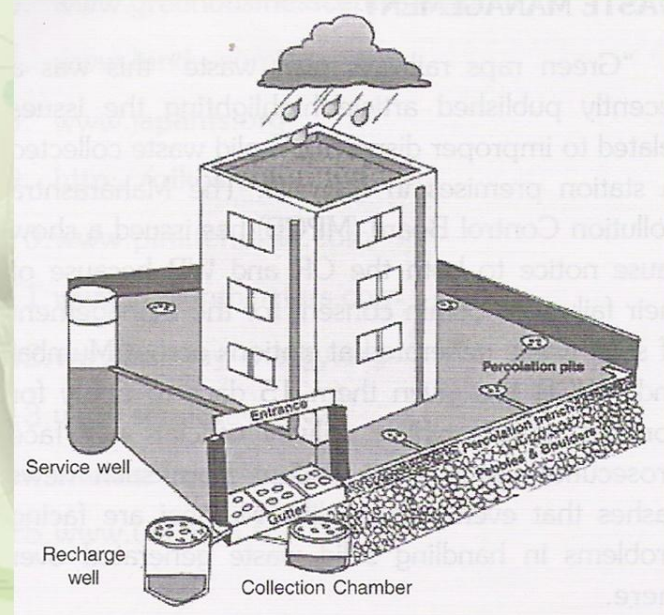
Use of low – flush toilets,  
water less urinals,  
sensors control taps for washbasin  
and  
water conserving system to  
minimize the waste of water

## Recycling of grey water



The dual plumbing system in which used water can be recycled for flushing of toilets and drain water can be used for irrigation and gardening purposes.

## Rain Water Harvesting







# Green Materials





# ***Structure design efficiency***

***Building / construction sector accounts for;***

***-- Half of total Energy usage***

***- Consumption of 1/3<sup>rd</sup> of raw material***

***- Causing depletion of natural resources***

***- Need to - Optimization / selecting***

***-- innovative structural systems***

***— which help minimizing weight of structure-***

***- Reducing self load/dead load of buildings***

***-for minimizing consumption of natural resources.—different Structure varieties having-typical shapes/ cross-sections -- being developed to optimize use of Materials***

# Green Material

- **Building materials considered 'green' include:**
  - rapidly renewable plant materials -- bamboo and straw,
- stone, recycled stone, recycled metal ,
- **Non-toxic, reusable, renewable, and/or recyclable Products include--**
  - - Recycled industrial goods--.
  - -- Coal combustion products, foundry sand,
  - -- Demolished debris in construction projects

## **Green materials are:**

- Made up of recycled content
- Containing natural/ renewable content
- Available Locally
- Reduced transportation.
- Salvaged/refurbished or remanufactured
- Reusable or recycled
- Durable - last longer than their conventional counterparts
- **Materials assessed on the basis of--**
  - -- Life Cycle Analysis (LCA) --
  - embodied energy,
  - durability,
  - recycled content,
  - waste minimisation, and
  - -- ability to be reused /recycled.

# ***Building Material choices***

- *Materials also help in modulating temperature within Building*
  - *Using UV reflective paints -on exterior walls-- reduce heat gain of the building.*
  - *Using;*
    - *-- light color material including*
    - *--China mosaic white finish,*
    - *-- vermiculite concrete,*
    - *-- polystyrene insulation –*
    - *as a roofing material*
    - *-- minimises heat gain*
    - *-- into building*
- 

# Green Material - Fly Ash Bricks





# Fly Ash Bricks- Advantages

- ***Reduced Embodied Energy***: using Fly ash- lime- Gypsum bricks-- 40% reduction in embodied energy of masonry.
- ***Environment Friendly***: Fly ash brick uses unfired Fly Ash technology -- CO2 emissions in manufacturing process limited..
- ***Excellent Thermal Insulation***: Buildings using fly ash bricks -- cool in summers and warm in winters.
- ***Fire Resistance: very high***-- as these bricks composed of fly ash as its major constituents, which is un-burnt residue of the coal fired in a thermal power plant.
- ***No Efflorescence***: Fly ash bricks resist salt and other sulphate attack, ensuring no efflorescence in structure.

# Autoclaved Aerated Concrete



## **Autoclaved aerated concrete**

- (sand, calcined gypsum, lime (mineral), cement, water and Aluminum powder,)
- -- versatile
- - lightweight construction material
- used as blocks which are:
  - Lightweight
  - low density with
  - excellent insulation properties.
  - good acoustic properties
  - durable
  - good resistance to sulphate attack
  - damage by fire /frost.
  - used as inner leaf of a cavity wall.
  - also used in outer leaf,
  - when rendered in foundations.

## **Autoclaved aerated concrete**

- easily cut to any required shape.

# UPVC( Unplastisized Polyvinyl chloride) doors and Windows



## The Vinyl windows

- excellent insulators :
- Reduce heating / cooling loads by:
  - preventing thermal loss through frame / sash material
- not affected by -
  - weather/ air pollution / salt, acid rain/ industrial pollution ,pesticides ,smog, discoloration/ structural damage .
  - user friendly
  - Eco- Friendly
  - ,-- readily accepted and safe

# Bamboo

## i. **Strength at par with hard wood**

--- Bamboo extremely strong natural fibre, on par with hardwoods-- when cultivated, harvested, prepared and stored properly

-- Bamboo, like true wood, is a natural composite material with a high strength-to-weight ratio useful for structures.

-- **Bamboo has higher compressive strength than wood, brick or concrete and a tensile strength that rivals steel**

- ii **High Flexibility** - Bamboo highly flexible--during growth trained to grow in unconventional shapes.

-- After harvest, may be bent /utilized in archways / curved areas.

iii. **Earthquake-resistance** - Great capacity for shock absorption, -- makes it useful in earthquake- prone areas.

**iv. Lightweight** - Bamboo extremely lightweight.

- Building with bamboo can be accomplished faster with simple tools than building with other materials.

-Cranes /other heavy machinery rarely required.

- v. **Cost-effective** – Economical

- especially in areas where cultivated/ readily available.

- Transporting cost also much lesser.

- Helps achieve cost effective construction.





# Bamboo

- vi. ***Durable*** - Long-lasting --as its wooden correlates, when properly harvested and maintained.
- vii. ***Fast Growing***--Bamboo fast growing species / renewable resource which can be cultivated in most types of soil. •
- viii. ***Simple designing***- Designs of Bamboo components being simple, there is no need of highly skilled labour.
- ix ***Reducing use of wood***-- Dependency on natural forests for wood reduced thus contributing to the protection of the environment.
- x ***Eco- friendly***-- As it can grow in many types of soil, bamboo cultivation is suitable for rehabilitation of degraded forests and other waste lands thus converting them into fertile lands
- xi ***Promoting Employment***-- Creating employment opportunities especially for rural people --as Bamboo manually woven before making them into Bamboo Mat / Boards, Bamboo Mat Veneer Composites and Bamboo Mat Corrugated Sheets.
- xii ***Promoting Welfare of society/poor***- **Promotes** overall welfare of the society, particularly of economically weaker section.
- xiii ***Reducing GLOBAL warming***- Captures 17 mts CO2 per hectare per year- more than any specie
- xiv ***Improves indoor air Quality***- **By** removing carbon and adding oxygen when used as Indoor plant



# India Pavilion made of Bamboo at Shanghai expo 2010





***Construction  
Technologies-  
On Site- Off Site  
Pre- fabrication***

# Pre- fabrication Construction/Advantages

- **Green Construction**

- -Modular buildings require less power consumption compared to traditional constructions,
- ---lower life cycle energy implications as compared to on-site construction
- -- have minimum requirement of water due to absence of onsite watering of brick/concrete
- -- Energy efficiency achieved through using recycled materials
- -- Resource efficient greener construction process-- due to reduced material waste/ use of recycled materials

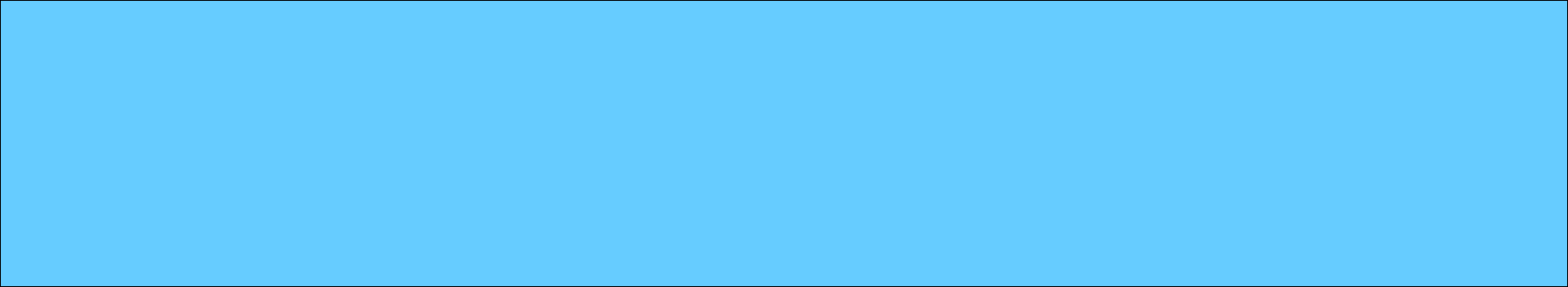
- **Flexibility**

- Flexibility --based on easy dismantling /Relocation of buildings to different sites,
- being made of numerous individual parts-- also permit flexibility in building structure/ design by changing design of specific prefab component.



# Crystal Palace London





# *Indoor Air Quality*



# Indoor Air Quality

- **Indoor air quality essential for**  
Ensuring quality in workplaces enables :
  - reduction in fatigue / tiredness of occupants and
  - fosters better health and performance.
- **When people themselves are main source of emission.**
  - Carbon dioxide concentration and indoor air quality in interiors important indicator-- that quality of indoor air is bad/good
- **Poor indoor air quality leads to**
  - tiredness,
  - lack of concentration and
  - can even bring about illnesses.
- **CO2 concentrations should not to exceed 1,000 ppm**

# Indoor Air Quality

## **Causes of poor indoor air Quality—**

- i. Poor ventilation**
- ii. Outdoor air quality/impurities**
- iii. Poorly insulated Building Envelop**
- iv. Smoking**
- v. Use of toxic building material**
- vi. Use of High VOC compound based paints for walls**
- vii. Dampness/water intrusion- microbial contamination**
- viii. Use of VOC based cleaning agents**
- ix. Poor Lighting**
- x. Furniture**
- xi. Floor Coverings**
- xii. Poor pollution controls-- during construction**
- xiii. Damaging existing vegetation/trees**
- xiv. Poor site planning/management**
- xv. Carpeting of floors**
- xvi. Using pesticides,**



# Promoting health and wellbeing

- Promoting health and wellbeing by;
  - **Bringing fresh air inside/ Delivering good indoor air quality--** through ventilation-- avoiding materials / chemicals -- creating harmful /toxic emissions.
  - **Incorporating natural light** / views--to ensure building users' comfort /enjoyment of surroundings/ reducing lighting energy needs .
  - **Designing for ears/ eyes** – through Acoustics /sound insulation-- for promoting concentration, recuperation/ peaceful enjoyment of a building-- in educational, health /residential buildings.
  - **Ensuring Environment comfort** --through right indoor temperature
  - **Adopting Passive design**
    - Using sustainable building materials-- like wood/recycled glass/renewable materials like rubber / bamboo.*
    - Choose interior finish products with Zero or low VOC emissions*
    - Using Indoor plants*
    - Eliminating dampness*
    - Avoiding Carpeting*
- 

# Improving Indoor Air Quality through Plants – Air Purifiers

**Areca Palm**



**Best air purifying plants for  
general air cleanliness**

**Snake Plant**

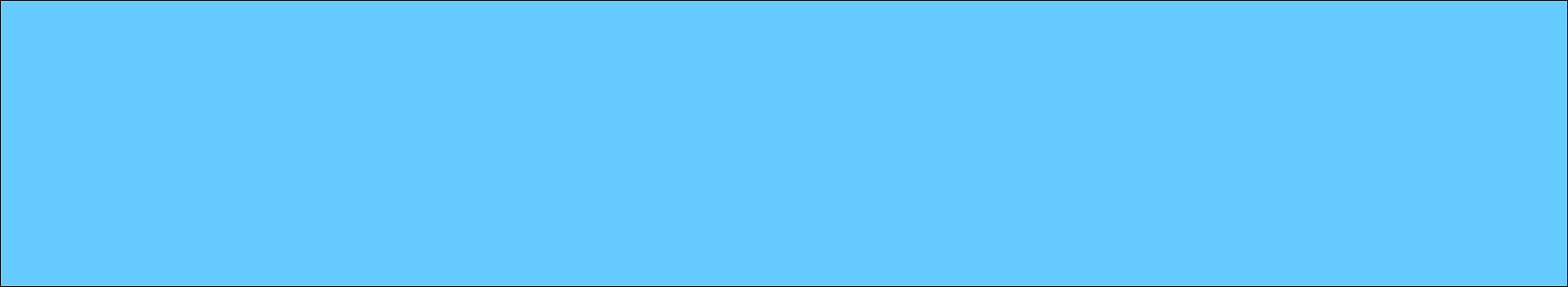


**Removes Nitrogen Oxides  
& absorbs formaldehydes**

**Money Plant**



**Best Air Purifier**



# ***Intelligent Buildings***



# INTELLIGENT BUILDINGS

- Intelligent buildings -- products of
  - Growth of information technology.
  - better building performance
  - Maximizing economy in buildings.
  - Minimizing maintenance.
- Intelligent buildings synthesis of--
  - Innovative building designing (with nature).
  - Using/integration of technology.
  - Using natural resources.
  - Skillful management.
  - High degree of automation.
- Convergence of green / intelligent buildings provide optimum solution for
  - Safe
  - Ambient work/living areas,
  - Creating highly sustainable/productive buildings.

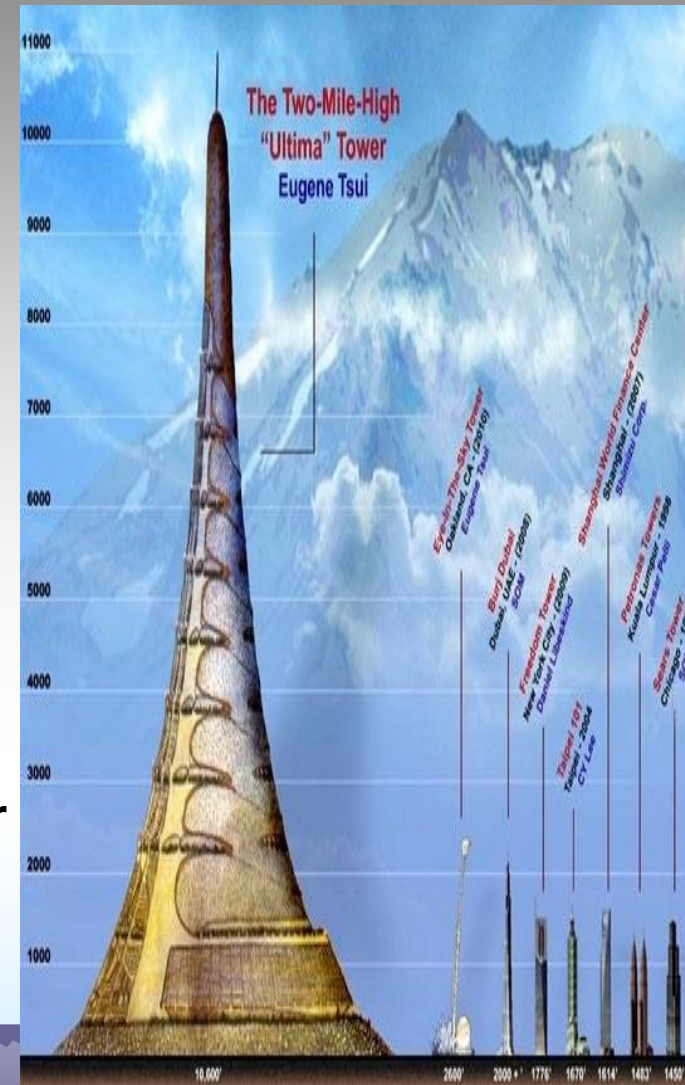




# Future Cities-Conceptual

## Ultima Tower- 2Mile High Sky City

- Location: Any densely populated urban environment
- Date: 1991
- Cost: \$150,000,000,000
- Population: 1,000,000
- Exterior surface area of building: 150,000,000 sft
- Enclosed volume: 53,000,000,000 cubic feet
- Total enclosed acreage: 39,000 acres
- 156 Chandigarh Sectors
- Elevator speed:-- 20 feet per second (13 miles per hour)
- 9 minutes and 40 seconds to reach top floor from ground floor.
- Dimensions: Height--10,560 feet;
- Diameter at the base--6000 feet;
- Number of stories--500;



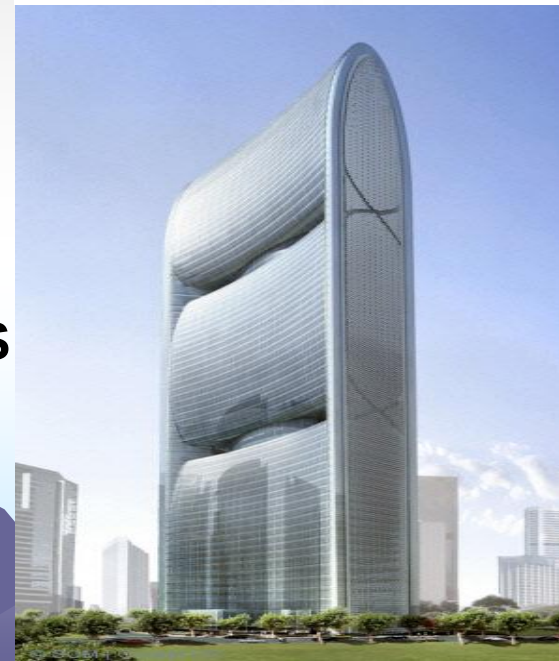
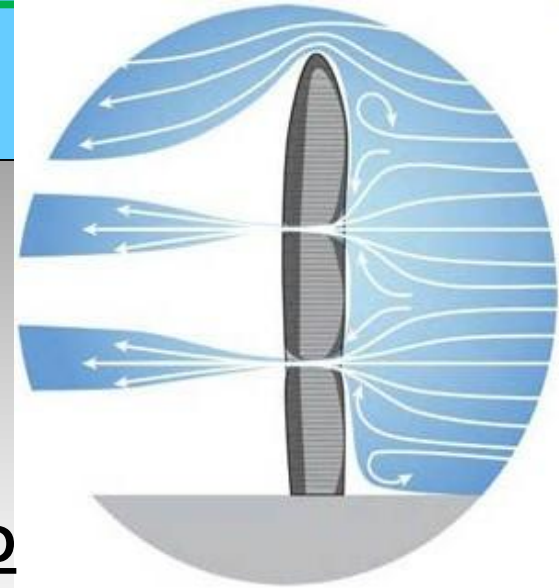
# PEARL RIVER TOWER- GUANGZHOU, CHINA

## NET ZERO ENERGY BUILDING



**YEAR OF COMPLETION- 2011**  
**SITE AREA-10635SQ.M.**  
**PROJECT AREA- 214,100SQ.M.**  
**(2.3MILLION SQ.FT.)**  
**NO. OF STORIES- 71**  
**HEIGHT OF BUILDING-309 M**  
**ENERGY EFFICIENCY ACHIEVED**  
**THROUGH**

- SOLAR PANELS/  
PHOTO VOLTAIC CELLS**
- WIND TURBINES**
- DAY LIGHT HARVESTING**
- DOUBLE SKIN CURTAIN WALLS**
- CHILLED CEILING WATER  
UNDER FLOOR VENTILATION**





# Godrej Sohrab ji Building- Hyderabad- India's first platinum rated building



# Bahrain World Trade Center - Bahrain



- Generating 15% energy from windmills
- Two 240 meter twin sky scrapers joined by three windmill--, each 3 meters wide, attached to walkways
- :designed/ built by Atkins in city of Manama



# ***Cooling Cities***



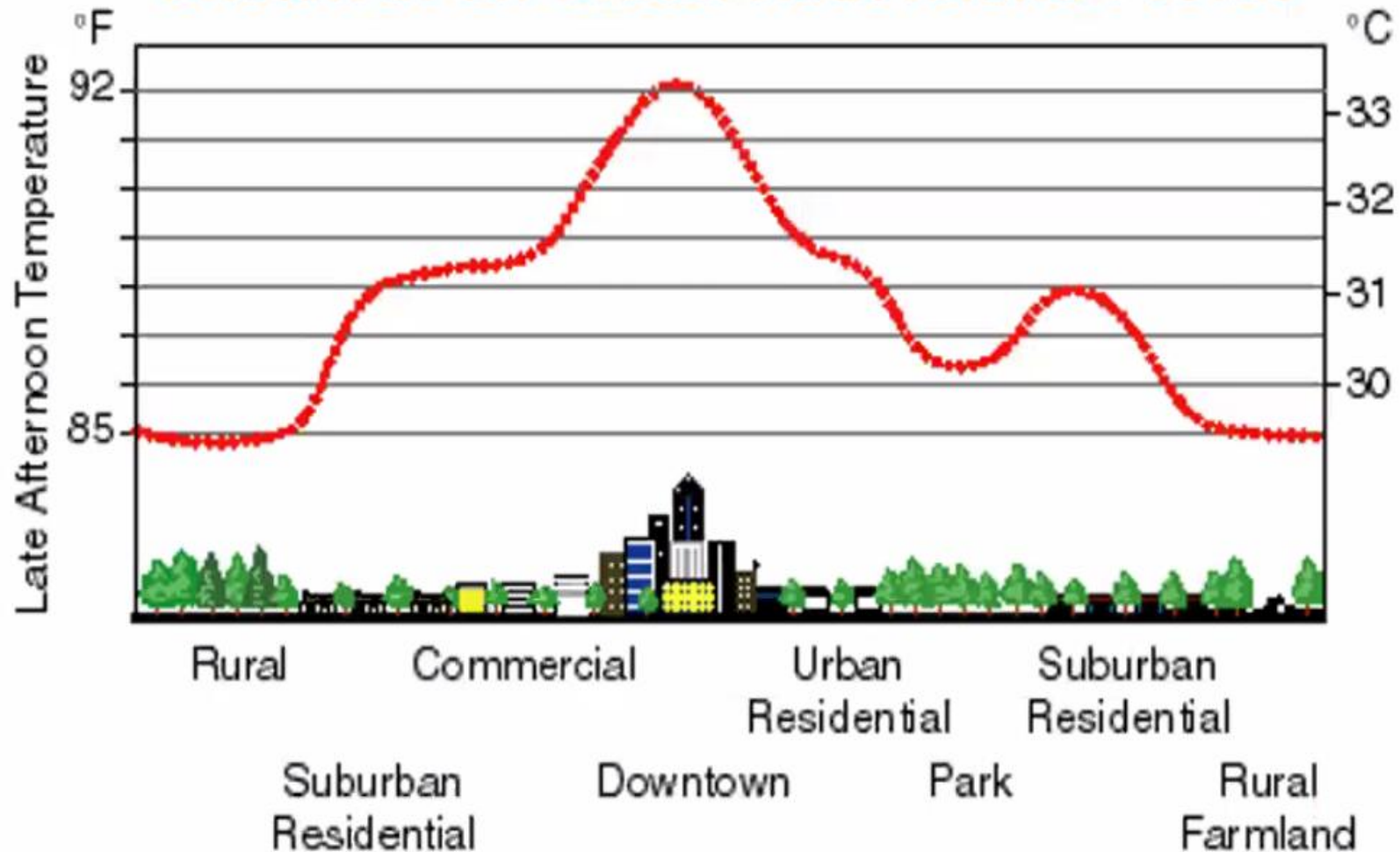


# ***Present Cities- Concrete Jungle !! ??***



# Urban Roofs : Heat Islands

## Sketch of an Urban Heat-Island Profile





# *Greening Cities*





# *Greening Buildings*





# *Greening Buildings*



# Conclusion- Green Buildings

- Practices / technologies for green building constantly evolving
- Differ from region to region—
- -- *However, fundamental principles remains almost same, ---*
- 1. Optimum Site Planning
- 2. Optimum Building Envelop
- 3. Ensuring high degree of Structure design efficiency
- 4. Ensuring optimum level of Energy efficiency,
- 5. Promoting Water efficiency,
- 6. Promoting Materials efficiency
- 7. Enhancing Indoor environmental quality
- 8. Operations/maintenance optimization
- 9. Waste / toxics reduction.
- 10- Making Optimum use of Sun, Air, Space, Greenery
- *On aesthetic side of green architecture ----*
- 11. Evolving sustainable design
- 12. Designing in harmony with nature-- natural features and resources
- 13. Using 'green' building materials from local sources,
- 14, reduce loads -- optimize systems--- generate on-site renewable energy.



# Conclusion- Green Buildings

- United Nations Framework– Convention on Climate Change states that:
  - Urban areas responsible for 70% of global energy consumption and CO2 emission
    - By 2030—82 billion sqm (900 billion sqft)
      - an area equal to 60% of total stock of world will be built
    - by 2050 building sector --must phase out CO2 ( Zero carbon built environment)
- --Buildings critical-- to address ecological concern
- --Going green -- necessity/ imperative to ensure sustainable tomorrow
- - Let us make green as
  - way of life,
  - make integral part of professional learning/education and
- -- way of professional practice
- --Together we can and we shall make difference

# ***'A Green building makes you***

***Happy, Healthy and More Productive***

- ***Provides highest quality of indoor environment***
- ***Optimizes Resources, , Reduces Waste,***
  - ***Reduces Carbon Footprints***
- ***makes building operations, cost effective and energy efficient-  
create win-win situation for owner; occupant; users; tenant***
  - ***'Natural Capitalism'***

