3

LANDSCAPE ARCHITECTURE

MODULE 3

VIth Semester B.Arch
Teaching Notes

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Syllabus

I. Landscape's effect on climate & microclimate, relationship between climate, landscape and architecture.

II. Landscape as environmental modifier against noise, soil erosion, land, air, water pollution, water logging & depletion of water resource.

III. Landscape water harvesting systems- swale, bio-swale, ponds- Use of Geo-textiles in landscaping.

IV. Urban open spaces, urban avenue, urban forest and urban heat island.

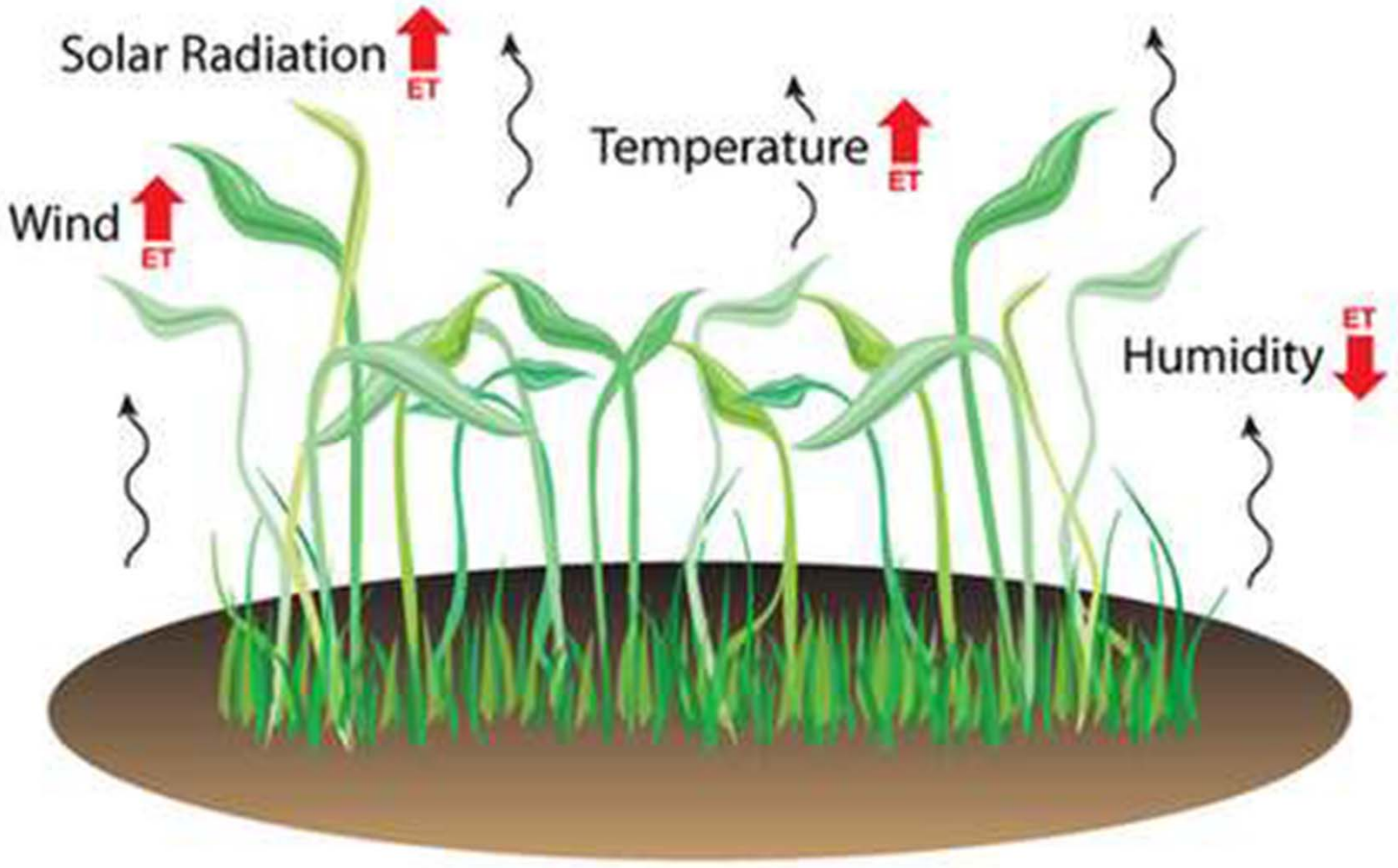
I.

Landscape’s effect on climate & microclimate, relationship between climate, landscape and architecture.

Microclimate control through landscaping techniques

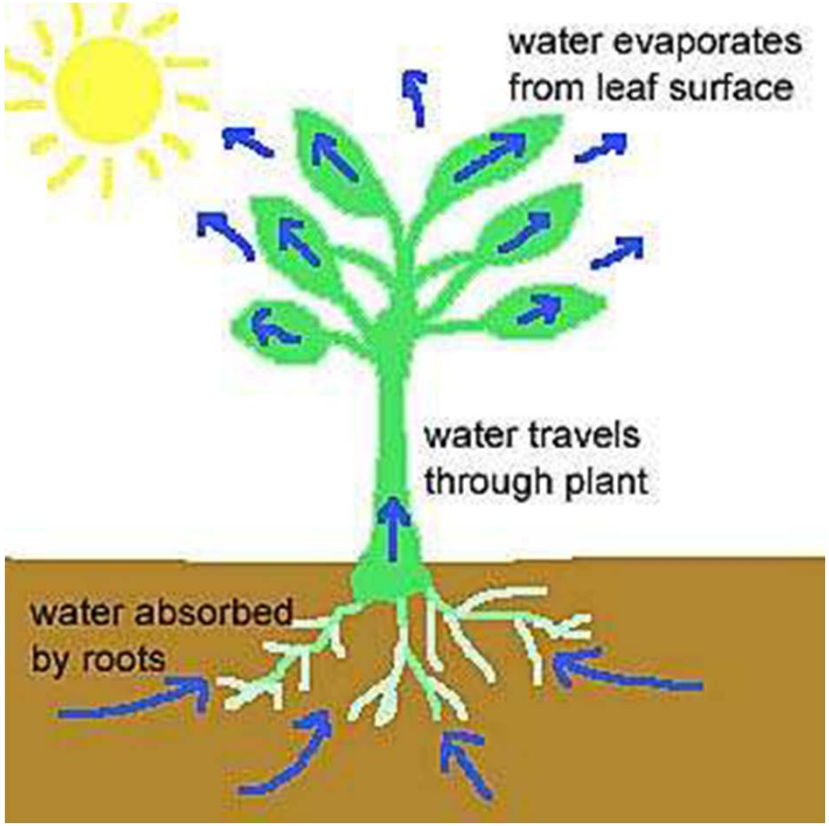
Sol-Air Temperature Control

• The use of ventilated shading provided by trees, shrubs and climbers reduces – solar radiation reaching ground and wall surfaces – reduction of air, ground and surface temperature



Air Temperature Control

- Ventilated shading
- Evapotranspiration

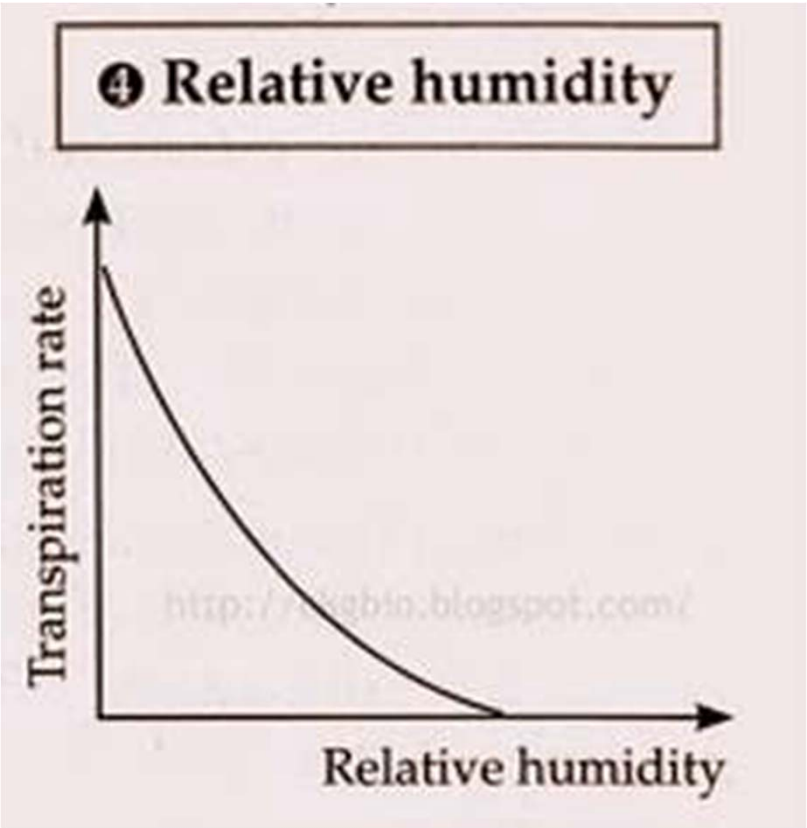


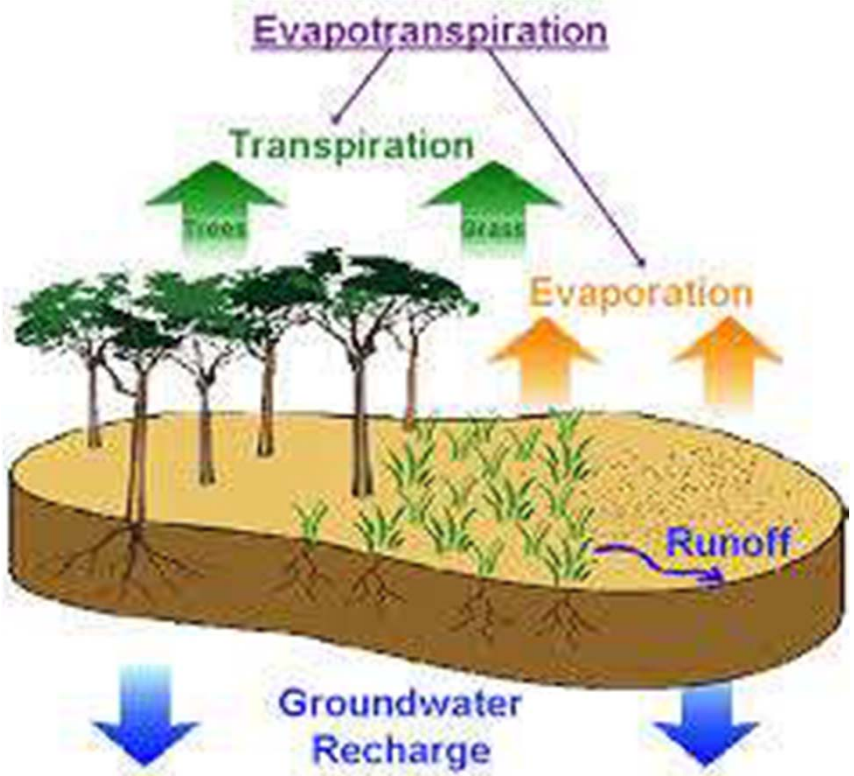
Humidity Control

• Increases relative humidity while reducing air temperature

– Water evaporating from the surfaces

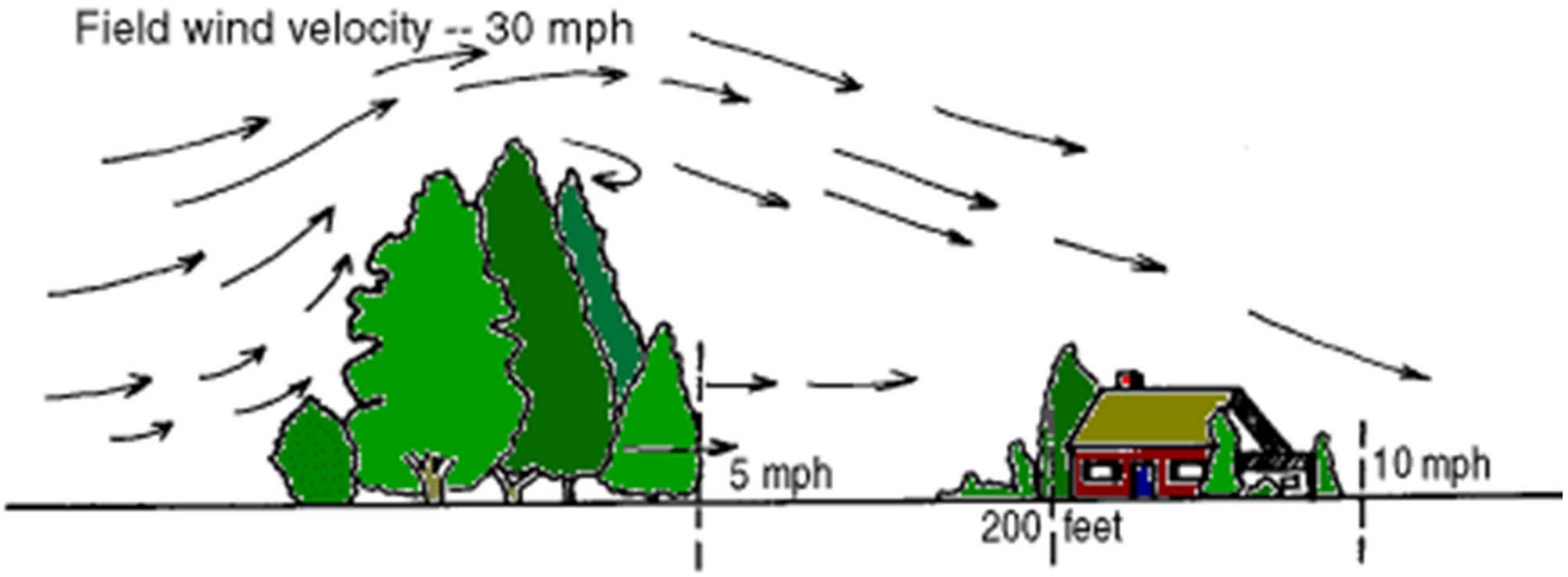
– water evaporating from the leaves





Control of Air Velocity and Wind Speed

- Plants are used to
  - induces air movement under and around trees
  - increase the velocity of stagnant and slow-moving air
  - reduce wind speed
  - filter dust

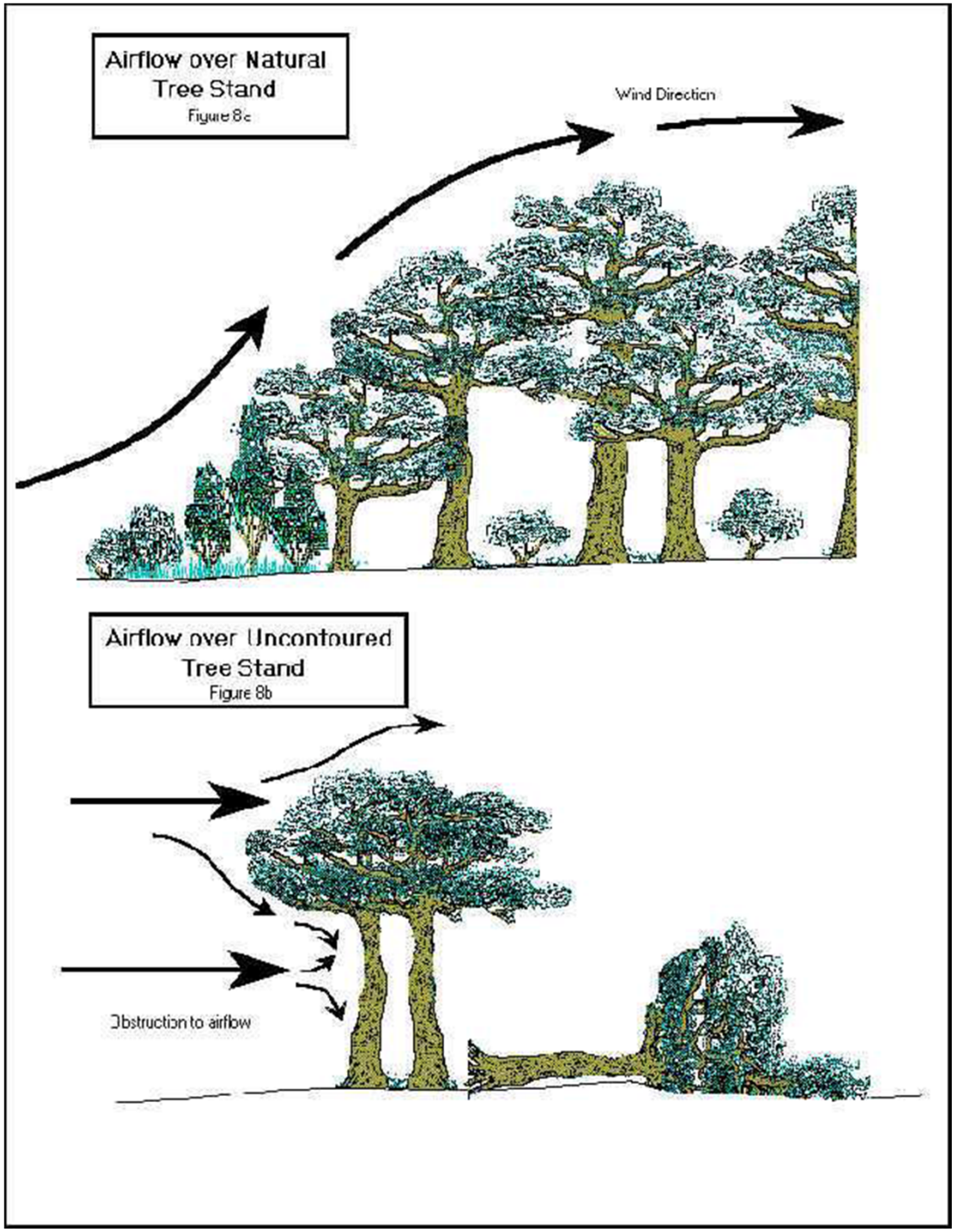


Control of Wind Direction

Fences, walls, hedges and trees can be combined to form an obstruction that will deflect the wind above the building.

- Trees make channel air flow towards living space.

- Larger groups of trees can also be used to channel the wind in a particular direction.

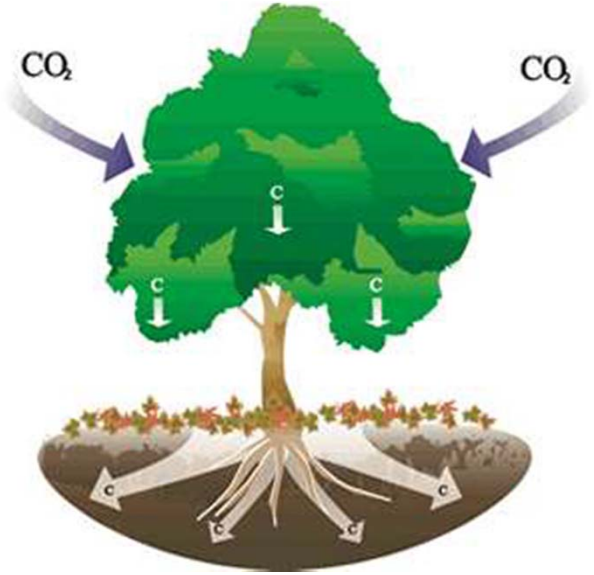


Pollution control

• Plants absorb carbon dioxide & other pollutants from automobiles.

• Buffer zones planted with trees are used for separating industrial areas from residential areas.

• The tree belts help reduce the dust content of air.



Glare Control

• Direct glare can be prevented by using trees to block off the relevant portions of the sky

• Indirect glare can be prevented by planting flowers, shrubs and grass on surfaces that would normally reflect light into the building

Landscape Elements for Microclimate Control

Hard landscaping elements

a) Steps and paving

• The choice of the surface finishing, material and construction of steps and paving

b) Walls and fences

• Walls are used to deflect the wind, and they can be used to channel the wind.

• Fences thus allow some wind to flow through them, even when they have climbers.

Hard landscaping elements

c) Slopes and barriers

• direct airflow

d) Stones and boulders

• direct airflow and provide shade

Soft landscaping elements

a) Trees and shrubs

- provision of shade
- control of relative humidity
- air movement.
- attainment of thermal comfort
- Ventilation

b) Lawns and flowerbeds

- reduce ground temperature
- prevent glare
- air freshness and fragrance.

Soft landscaping elements

c) Pools and ponds

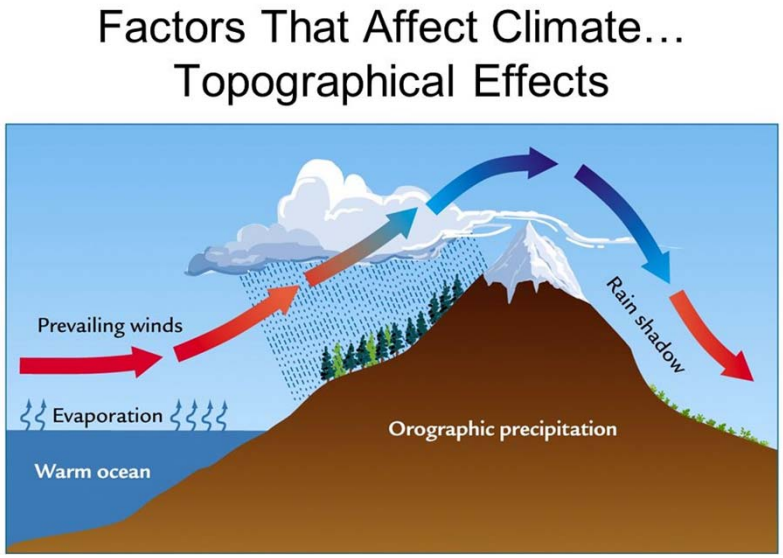
- Humidification
- Evaporative cooling

d) Mulches

- retain moisture
- reduce surface and air temperatures
- absorb heat

IMPACTS OF CLIMATE ON LANDSCAPE

Influence of climate on landscape space related to the specific factors (topography design, waterscape, vegetation, ground paving and landscape facilities).



IMPACT ON TOPOGRAPHY DESIGN

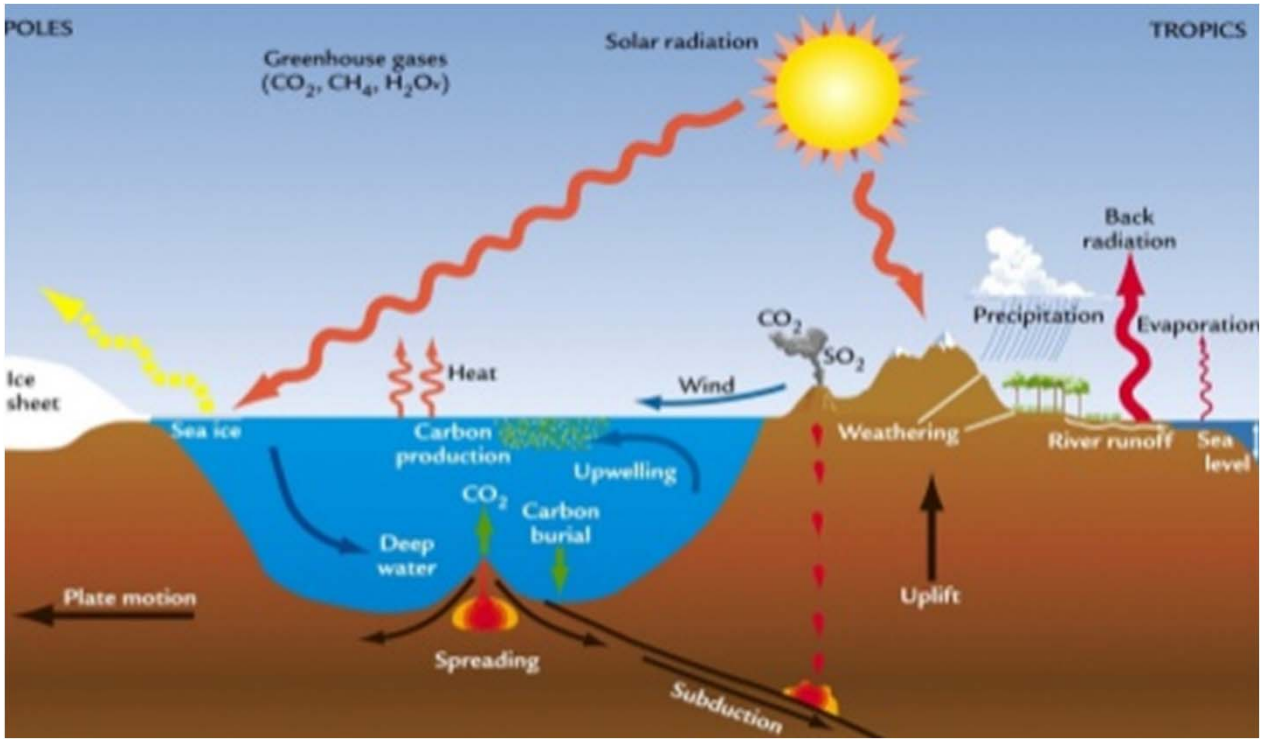
- Due to the topography and geographic range, slope and elevation, direct solar radiation and sky diffuse difference, the load on the ground of the solar radiation varies from place to place.

- Secondly, the slope surface and the sun angle difference influenced by solar radiation intensity, such as: with the sun light vertical slope surface to receive the maximum amount of radiation.

- Undulating terrain can significantly change direction near earth atmospheric circulation, thus affecting the urban wind environment. This forms the local terrain wind.

- Local terrain wind is regional climate impact phenomenon, the scale is about level less than 10 km, vertical 1 km.

IMPACT ON WATERSCAPE



- Waterscape form of city landscape is generally divided into static and dynamic landscape water landscape. Water landscape is divided into rivers, lakes and ponds, pond and pond etc.

- Dynamic water landscape is divided into water, water fountains, water curtain wall, etc. Static water is much larger than the open area of the surface of the water. Open, not only can form enlarged water landscape, and rivers and lakes belongs to natural features, often at 1000 areas, the waters as the wild animals and plants to provide habitat.

- Dynamic water forms, mainly in water, water fountains, water curtain wall, etc. and hydrostatic comparison, water flow due to the contact surface with the air increases, the formation of water mist can more effectively increase the air humidity.

- Effect of water on the city air temperature is mainly influenced by three factors. One is because of the surface reflectance, surface reflectance less than the land. Under the same conditions, the surface of the water can absorb more solar heat than the land surface, which makes the surface temperature rise.

- under the same external conditions, running the fountain prompted water molecules with air heat exchange, to reduce the effect of air temperature,

IMPACT ON THE PAVEMENT

- In addition to the cooling effect of trees, the use of high albedo materials can reduce absorption of solar radiation through urban ground surface and building envelopes and keep their surfaces cooler.

- Hard surfacing refers to the processing of natural building materials, such as natural stone, wood or cement prefabricated blocks and other types of artificial building materials.

- According to the material and texture, it can be divided into stone, wood, brick and wood, concrete, gravel, pebbles, wood and other recycled materials .

- Stone is the most widely used material in paving materials. There are many types of stone, natural texture of the limestone, the layered conglomerate and the colour of the bright colour of the granite.

- Wood gives a natural and comfortable feeling to the human. Wood, in addition to the traditional wooden platform and pavilion gallery use, can also be waste wood, bark and other paved to the edge of the sidewalk or tree pool planting pool .

- This can achieve the coverage of bare soil, is conducive to the soil moisture and absorb rain and other ecological environmental protection effect, is an excellent water permeability material.

FURTHER IMPACT ON LANDSCAPE DESIGN

- Through reasonable selection of landscape facilities and materials, the climate of the landscape space has a moderating effect.

- Non transparent material of the landscape pavilion, can effectively block the summer heat of the sun, but cannot guarantee the effective use of the winter sun. And transparent glass or other material landscape pavilion, which can ensure almost all of the solar radiation through the pavilion on the top surface of, can obviously improve the temperature of the space inside the pavilion. Although the winter to ensure the sun's demand, but it consider the summer heat of the sun. Need to combine the design of green planting trees collocation, to summer sun, the double effect of winter light.

- Landscape facilities can be separated by space, blocking air flow in the air, so as to achieve the effect of landscape space stroke environment compared to the simple landscape facilities, the impact of space on the wind, combined with the common role of green planting design and landscape facilities, can increase the impact on the space between the stroke environment. The plant itself has certain closeness, can play the role of the wind screen in the landscape space, and dense plants can be achieved to reduce the wind speed of 75% - 85%

- In summer, the main demand for human comfort in the environment is to decrease the temperature and increase the humidity.
- Pavement materials should be low heat absorbing materials, to reduce the absorption of solar radiation. At the same time, it has the function of considering the material with low reflectivity, which can reduce the temperature of space environment.
- Because of the relatively high absorption rate and reflectivity of the concrete to the solar radiation, it should avoid the use of large area or through the planting of green combination design, to achieve the purpose of cooling.
- Grassland has the advantage of low reflectivity and absorbing solar radiation, in the design of the ground pavement, can be combined with embedded grass, can effectively improve the regional climate.
- Compared with the natural ventilation design in summer, winter needs more regional wind invasion. Effective wind control can increase the comfort of people in the environment.
- In summary, the landscape facilities through different materials and design of the facilities can effectively on the solar radiation, air temperature and humidity, wind environment impact. Landscape facilities design of urban landscape space should be integrated landscape facilities for the design of spatial and climatic factors

II.

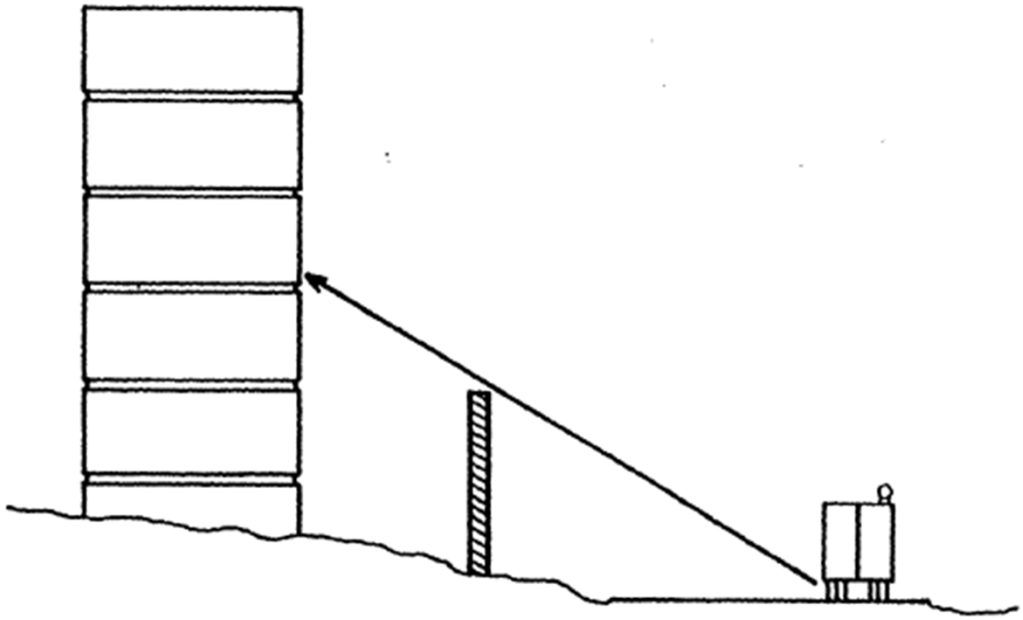
Landscape as environment modifier against noise, soil erosion, land, air, water pollution, water logging & depletion of water resource.

Against noise

Landscape techniques to reduce noise impact

- **Acoustical site planning**
- **Acoustical architectural design**
- **Barriers; earth berms, walls, fences as barriers,**
- **Plantings**
- **Combinations**

Acoustical site planning



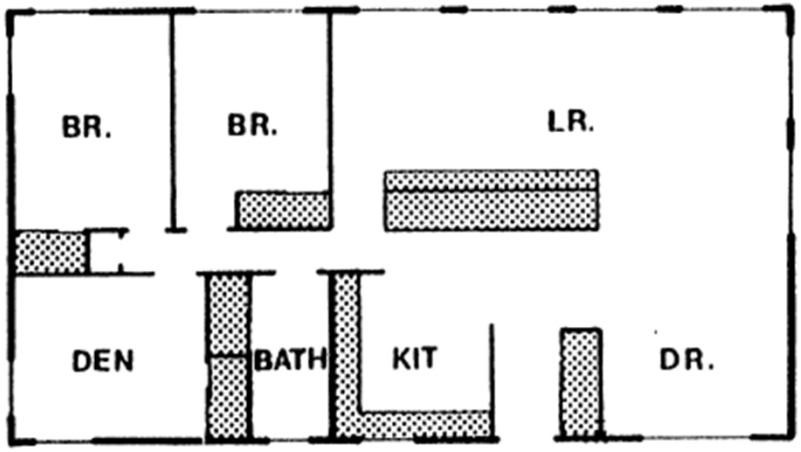
Noise barriers can shield only the lowest floors of a building.

Many site planning techniques can be employed to shield a residential development from noise. These can include:

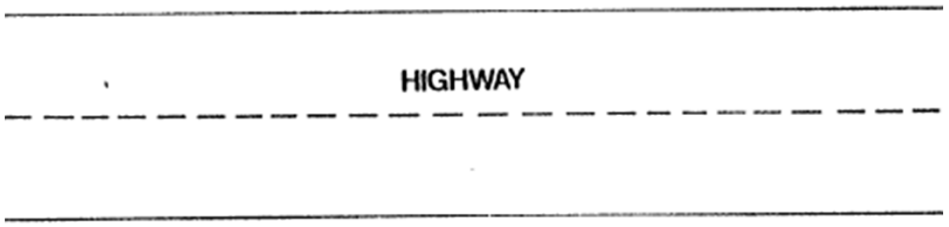
- increasing the distance between the noise source and the receiver;
- placing non residential land uses such as parking lots, maintenance facilities, and utility areas between the source and the receiver;
- locating barrier-type buildings parallel to the noise source or the highway; and
- orienting the residences away from the noise.

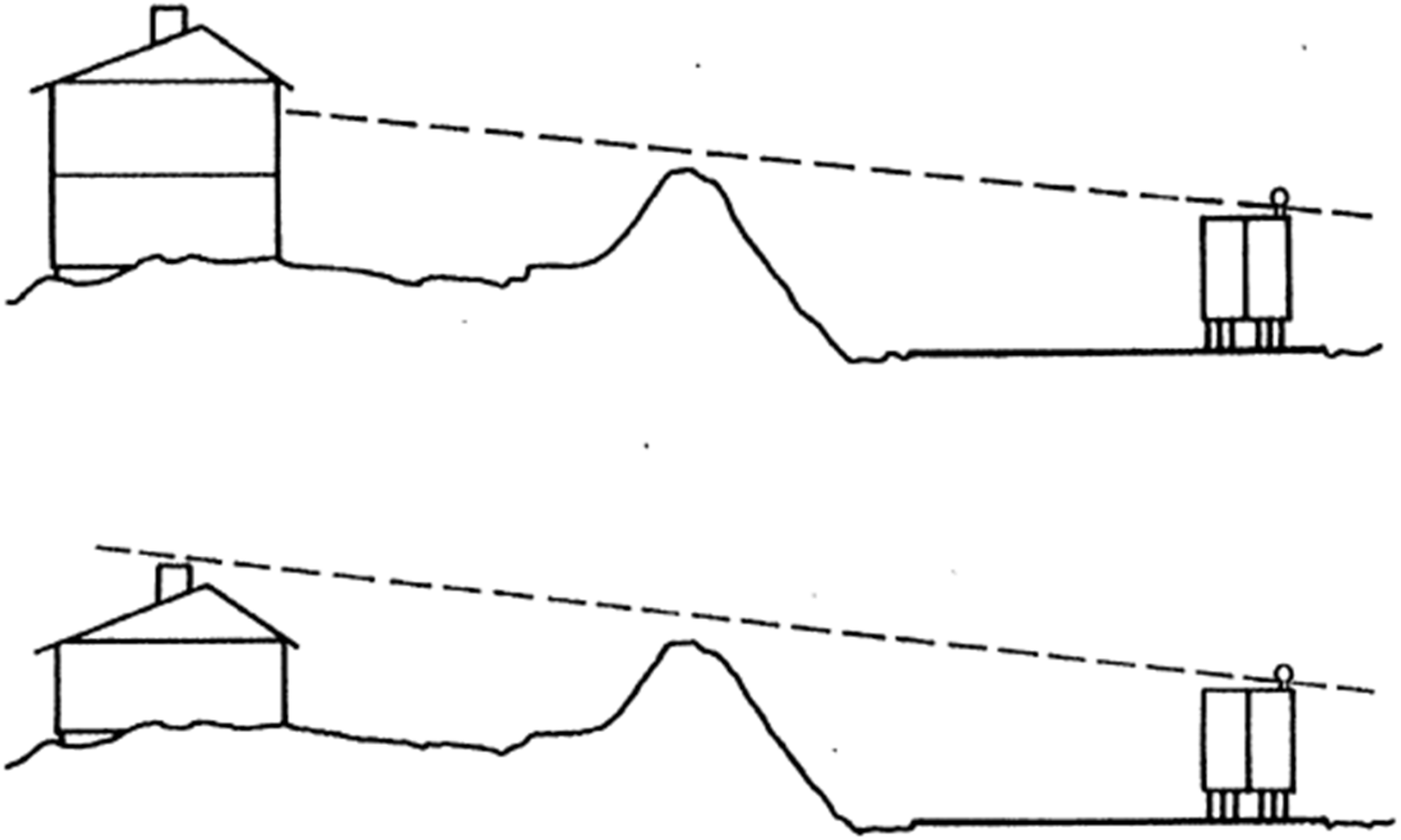
Acoustical architectural design

Noise can be controlled in a building with proper architectural design. By giving attention to acoustical considerations in the planning of room arrangement, placement of windows, building height, balconies, and courtyards, the architect may achieve significant noise impact reduction, without the need for costly acoustical construction.

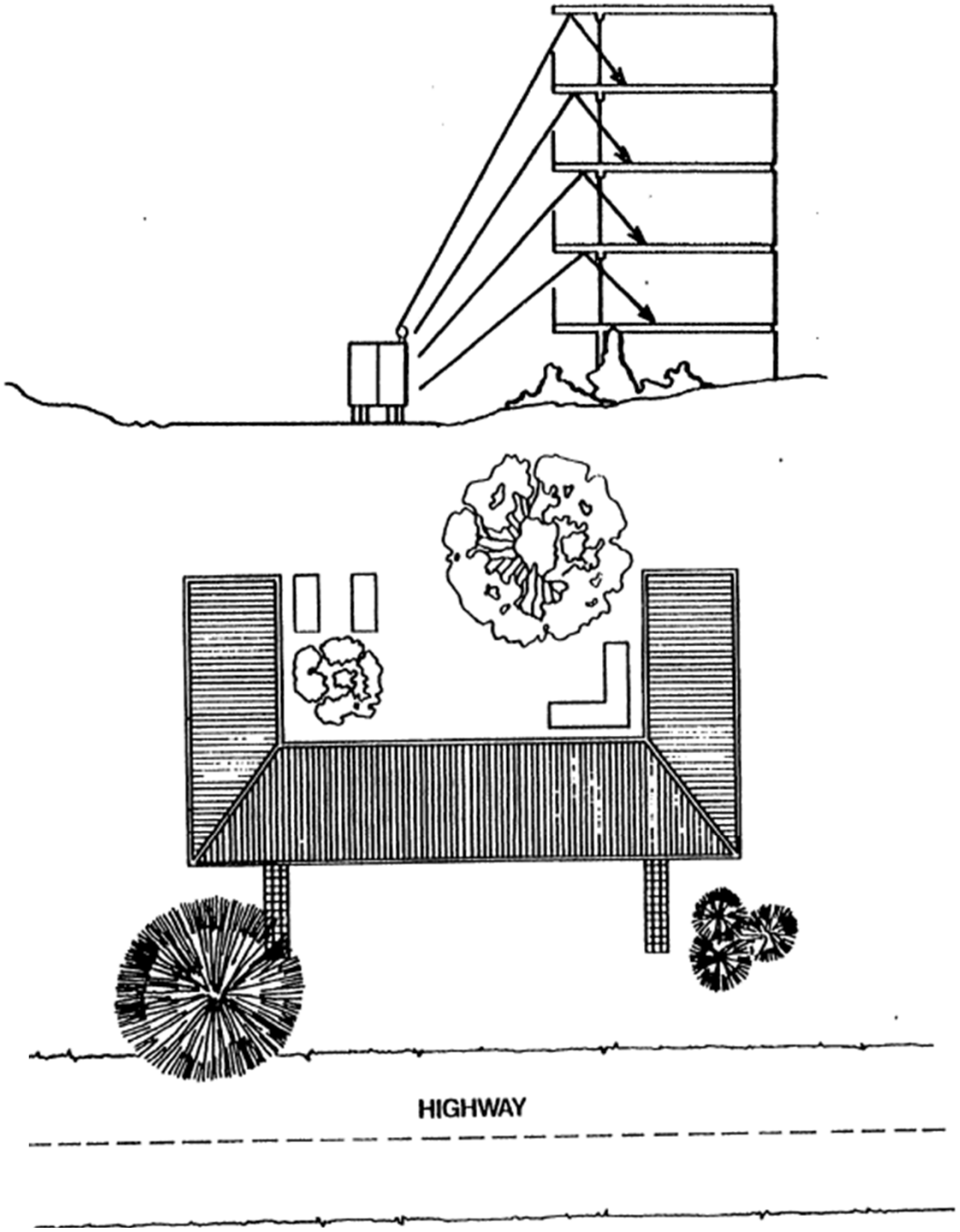


Use of acoustical architectural design to reduce noise impacts on more noise sensitive living spaces





Noise impacts can be reduced by use of single story houses.



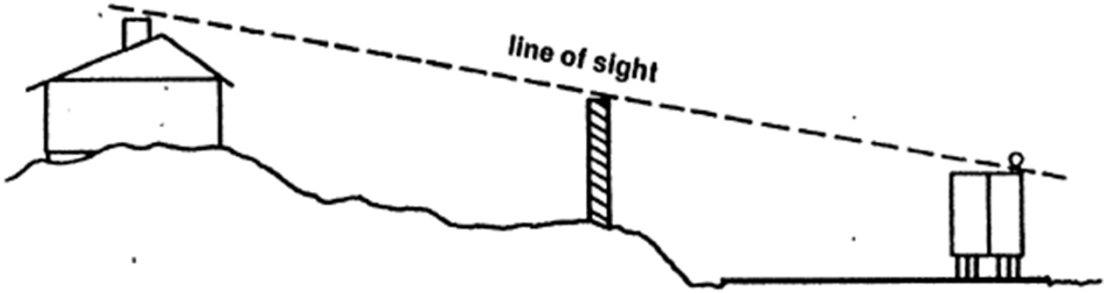
The standard jutting balcony facing the road may reflect traffic noise directly into the interior of the building.

Use of courtyard house to obtain quite outdoor environment

Barriers

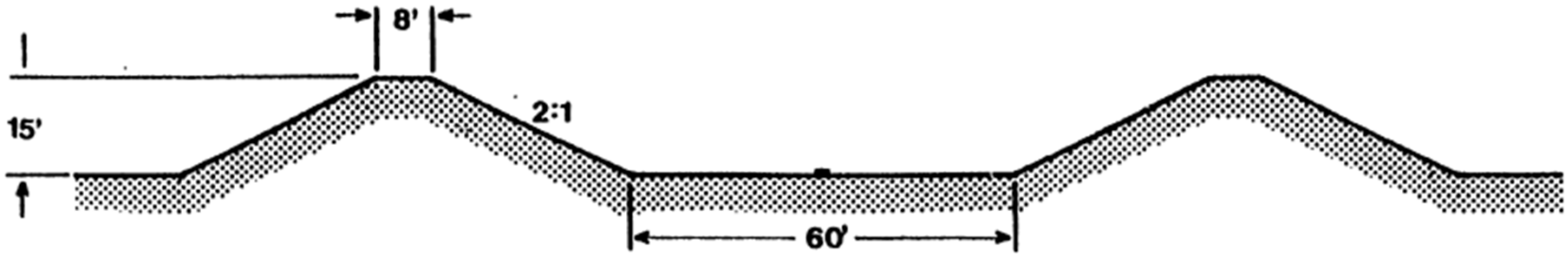
A noise barrier is an obstacle placed between a noise source and a receiver which interrupts the path of the noise. They can be made out of many different substances:

- sloping mounds of earth, called berms
- walls and fences made of various materials including concrete, wood, metal, plastic, and stucco
- regions of dense plantings of shrubs and trees
- combinations of the above techniques

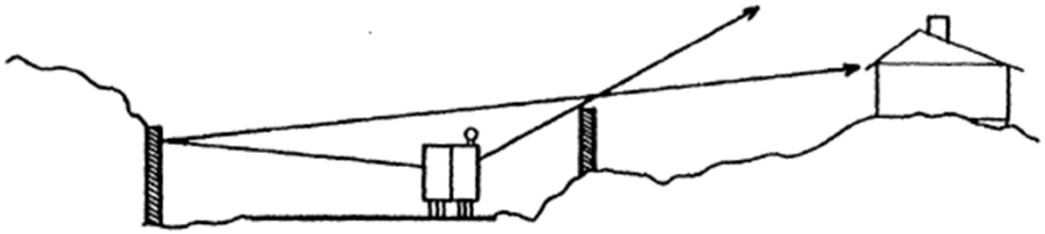


To be effective, a barrier must block the "line of sight" between the highest point of a noise source and the highest part of a receiver.

An earth berm, a long mound of earth running parallel to the highway, is one of the most frequently used barriers. Figure 4.17 shows a cross-section of a berm.



Cross section of a berm



Wall barriers may reflect sound from one side of the highway to the other.

Plantings

- Plants absorb and scatter sound waves. However, the effectiveness of trees, shrubs, and other plantings as noise reducers is the subject of some debate.

- Plantings in a buffer strip, high, dense, and thick enough to be visually opaque, will provide more attenuation than that provided by the mere distance which the buffer strip represents. A reduction of 3-5 dBA per 100 feet can be expected. Shrubs or other ground cover are necessary in this respect to provide the required density near the ground.

- The principal effect of plantings is psychological. By removing the noise source from view, plantings can reduce human annoyance to noise. The fact that people cannot see the highway can reduce their awareness of it, even though the noise remains.
- Time must be allowed for trees and shrubs to attain their desired height.

- Because they lose their leaves, deciduous trees do not provide year-round noise protection.

- In general, plantings by themselves do not provide much sound attenuation. It is more effective, therefore, to use plantings in conjunction with other noise reduction techniques and for aesthetic enhancement.

Combination of Visual Barrier Designs

- Often, the most economical, acoustically acceptable, and aesthetically pleasing barrier is some combination of the barrier types previously discussed.

- In addition to cost advantages, an earth berm with a barrier wall on top of it possesses several other advantages over both a wall or a berm alone: 1) it is more visually pleasing than a wall of equivalent height; 2) the berm portion of this combination is less dangerous for a motorist leaving the roadway; 3) the non-vertical construction of the berm does not reflect noise back to the opposite side of the highway the way a wall does; 4) the combination requires less land than would be required for a berm of equivalent height and slope; and 5) the wall provides a fencing function not provided by a berm.

- Another combination to be considered is that of plantings in combination with a barrier. Not only do plantings and ground cover provide some additional noise attenuation, but they also increase visual appeal.

Figure 4.19 Summary of Physical Techniques to Reduce Noise Impacts

Physical Technique	Potential Effectiveness	Situations Where Most Effective	Cost	Relevant Administrative Technique	Comments
Acoustical Site Planning	Good-excellent: depends on size of lot and natural terrain.	Before building construction, before subdivision development	Low. only costs are fees of acoustical consultant and site planner.	Building code* Health code	Fairly inexpensive but requires space which may be unavailable. Has limited sound reduction. Positive aesthetic impacts.
Acoustical Architectural Design	Fair	Before building construction.	Low: only cost is that of acoustical consultant	Building code* Health code	Low cost but limited effectiveness.
Acoustical construction.	Excellent for interior, poor for exterior.	During building construction best. Most costly after construction.	Varies with amount of noise reduction desired but generally high especially after construction.	Building code* Health code	Most effective noise reduction for interiors
Barriers	Fair-excellent, depends on height and mass	Varies with type of barrier	Moderate-high: varies with type of barrier, see below.	Zoning, subdivision rules, health code	High noise reduction and potentially low cost. Achieves exterior noise reduction. Can have adverse aesthetic impacts.
Earth Berms	Good-excellent	Best during road construction when earth is available. Costly after road construction. Impractical in densely populated areas where land is scarce.	Moderate-high: depends on availability of earth.		Good noise reduction properties and aesthetic appeal, but requires space and requires maintenance.
Walls and Fences	Poor-excellent, depends on height and mass	Any time	Low-high: depends on height and thickness.		Requires little space and no maintenance, but may be aesthetically unappealing and can reflect noise to other side of road.
Plantings	Poor	After road construction. After building construction.	Moderate high: depends on size of buffer strip.		Poor noise reduction but often necessary for aesthetic appeal. Best used in combination with other techniques.
Combinations	Good-excellent.	Depends on particular combination.	Moderate-high: depends on type of barrier used		Potentially high noise reduction and aesthetic appeal.

*Administrative techniques which can achieve any physical technique are health codes, occupancy permit procedures, architectural review boards, and municipal design services.

Against soil erosion

Natural erosion occurs due to the action of wind, water and glaciers. Erosion is known as " the great leveler" because it persistently removes material from higher elevations and fills low areas with sediments. Valleys develop along with the streams and gradually enlarge as the hills erode. Soil and rock material eroded from one area is deposited in another as sediment.

Erosion by water

- In humid and sub humid regions, on gentle sloping landscape devoid of vegetation cover, top fertile soil is stripped off by surface runoff.
- On sloping landscape, severe soil erosion results in formation of deep network of gullies and extensive network of 5-10 metre deep ravines along river courses.
- It also occurs wherever rainfall strikes bare soil or the runoff flows over insufficiently protected soil.
- Erosion damages the upland areas from which soil and plant nutrients are removed and also the lowlands where sediments are deposited.
- It pollutes waters, fills in river channels and reservoirs, resulting in flooding. Soil properties, especially texture and structure, influence the ease or difficulty with which the water percolates down.
- Water erosion and sedimentation can be controlled by reducing the energy of the erosive agents such as runoff or by increasing the soil's resistance to erosion.

- Water erosion occurs when conditions are favourable for detachment and transportation of soil material. Climate, soil erodability, slope gradient, length and surface and vegetative conditions influence how much erosion will take place.
- The principles of water erosion control are to reduce raindrop impact on the soil, reduce runoff volume and velocity, increase soil resistance to erosion, management practices that effect one or more of these principles will help to control water erosion.

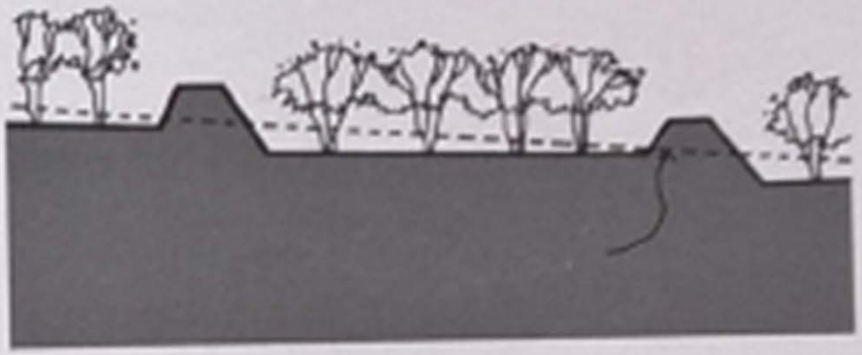
Benefits of Controlling Erosion

- Reducing erosion keeps streams, ponds and lakes from filling rapidly with sediment. Keeping sediment out of water also avoids the build up of plant nutrients in the water and thereby reduces unwanted growth of algae and other vegetation. Pollutants attached to soil particles are best kept out of water by keeping the soil on the land.

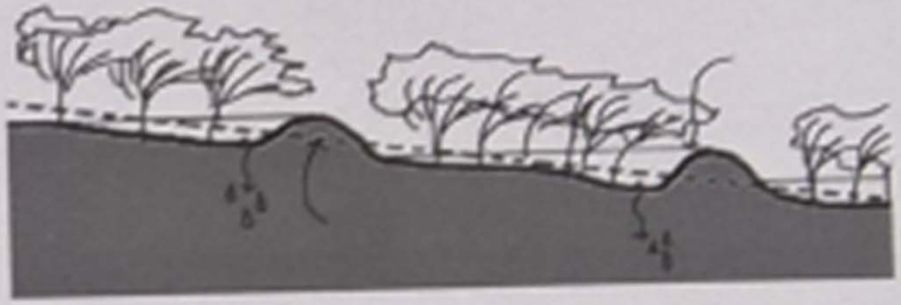
- Erosion cannot be prevented, but it must be limited to tolerable rates. Methods for predicting erosion rates are needed to ascertain the erosion hazard with present management and to evaluate alternate methods of crop and soil management. Factors affecting erosion are topography, depth, permeability, texture and structure of soil.

Conservation structures

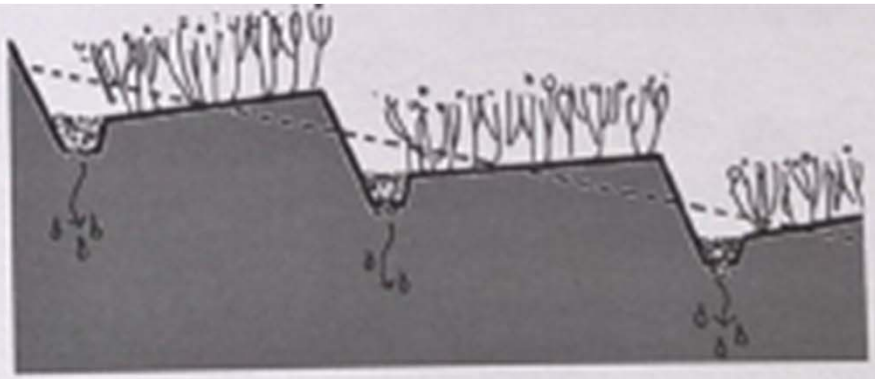
- These comprise of modifying the topography suitable or adding small structural elements or a combination of both that is designed to reduce/ control factors that affect erosion.
- There are both passive and engineered methods of erosion control. Following are a few of the sustainable options:



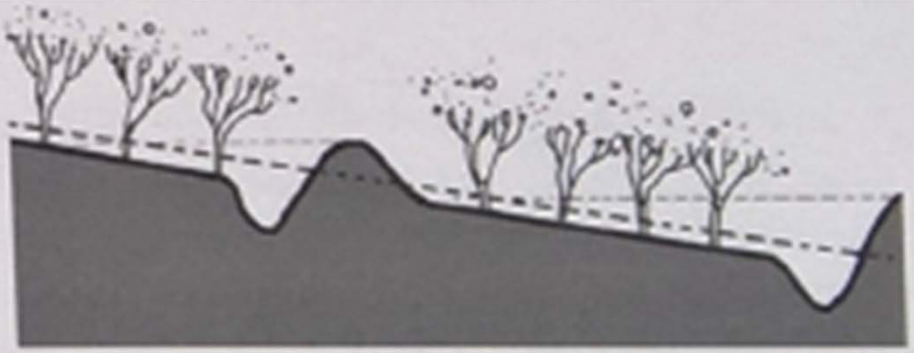
Bench terrace involves converting the original ground into level step like fields, by half cutting and half filling, which reduces the degree of the slope. They are useful in areas with limited arable land and steep slopes.



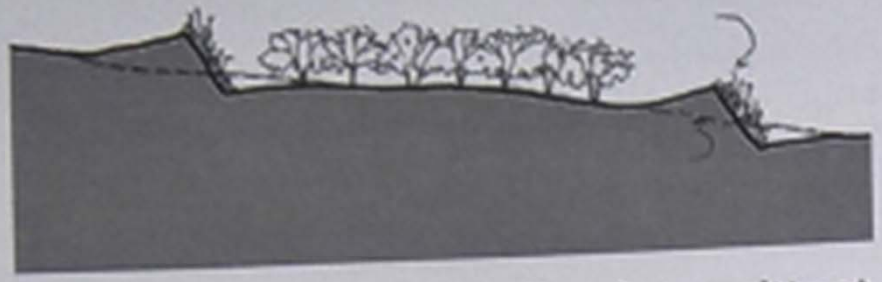
Steep backslope terraces reduce the gradient and redirects runoff by incorporating a steep back slope which is permanently vegetated. The remaining portion of the terrace is relatively flat and can be cultivated. They are generally used in places where the slope is moderate.



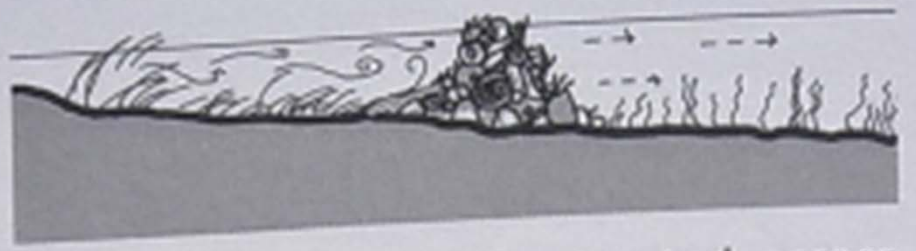
Contour bunding is essentially the same as level terraces or ridge type terraces. The bunds act as a barrier to the flow of water and at the same time stores water hence increasing the soil moisture. The bunds are spaced such that the flowing water is intercepted before it attains the erosive velocity.



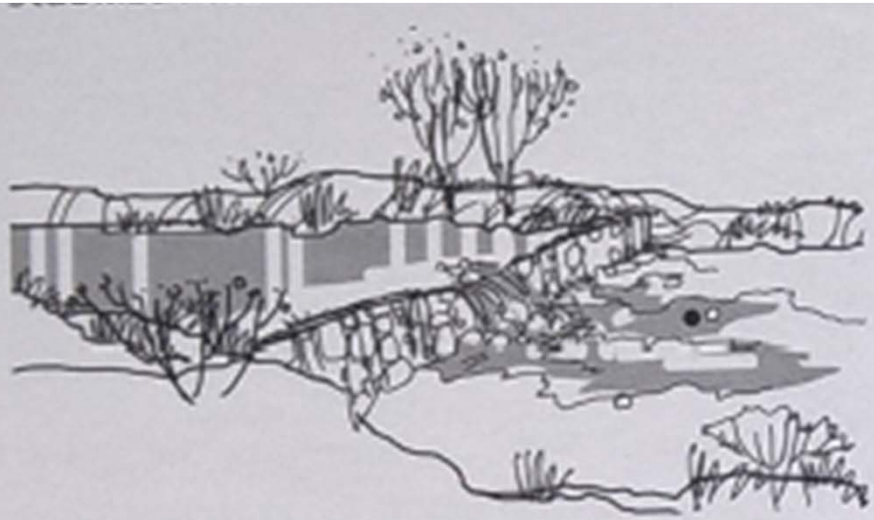
Graded terrace consists of a channel with a ridge on the downhill side. The channel slopes gently towards a protected outlet. Graded terraces reduce erosion by shortening slope lengths thereby reducing velocity and intercept runoff.



Contour trenches are shallow/intermittent excavations across the land slope that forms a small earthen bund on the downstream side. The trenches aid in percolating the runoff and help in establishment of the plantations made on the bund for stabilization.



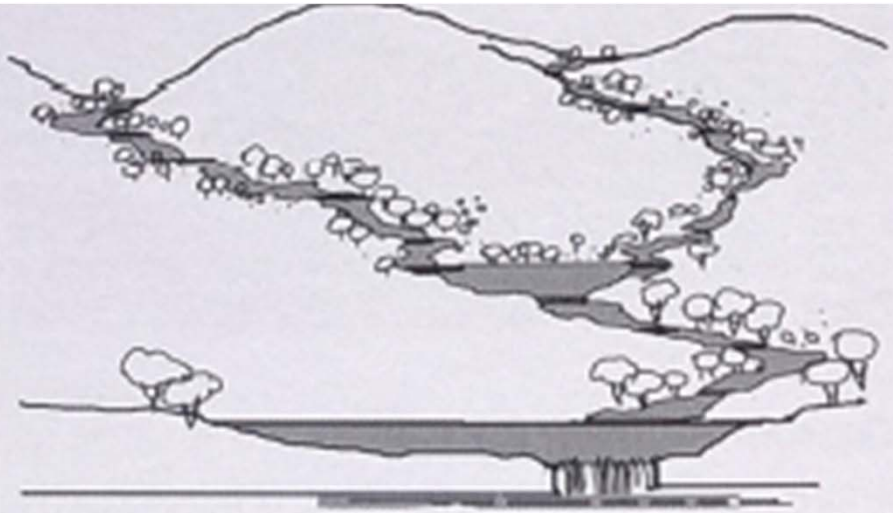
Stream bunding are constructed across bigger streams to conserve the water. The impounding of water facilitates percolation of water into deeper soil profile. The water released from bunds is thus free from silts and has very low velocity.



Chute spillways collect runoff water at one elevation and carry it down a slope to lower elevations. Rocks are placed on the channel and the joints are filled with a sand-cement mixture. Reasonably satisfactory, its advantage being that less cement is consumed.

Gabion structure is a type of check dam constructed across small streams to conserve flow of water in such a way that no submergence takes place beyond the water course. Locally available boulders packed in a steel wire mesh are placed across the nalla constitute a gabion structure.

Drop structures may be used for relatively small water volume and short water drops, but reinforced concrete is needed where the volume is large or the drop great.

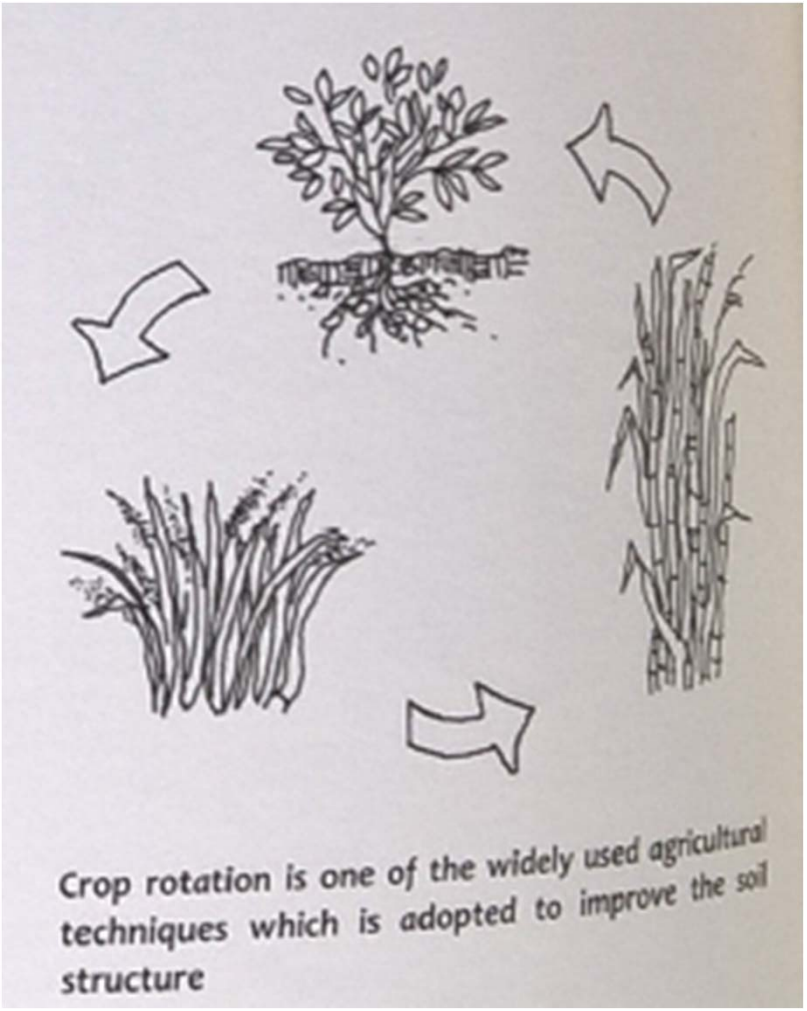


Check dams are constructed across small streams, having a gentle slope and are feasible both in hard rock and alluvial formation. Besides all these structures, there are many structures as per the region and the local traditional practices adopted especially in rural areas for addresing the issue of soil erosion.

Other factors responsible for degradation of natural soil include salination, alkalization which result in deterioration of the soil texture, reducing uptake of nutrients by plants.

Human factors include improper irrigation with saline/ saudic water, extensive use of chemical fertilizers, mining and quarrying resulting in drastic changes in natural topography and drainage patterns, loss of vegetation cover.

There are many agricultural techniques which my be adopted to improve the soil structure in terms of its nutrient intake, texture and fertility, including planting of trees, roots of which have a capacity



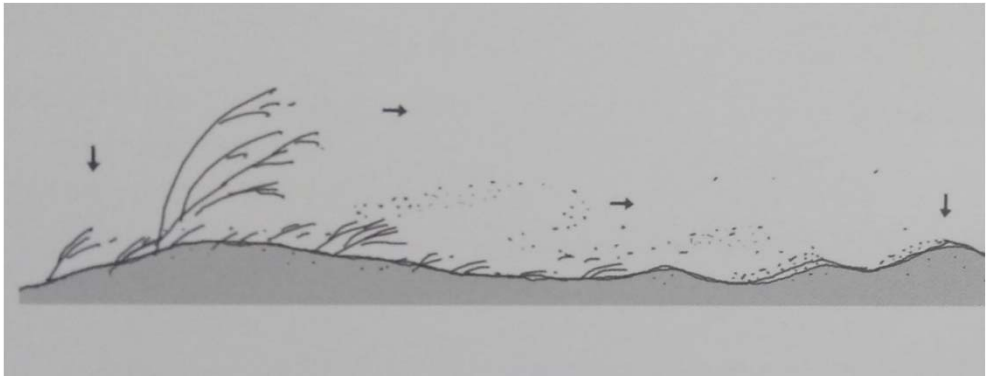
Crop rotation is one of the widely used agricultural techniques which is adopted to improve the soil structure

Wind

- In arid region, on sandy terrain, devoid of vegetation cover surface fertile soils of agricultural fields are blown away by the wind and trapped nearby in the form of sand sheet/ sand hummocks.

- Sand dunes covered with vegetation are stable but partially vegetated and bare sand dunes are source of blown sand.

- The blown sand when trapped engulfs agricultural field, roads, railways and buildings. Thus, both the erosion and deposition of sand causes soil degradation.



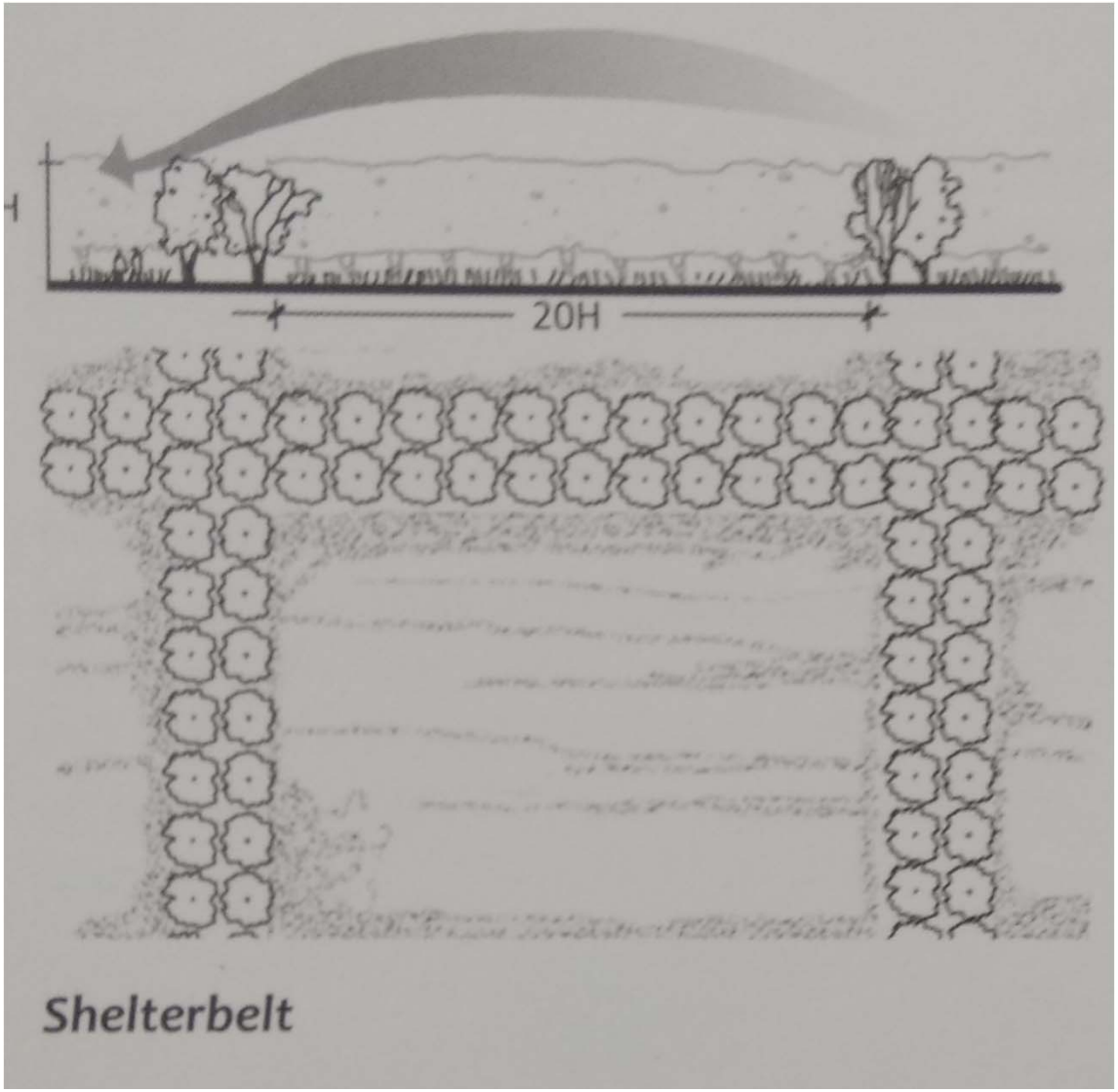
Erosion prevention techniques

By vegetation

- The use of vegetation for controlling wind is widely recognized as an effective way of conserving soil and reducing erosion by wind.
- Vegetation is used for modifying the microclimate, by obstructing, guiding, deflecting or filtering wind currents.
- Vegetation areas designed to fulfil these general functions are usually classified as windbreaks and shelterbelts.

Shelterbelts

- Shelterbelts are extensive barriers of trees protecting fields. It usually consists of several rows of trees.



Shelterbelts

- Species are chosen with particular regard to their physical and growth characteristics, and their effectiveness in achieving their desired results.

- Shelterbelts should be regarded as living group of trees to be managed in perpetuity.

- Their location can be related to local features such as public and private road networks, building, irrigation and water conservation work and methods and soil management practice.

- Effectiveness of shelter planting depends more on height and permeability than on width.

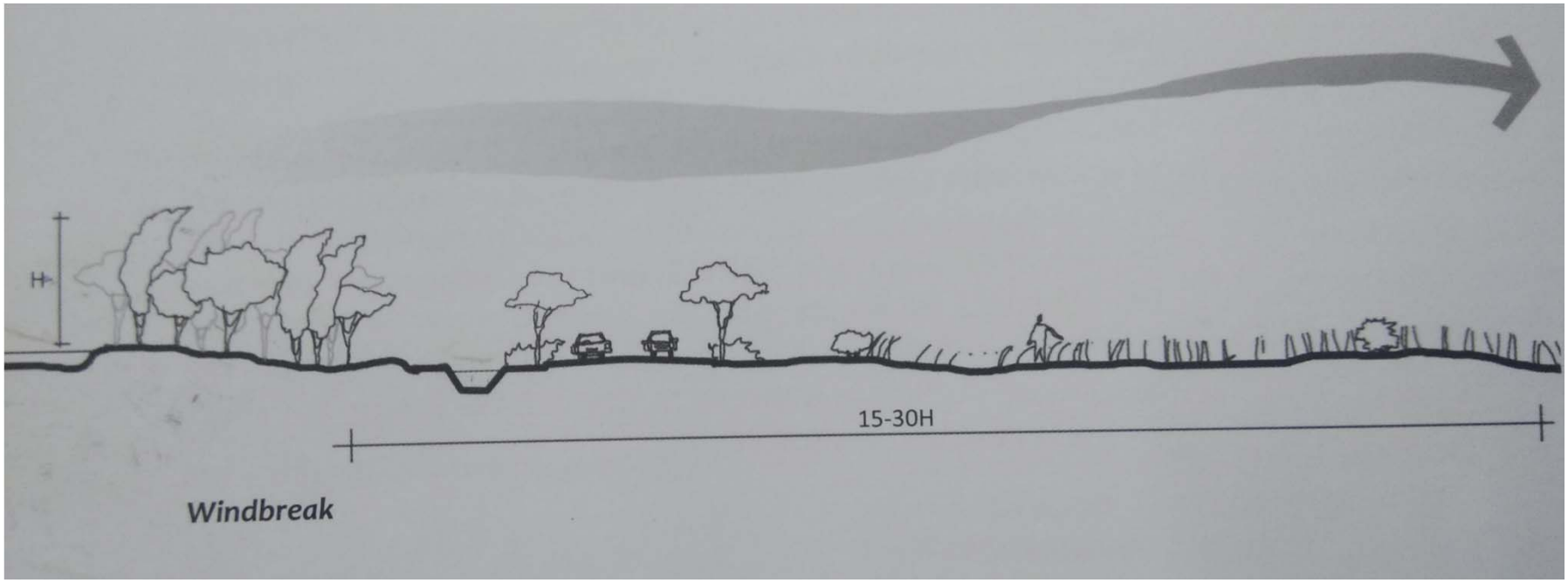
- The width influences the general microclimate but above a certain minimum width it does not affect greater reduction in wind velocity.

- Protection obtained by the shelterbelt varies in relation to height (H) of shelterbelts.

H	wind reduced by 90%
2H	wind reduced by 75%
5H	wind reduced by 50%
10H	wind reduced by 20%

Windbreaks

- Windbreaks are protective planting around an area, garden or orchard.
- They provide shade for buildings or cattle pens, and they have an aesthetic value in areas which do not have much existing vegetation cover.
- A windbreak generally consists of a single or double row of trees.



Benefits of Windbreaks

- Windbreaks are important for agriculture under arid and semi arid conditions.
- They fulfill essential microclimate functions in urban and rural environments.
- They reduce wind velocity resulting in the arrest of movements of sand and soil particles.
- They prevent soil erosion, modify microclimate, reduces evaporation of soil moisture.
- They protect livestock and have an overall beneficial effect on growth of plants.

Landscape measures to prevent depletion of water resources

- **Water conservation** includes all the policies, strategies and activities to sustainably manage the natural resource of fresh water, to protect the hydrosphere, and to meet the current and future human demand.
- Population, household size and growth and affluence all affect how much water is used. Factors such as climate change have increased pressures on natural water resources especially in manufacturing and agricultural irrigation.

The goals of water conservation efforts include:

- **Ensuring availability of water for future generations** where the withdrawal of freshwater from an ecosystem does not exceed its natural replacement rate.
- **Energy conservation** as water pumping, delivery and wastewater treatment facilities consume a significant amount of energy. In some regions of the world over 15% of total electricity consumption is devoted to water management.
- **Habitat conservation** where minimizing human water use helps to preserve freshwater habitats for local wildlife and migrating waterfowl, but also water quality.

Landscape measures to prevent depletion of water resources

Go Native

- Use native plants in your landscape. They look great, and don't need much water or fertilizer.
- Also choose grass varieties for your lawn that are adapted for your region's climate, reducing the need for extensive watering or chemical applications.

Harvest rainwater

- Digging ponds, lakes, canals, expanding the water reservoir, and installing rain water catching ducts and filtration systems on homes are different methods of harvesting rain water.
- Many people in many countries keep clean containers so they can boil it and drink it, which is useful to supply water to the needy.
- Harvested and filtered rain water can be used for toilets, home gardening, lawn irrigation, and small scale agriculture.

Landscape measures to prevent depletion of water resources

Protect groundwater resource

- When precipitation occurs, some infiltrates the soil and goes underground.[Water in this saturation zone is called ground water.
- Contamination of groundwater causes the groundwater water supply to not be able to be used as a resource of fresh drinking water and the natural regeneration of contaminated groundwater can take years to replenish.
- Some examples of potential sources of groundwater contamination include storage tanks, septic systems, uncontrolled hazardous waste, landfills, atmospheric contaminants, chemicals, and road salts.

Use drip irrigation

- Drip irrigation is the most expensive and least-used type, but offers the ability to deliver water to plant roots with minimal losses.
- However, drip irrigation is increasingly affordable, in light of rising water rates. Using drip irrigation methods can save up to 30,000 gallons of water per year when replacing irrigation systems that spray in all directions.

Air pollution control by plants

- Air pollution may be caused by areas or point sources such as cities, industrial areas, factories or by linear sources such as highways.

- Vegetation buffers can minimize the build-up of pollution levels in urban areas, by acting as pollution sinks.

- Studies have established that air pollution, smoke and sulphur dioxide leads to an exacerbation of chronic respiratory diseases and they are linked to lung cancer, pnemonia, tuberculosis, chest disease in children, stomach cancer and cardiovascular diseases.

- Lead from vehicle exhausts may have an adverse effect on mental health of children, asbestos from disintegrating clutch and brake linings has been considered as a causal factor in lung cancer.

Air pollution control by plants

Effect of Plants

Plant leaves function as efficient gas exchange systems. Their internal structure allows rapid diffusion of water soluble gases. These characteristics allow the plant to respire and photosynthesise, and they can also remove pollutant from the air.
Some of the beneficial results of plantations may be:

a) They are good absorbers of sulphur dioxide.
b) Parks with trees have an SO2 level lower than city streets.
c) Roadside hedges can reduce traffic generated air borne lead, on leeward side.
d) Heavy roadside planting in the form of shelterbelts can result in a reduction in airborne lead.
e) Complete dust interception can be achieved by a 30 m belt of trees. Even a single row of trees may bring about 25 percent reduction in airborne particulate.

Choosing Plants

The three main criteria for selection of plants may be:

a) Tree, shrubs should have a dense foliage with a large surface area, because leaves absorb pollutants.
b) Evergreen trees are found to be more effective.
c) The species chosen must be resistant to pollutants, particularly in the early stages of their growth.

Air pollution control by plants

The following species may be examined for their likely potential for pollution control:

Acacia arabica (Babul)
Citrus species
Dyospyros species
Ficus bengalensis (Banyan)
Ficus religiosa (Peepal)
Lilium spp. (Lily)
Polyalthia lotigifolia (Ashok)
Tamarindus indica (Imli)
Thuja occidentalis (Cedar)
Prosopis Juliflora (Mesquite)
Zizypus jujuba (Jujuba), etc.

Air pollution control by plants

- Filtering of pollutants is most effective when plants are close to the source of pollution.
- The design of shelterbelts against pollution is similar to those for protection from wind. They should be permeable to encourage air turbulence and mixing within the belt. There should be no large gaps.
- The profile should be rough and irregular and should present a tall vertical leading edge to the wing. Spaces should be left within the shelterbelt to allow gravity settlement of particles.

Applications

- Air pollution shelterbelts may be used to protect sensitive land uses from air pollution. For instance school playgrounds, children play area and residential estates close to major roads may be so protected.
- Shelterbelt protection may also be provided for hospitals, institutions, etc, where the vegetation may also be a visual screen and a partial noise barrier.
- Vegetation may also be used where the existing means of pollution control have proved inadequate.

III.

Landscape water harvesting systems- swale, bio-swale, ponds- Use of Geo-textiles in landscaping.

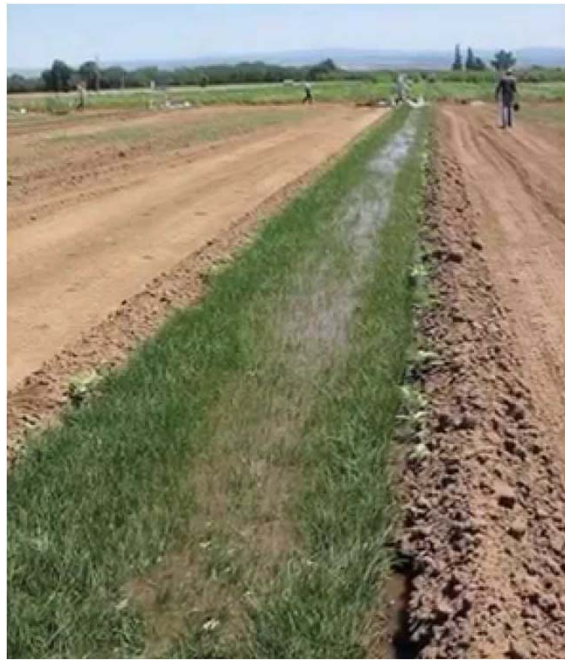
Due to rapid urbanization and growth of new settlements and towns, natural areas are being converted into hard paved areas.

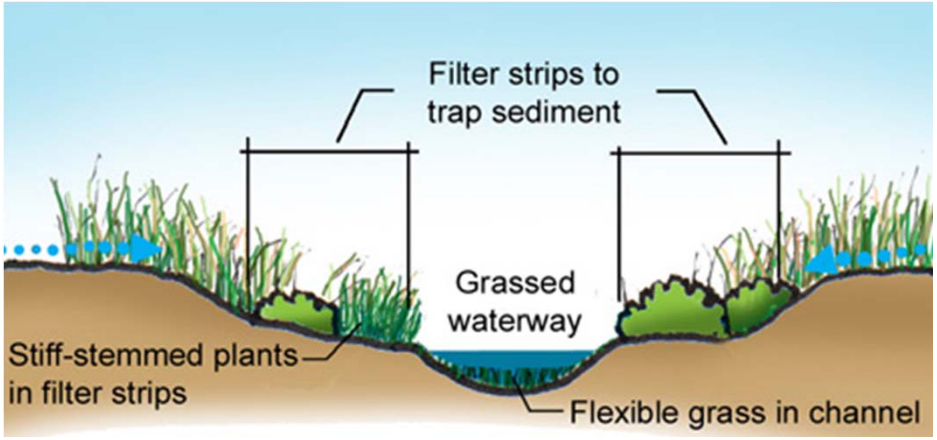
With more and more impermeable surfaces, there is very less percolation of water in sub-surface hence depletion of ground water table, increase in the velocity of surface runoffs and deterioration in the quality of water.

In this scenario, water conservation measures, especially in urban areas, become need of the hour.

Vegetative waterway

They are natural or constructed channels that have been shape to transport water at a non-erosive velocity from fields, diversions, terraces, and road ditches.



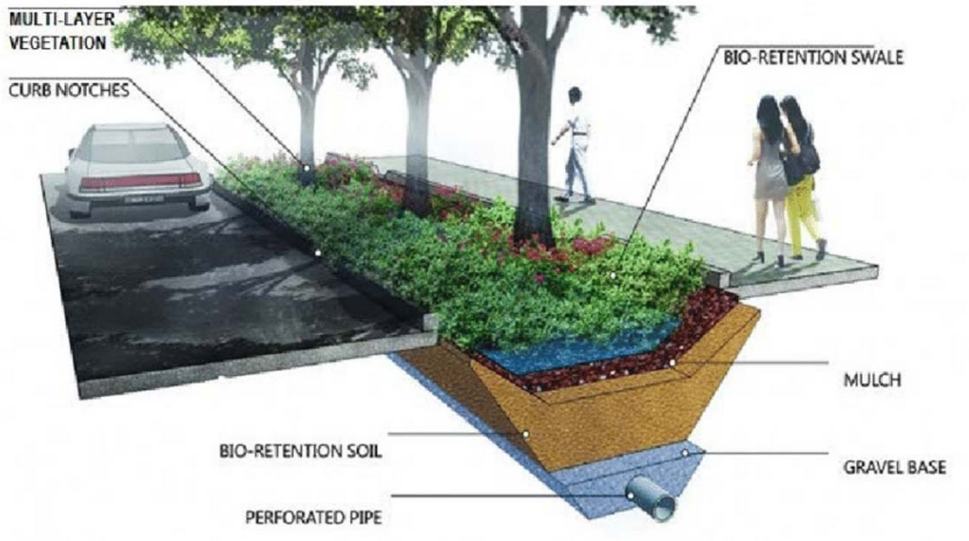


Bioswale

Bioswales are linear channels designed to concentrate and convey stormwater runoff while removing debris and pollution.

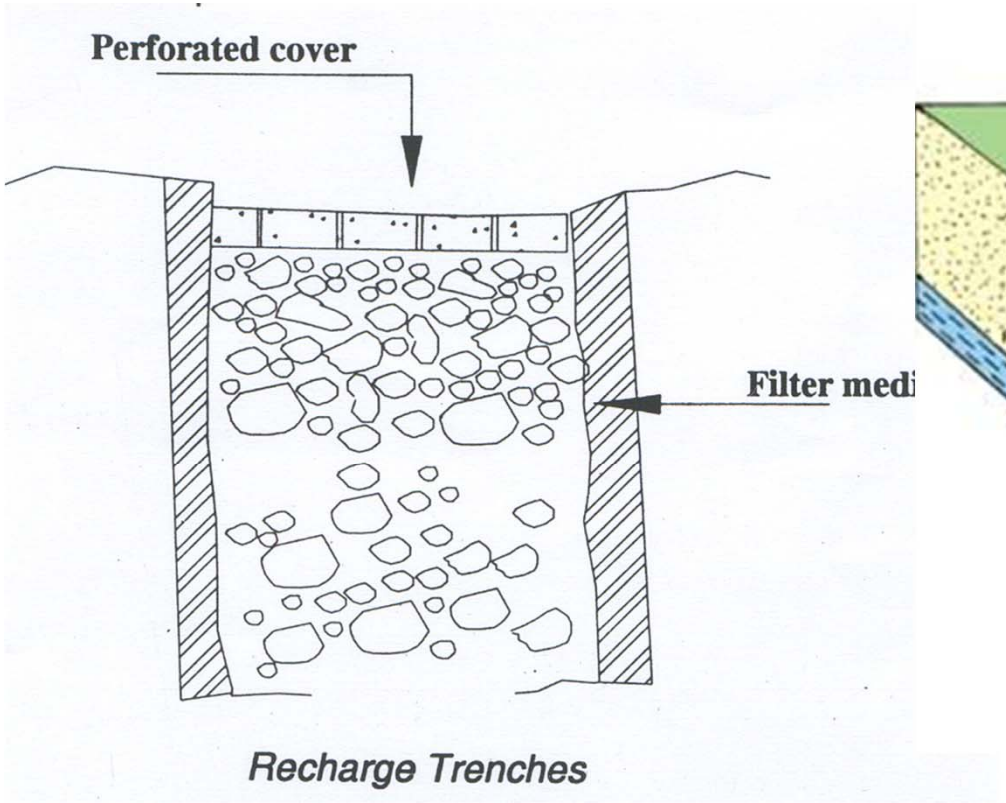
Bioswales can also be beneficial in recharging groundwater. **Bioswales** are typically vegetated, mulched, or xeriscaped. They consist of a swaled drainage course with gently sloped sides (less than 6%).

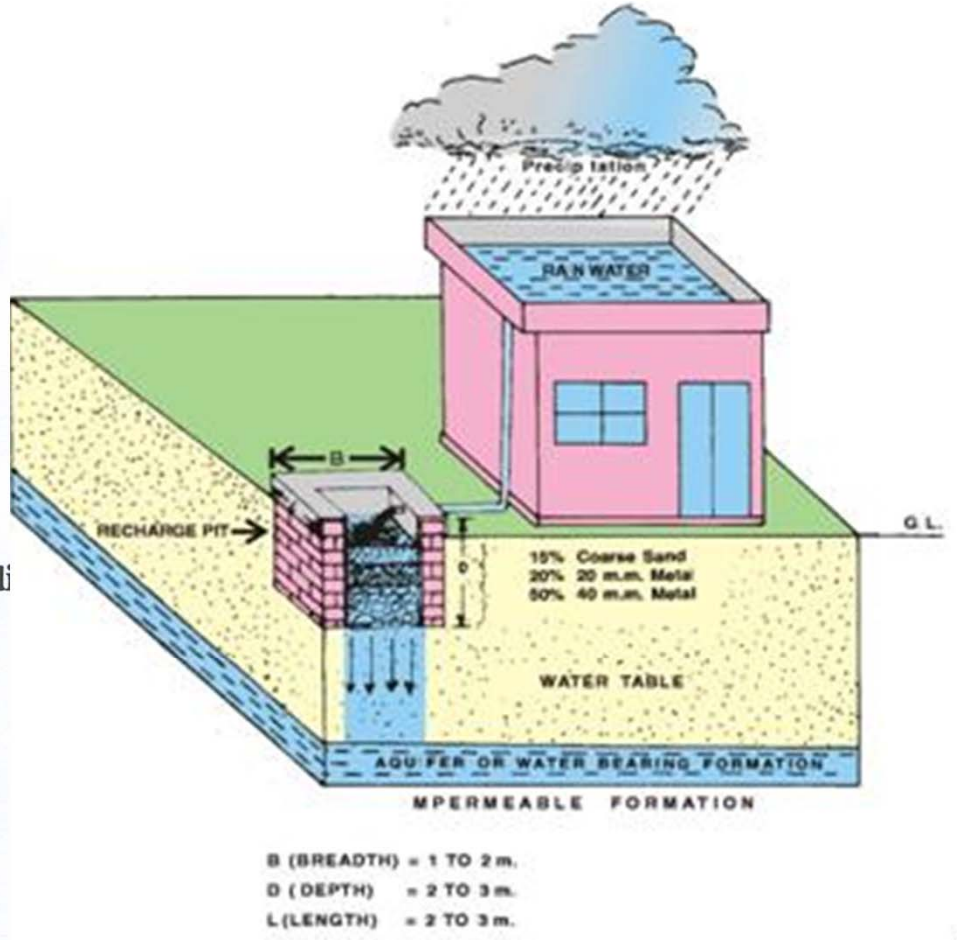
Bioswale concept diagram: (1) Dirty and polluted water from rooftops, roads and parking lots enters the bioswale; (2) Water is slowed down by various plants and rocks, pollutants settle out, clean water infiltrates the soil; (3) Water enters the perforated pipe and is slowly absorbed into the ground; (4) Excess stormwater exits the bioswale and flows through the pipe into the recipient, cleaner then when it entered and in the amount significantly reduced



Recharge trench

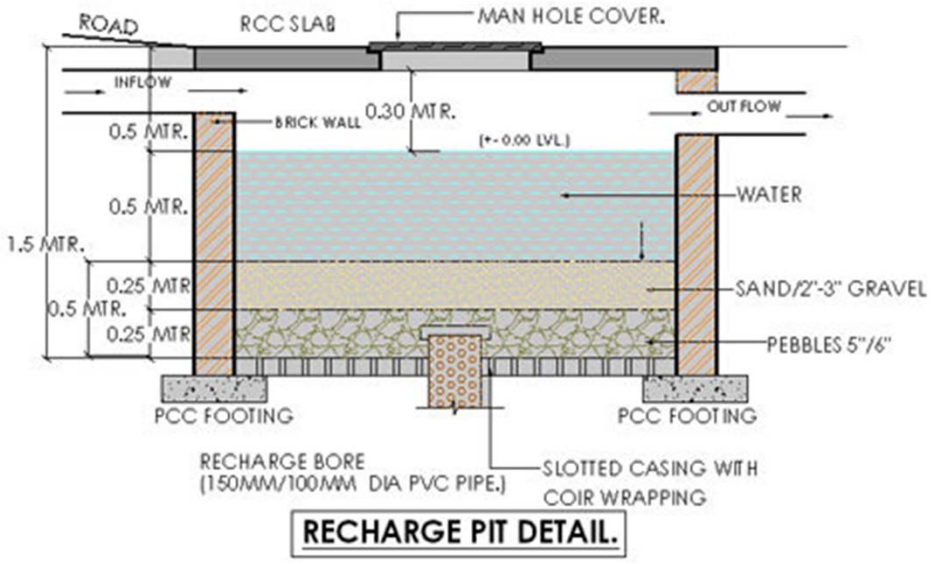
It is trench excavated on the ground and refilled with porous media like pebbles, boulders or brickbats. The gully floor below the notch must be protected to prevent erosion due to falling water, loose stones are suitable of they are large enough to resist movement by floodwater.



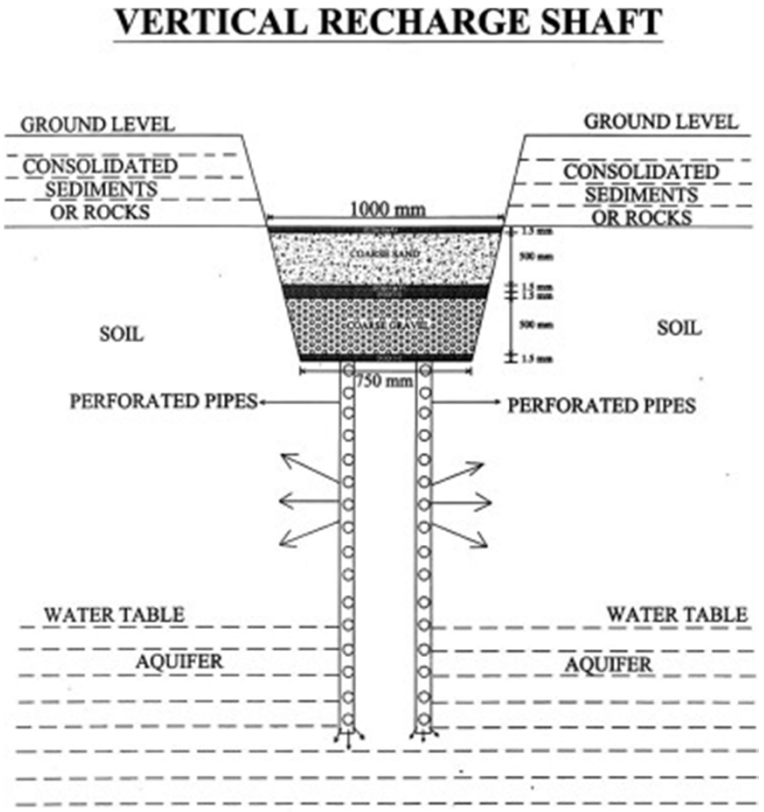


Pits and shafts

Recharge pits and shafts are usually adopted for effecting direct point recharge and are highly relevant from recharge point of view of spot sources.

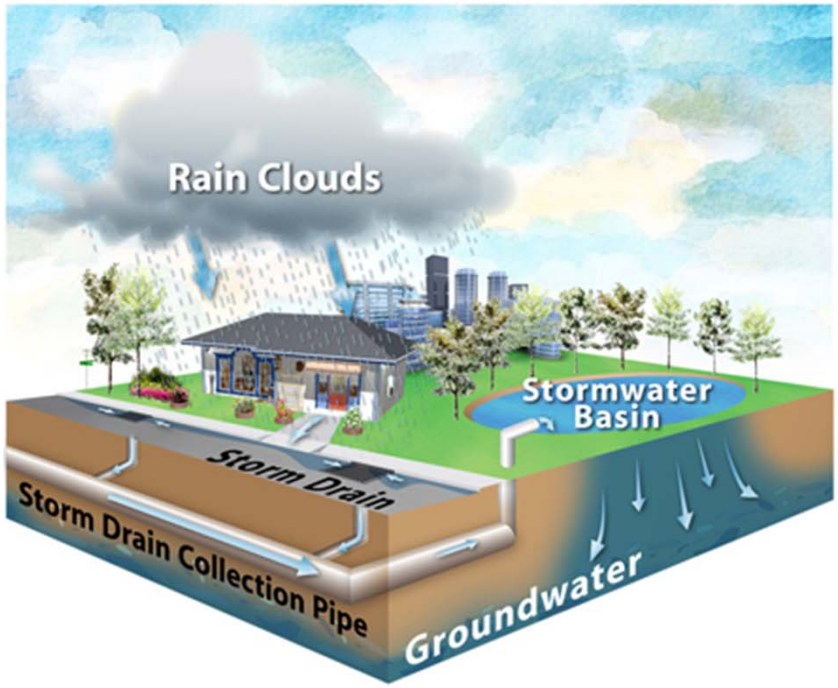


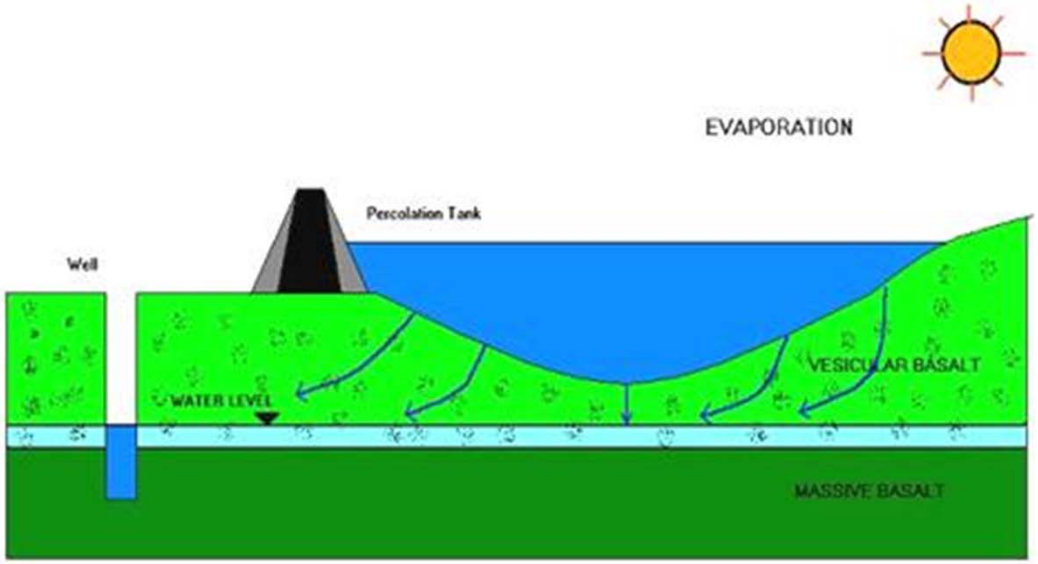
RECHARGE PIT DETAIL.



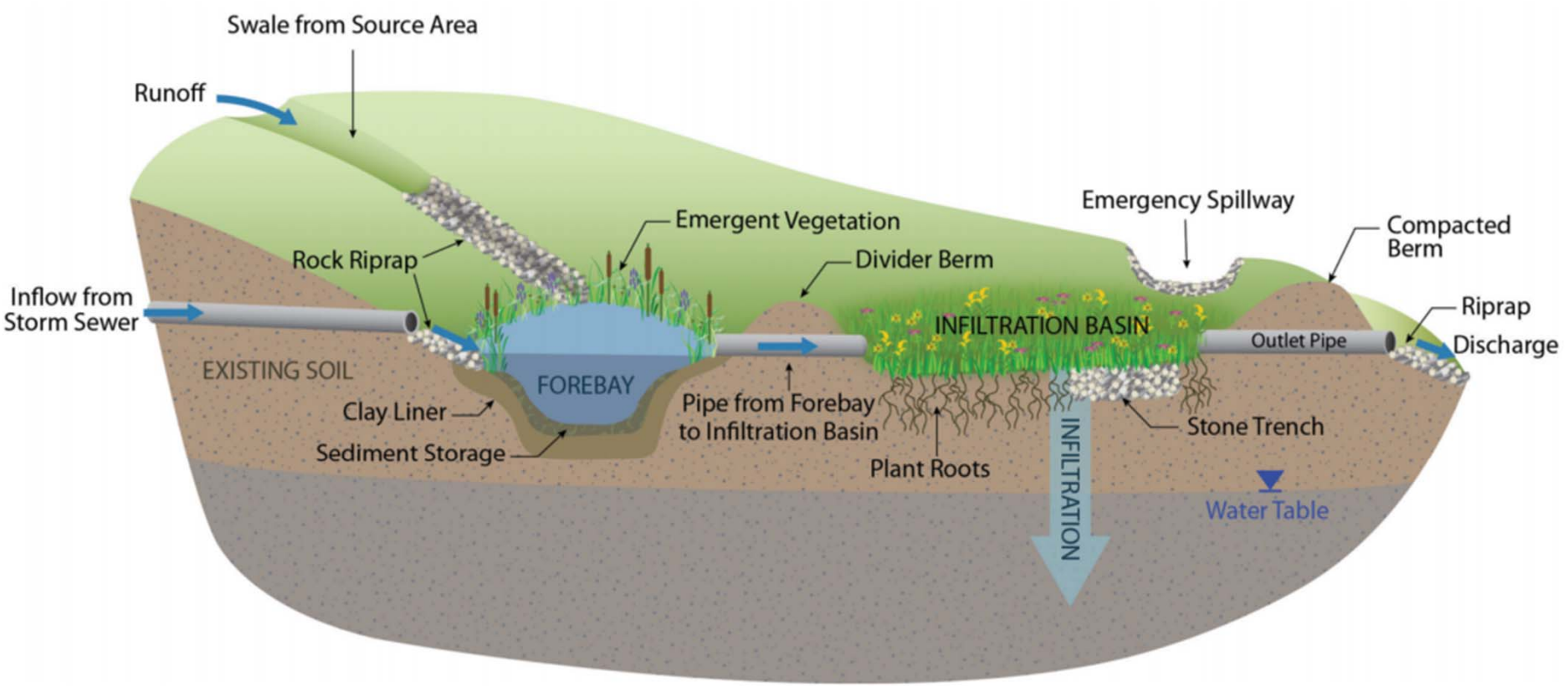
Basin/ Percolation tanks

Percolation tanks, located at hydro- geologically favourable points are conservation structures aimed at including maximum percolation of harvested rainwater.



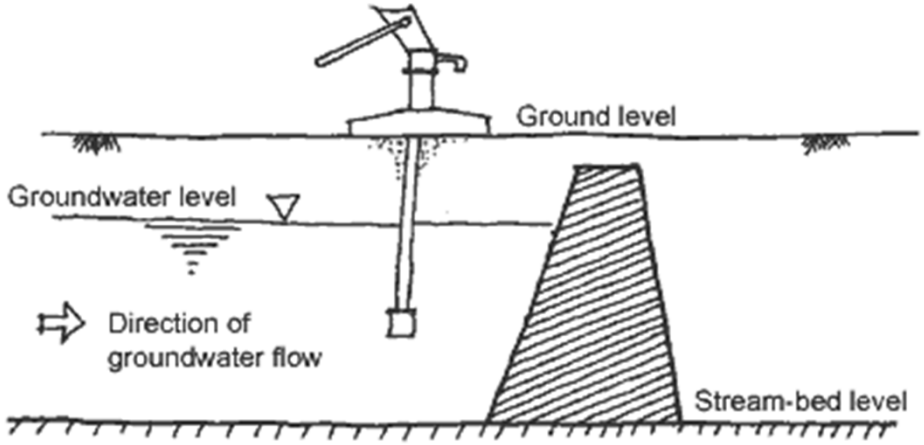


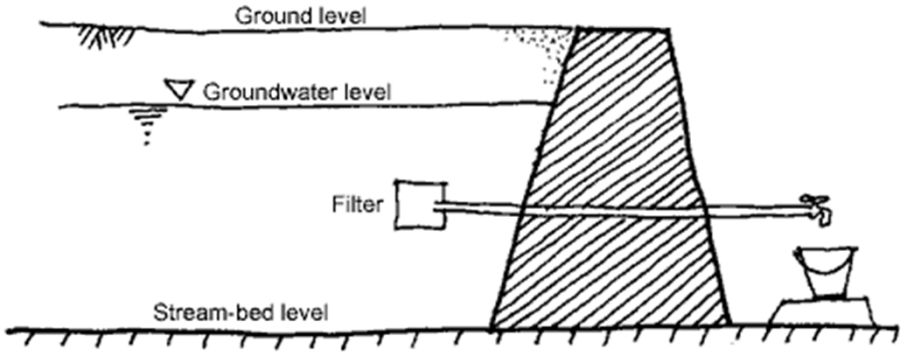
Basin/ Percolation tanks



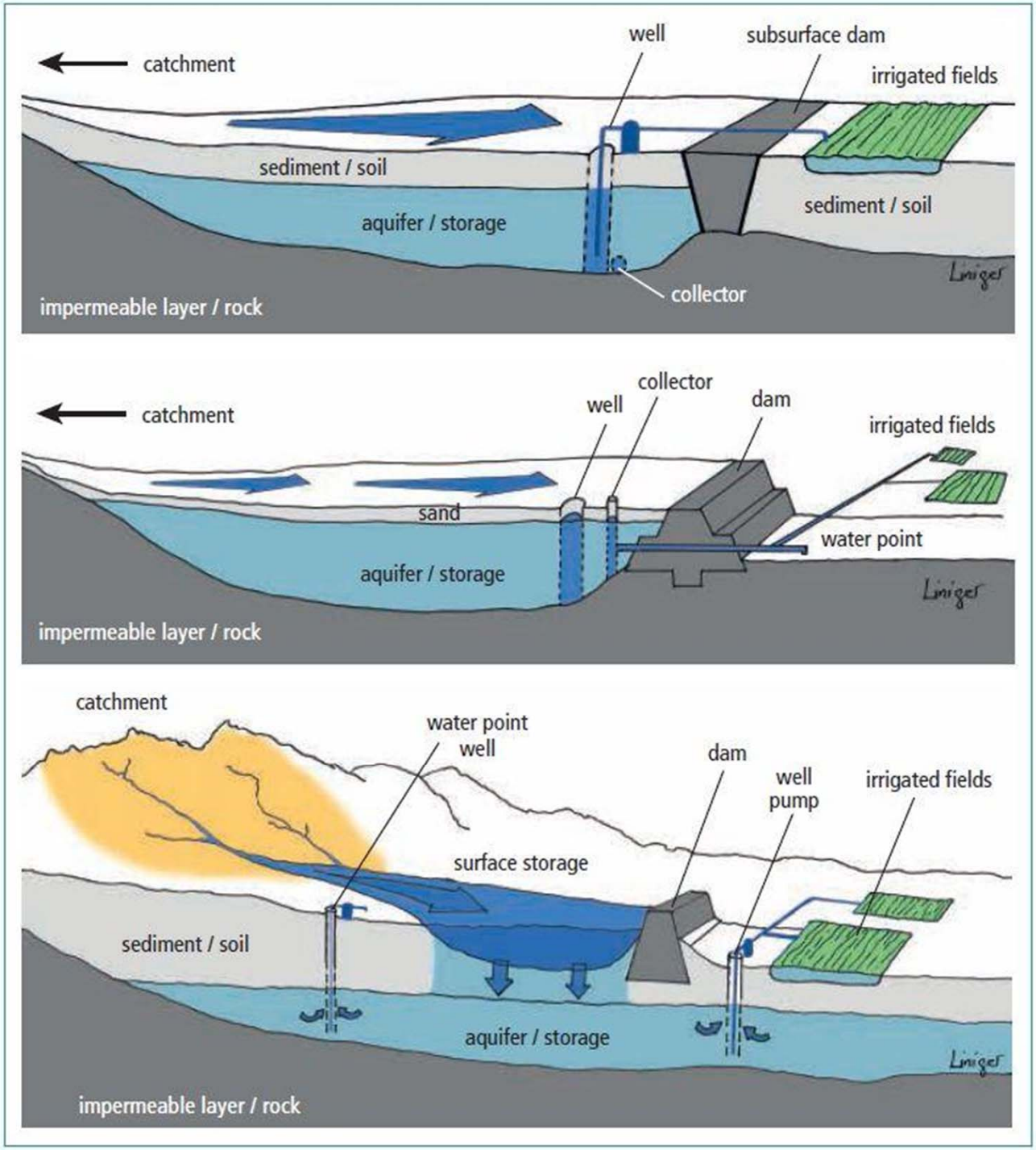
Groundwater dams

Groundwater dam is similar to a check dam with the difference that the dam is constructed below ground to conserve mainly sub-surface flow (ground water).





Groundwater dams



Storage tanks

Storage tanks through conventional or specially designed structures are used generally for storing rain water.

1 Rainwater Filter Diverter
The filter diverts the water from the rooftop into the storage tank, as the water passes through the unit is re-moves dirt and debris.

2 Calmed Inlet
The calmed inlet introduces water to the tank from the bottom up allowing oxygenated water to enter the tank which keeps the existing water from stagnating.

3 Overflow Siphon
The siphon prevents the tank from overflowing diverting any excess water to drainage whilst removing pollen from the water surface keeping it clean.

4 Submersible Pump
A variety of pumps can be used both manually and automatically so the water har-vested can be utilised in a process.

Rainwater Harvesting is the process where by you collect rainwater from rooftops which is stored in tanks to then be used in a variety of processes both manual and automatic.

Village tanks

Village tanks can be gainfully used as recharge structures by desilting and by providing appropriate modifications like cut-off trench in the upstream ride.

Diversion channel

Diversion serve many purposes ranging from diverting runoff water away from a gully or around a cultivated field to carrying runoff to ponds and storage reservoirs.

The other techniques for conserving water also include regular desilting of tanks, interwatershed transfer, stream augmentation settlement, legoon levelling etc. Adoptability of a particular technique depends on local site conditions and extent of the issue.

Rainwater harvesting

- Rainwater harvesting refers to the collection and storage of rain water. It also refers to other measures aimed at harvesting surface water and groundwater and prevention of its loss through evaporation and seepage.

- It also includes collection of rainwater from roofs of the buildings to directly store it or use it to recharge the ground water aquifer.

- It makes optimum use of rainwater, which is the ultimate source that feeds all the secondary sources of water like rivers, lakes, and groundwater.

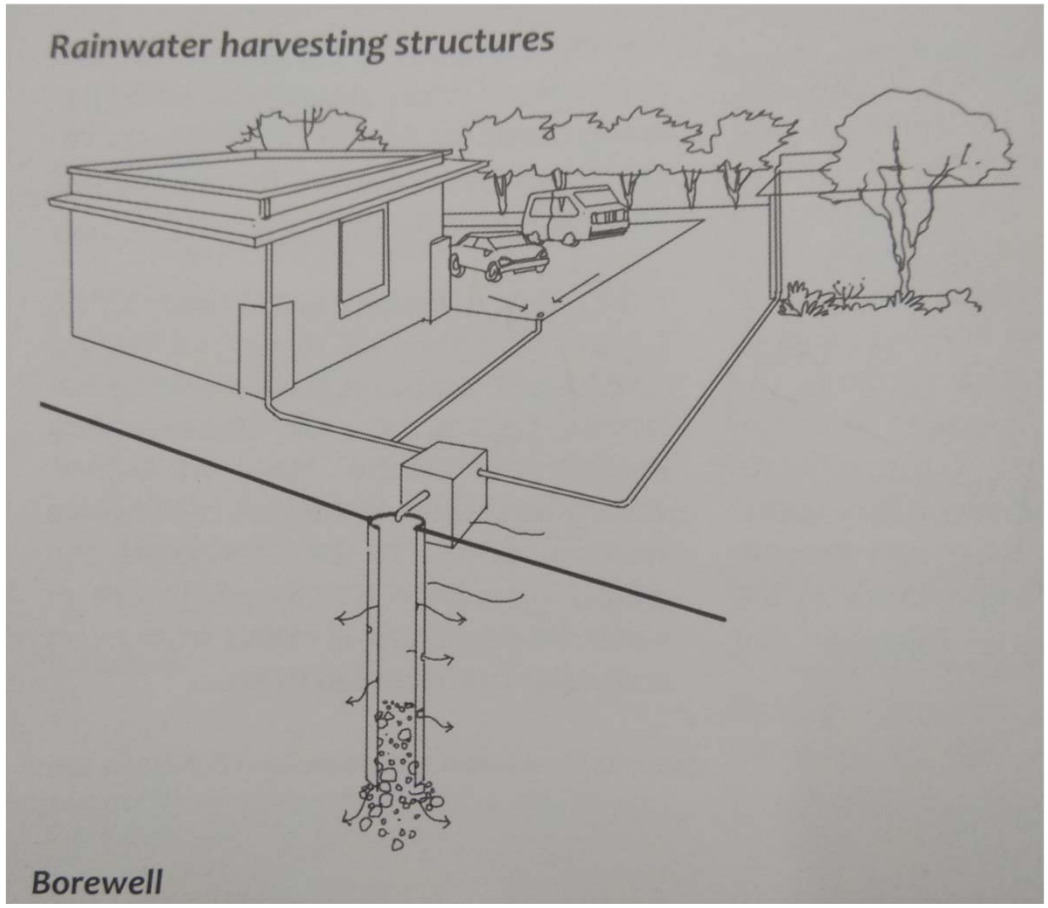
- It is of utmost importance in dry and arid areas like states of Rajasthan and Gujarat.
- Broadly, rainwater is harvested for two objectives of direct storage, (above or below ground) for various purposes and recharging of groundwater, hence reducing demand for fresh water.

- India has a community based rural centric traditional system of water harvesting spread over various regions including Rajasthan, Gujrat, Leh, Karnataka, Andhra Pradesh, and Odisha. Many water harvesting structures and water conveyance systems specific to the eco regions and culture have been developed. Source for harvesting is mainly from rivers and water from flooded rivers.

RAINWATER HARVESTING STRUCTURES

Borewell

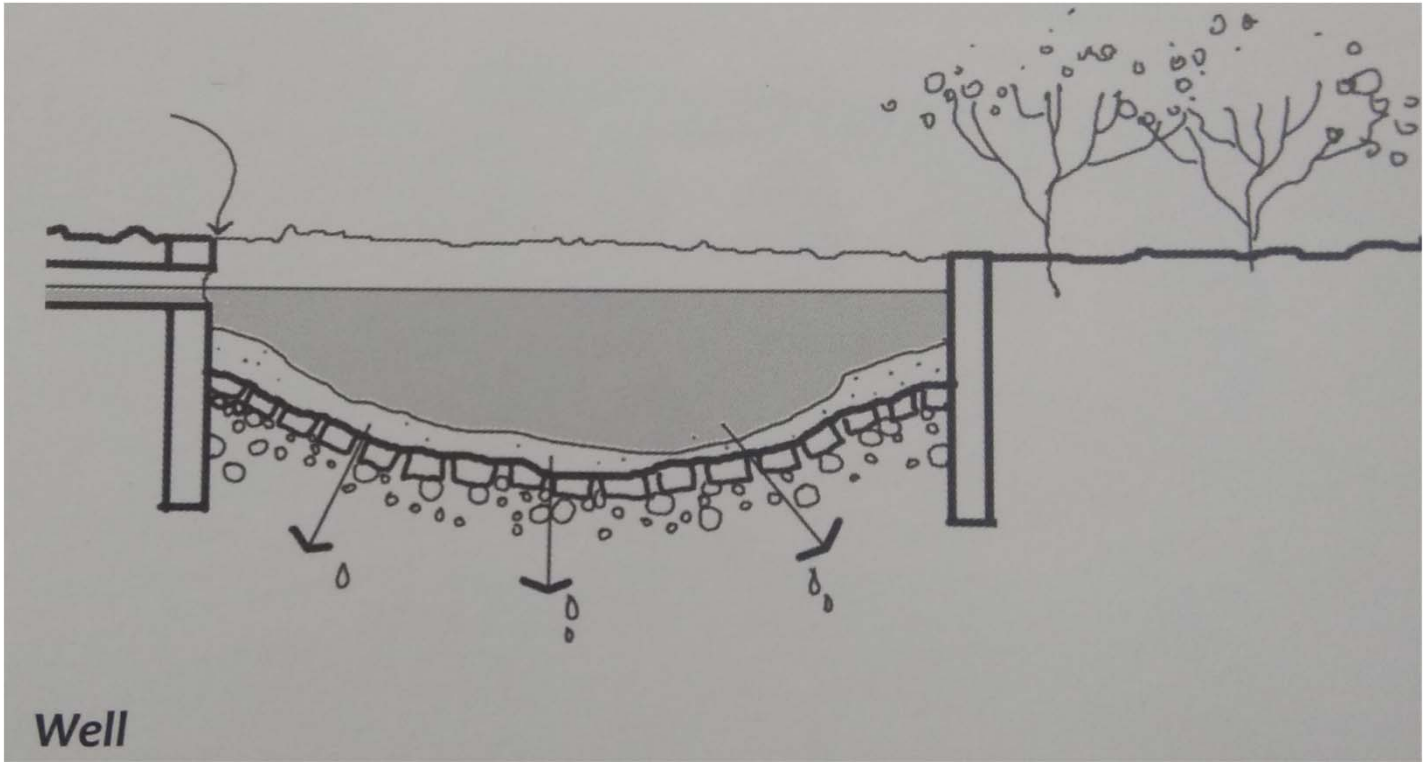
Rainwater of the rooftop as well as the surface runoff is diverted by drainpipes to a settlement or filtration tank from which it flows into a recharge borewell/dug well which has its outer pipe (casting) as slotted r perforated so that water can percolate.



RAINWATER HARVESTING STRUCTURES

Well

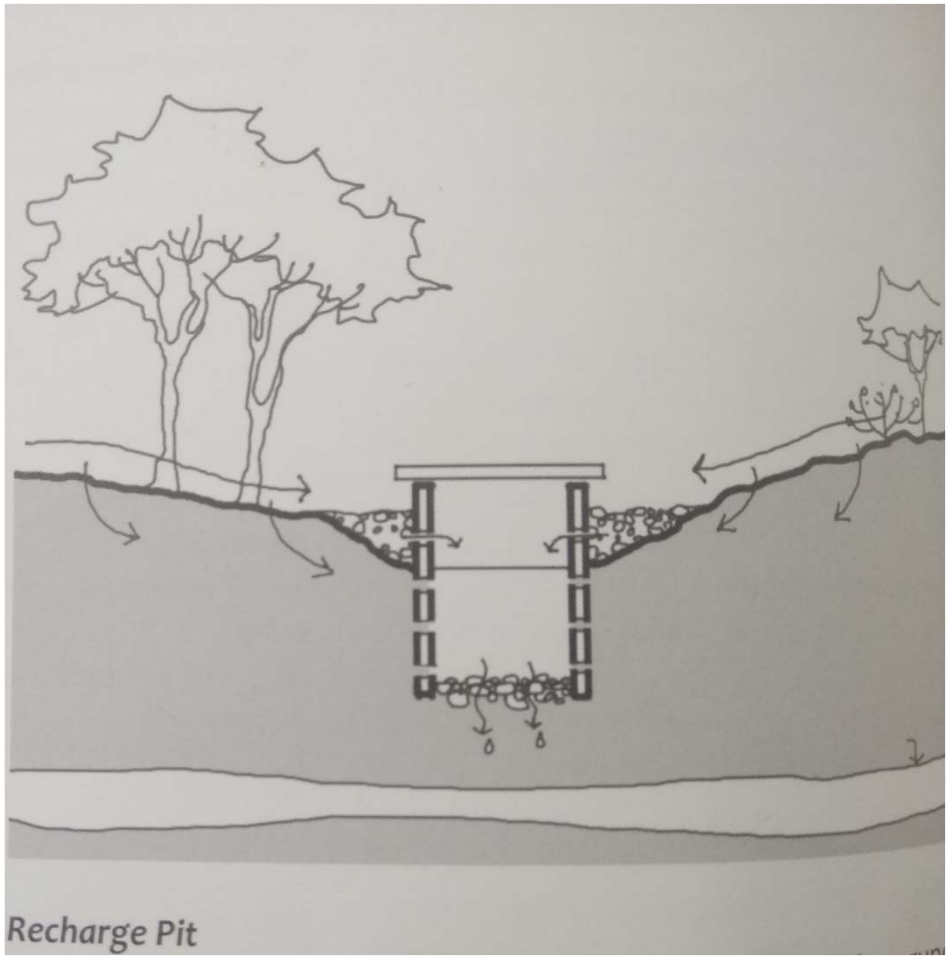
In this case, the well lining has weep holes at regular intervals to allow seepage of water through the sides. It is shallower than the water table so that it has sufficient thickness of soil through which it passes before joining groundwater. Any old abandoned well can be used for recharging. The bottom of the well is regularly desilted to maintain its intake capacity.



RAINWATER HARVESTING STRUCTURES

Recharge Pit

A medium sized excavated pit is located near the surface runoff spot point to trap the flow. It is lined with a brick/ stonewall with openings at regular intervals.

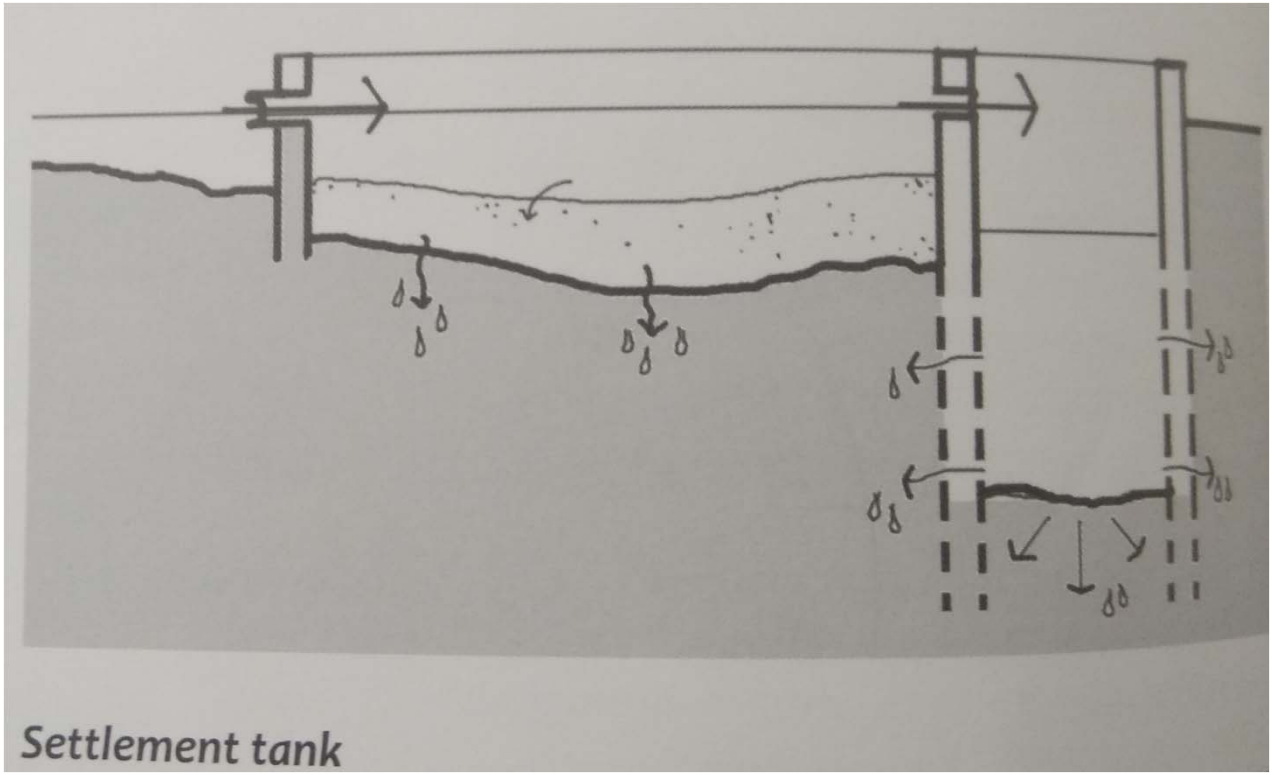


Recharge Pit

RAINWATER HARVESTING STRUCTURES

Settlement tank

It is used to remove silt and other impurities from rainwater. It can have an unpaved bottom surface to allow standing water to percolate into the soil. It has provision for inflow, outflow and overflow. It holds excess of water till it is soaked up by the recharge structure. N container masonry or concrete or underground tank, old disused tanks my be used as a settlement tank.



Settlement tank

GEOSYNTHETICS

Geosynthetics are materials made from various types of polymers , used with geological materials like soil, rock etc. to enhance, improve or modify the behaviour of various civil engineering works.

Geosynthetics are available in a wide range of forms and materials, each to suit a slightly different use.

These products have a wide range of applications and are currently used in many geotechnical, transportation, hydraulic, and private development applications including roads, airfields, embankments ,retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners, landfill covers, mining, and agriculture.

Geosynthetics are Classified as follows

1. Geotextiles
2. Geogrids
3. Geonets
4. Geomembranes
5. Geosynthetic clay liner
6. Geocells
7. Geofoam
8. Geocomposites

1. GEO-TEXTILE

Geotextiles are permeable fabrics which when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain.

Characteristics-

- Porous and allow flow of water through it.
- Most used Geosynthetics.
- Available in rolls of 5.6m wide and 50-150m long.

Geotextile fabrics come in two basic forms :

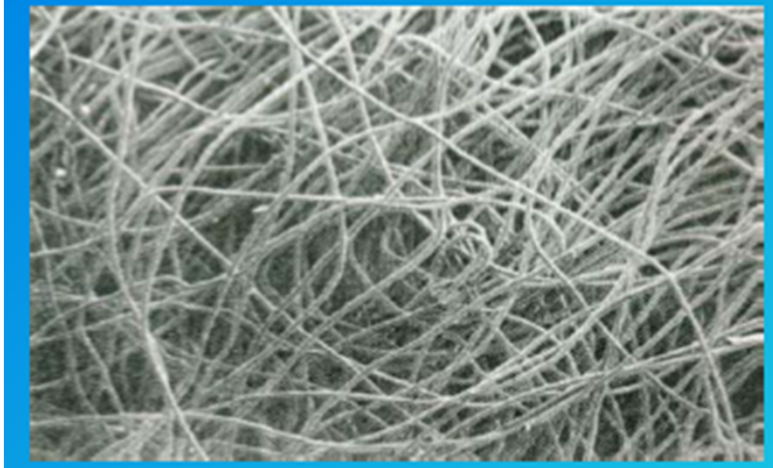
1. Woven

Microscopic View

- Uniform and regular interweaving of threads or yarns in two directions.
- Regular Visible Construction Pattern.
- Function: Soil Separation, Reinforcement, Load distribution, Filtration, Drainage
- Have high tensile strength and relatively low strain.

2. Non Woven

Microscopic View

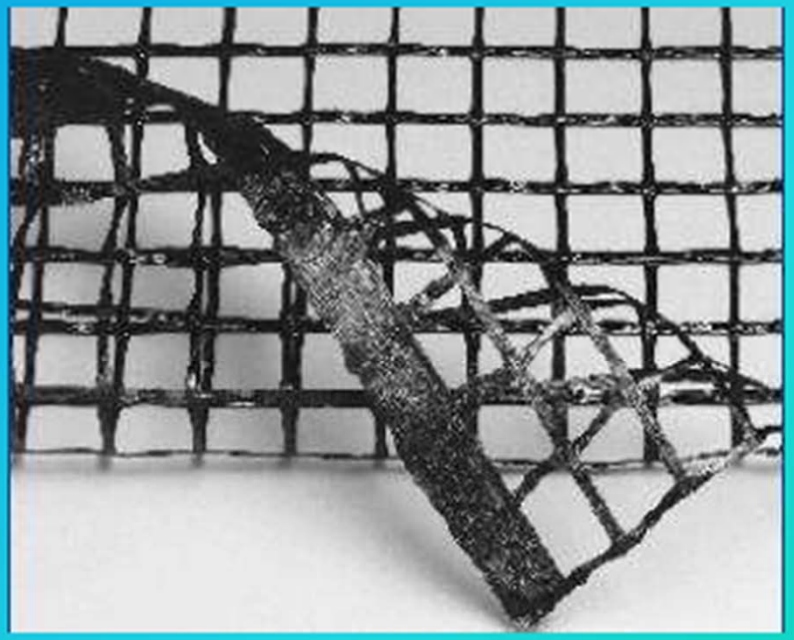


- Formed by heat bonding, resin bonding or needle punching.
- No visible thread pattern.
- Function: Soil separation, stabilization, load distribution, but not used for reinforcement.
- They have high strain and stretch considerably under load.

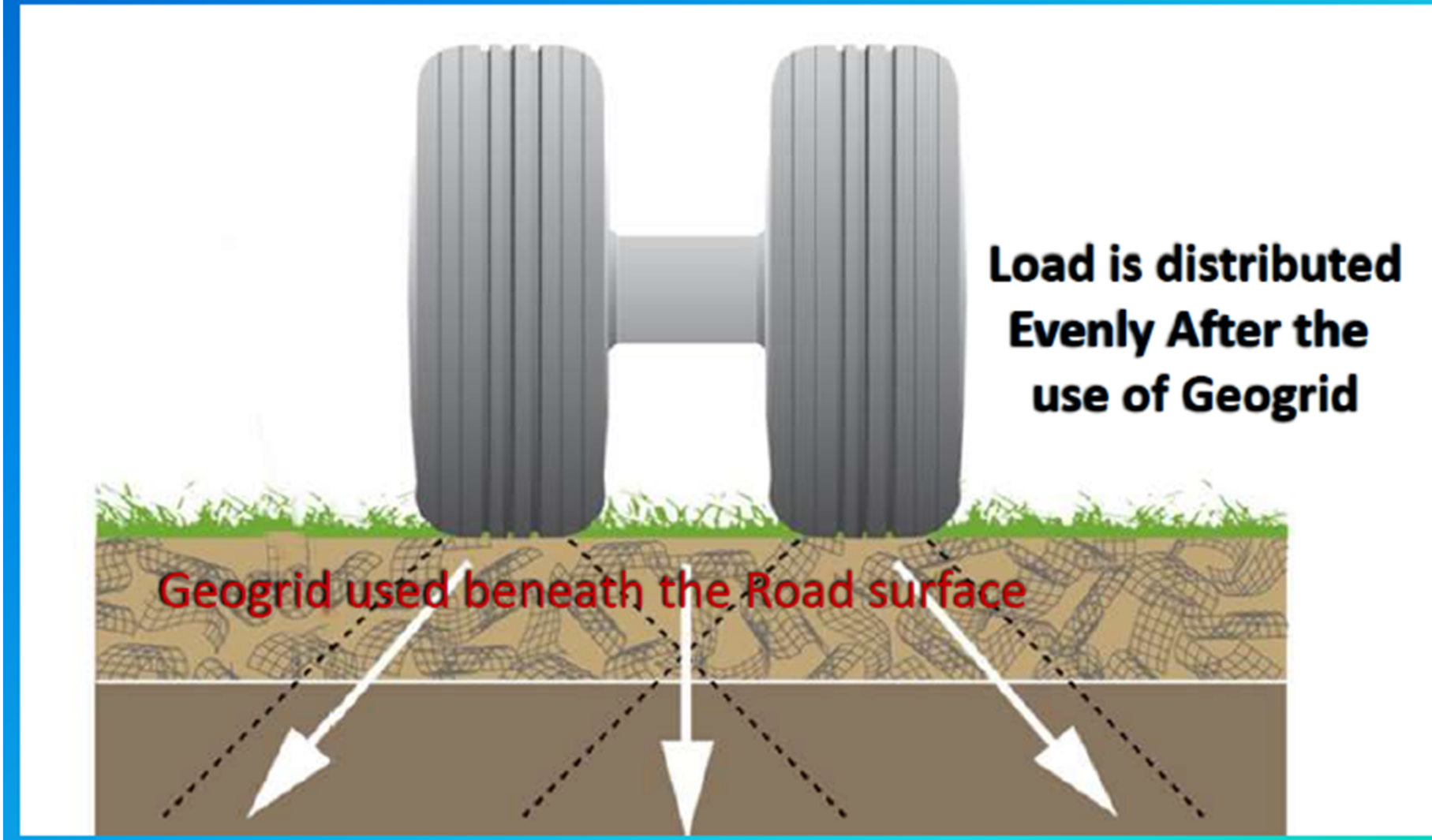
2. GEO-GRIDS

A Geogrid is geosynthetic material used to reinforce soils and similar materials. Geogrids are commonly used to reinforce retaining walls, as well as sub bases or subsoil's below roads or structures.

- They have open grid like configuration i.e. they have large aperture between individual ribs.
- They have Low strain and stretch about 2% under load.
- Strength is more that other common geotextiles.
- Function: Used exclusively for reinforcement



How Geogrid Improves the durability of Roads:



Use of Geogrid for Soil Reinforcement →


Use of Geogrid in Grass Lanes

3. GEO-NETS

A **geonet** is a geosynthetic material consisting of integrally connected parallel sets of ribs overlying similar sets at various angles for in-plane drainage of liquids or gases.

- Geonets are made of stacked, criss-crossing polymer strands that provide in-plane drainage.
- Two layers of strands are called “bi-planar”.
- Three layers are called “tri-planar”.

Bi-Planar

Two layers of strands

Three layers of strands

Tri-Planar

4. GEOMEMBRANES

A Geomembrane is very low permeability synthetic membrane barrier used to control fluid or gas migration in a structure, or system.

Characteristics-

- ❖Impermeable and usually non-woven,
- ❖Used as a fluid barrier in designing drainage systems, etc.
- ❖Used as damp proof course in floors, roofs etc.


Geomembranes used in
Agricultural Ponds

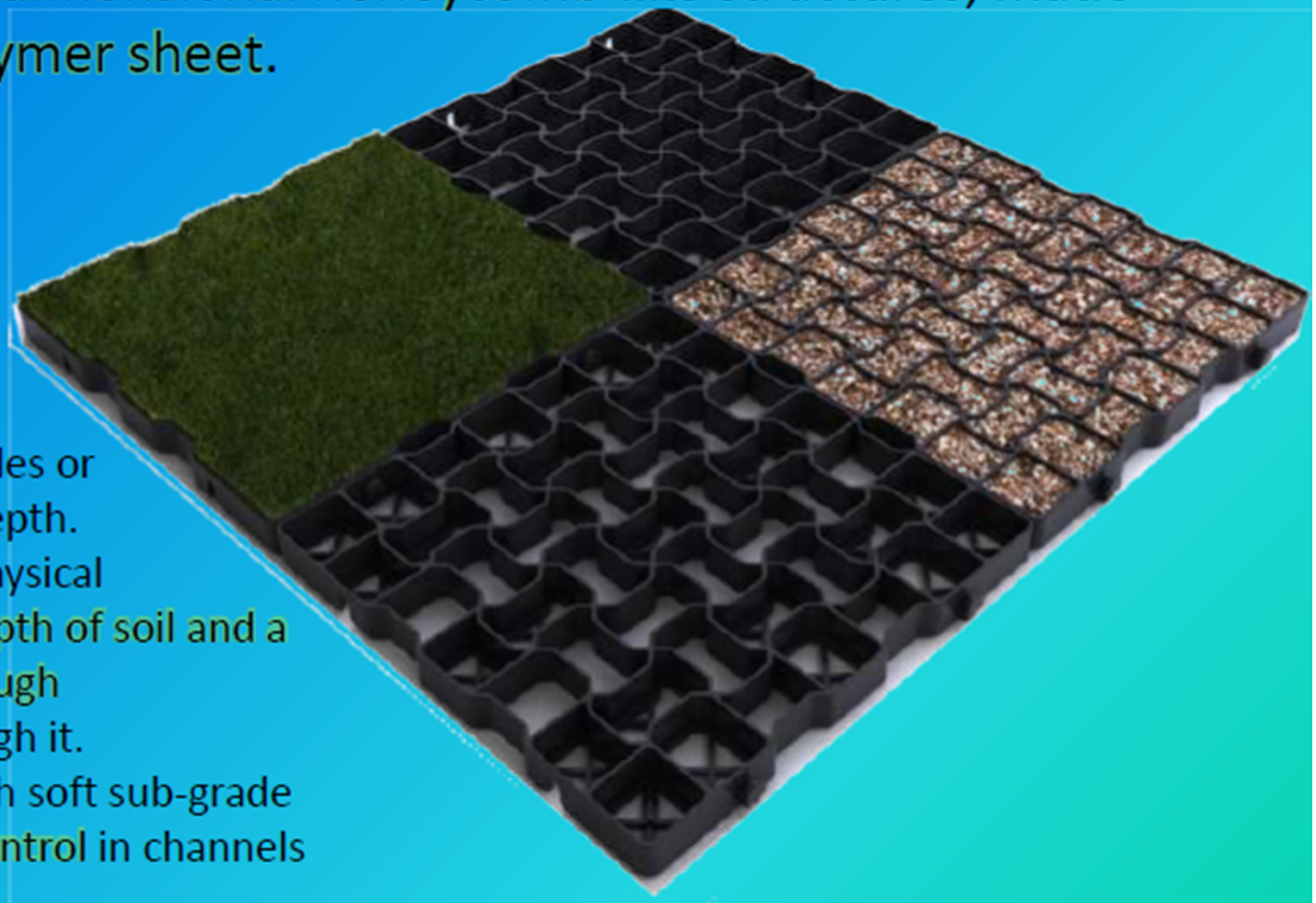
5. Geosynthetic clay liner

It is a woven fabric-like material, combination of geotextiles and geomembranes used as a barrier for liquid or solid waste containment. primarily used for the lining of landfills.

GCLs are manufactured by sandwiching the bentonite within or layering it on geotextiles and geomembranes , bonding the layers with needling, stitching or chemical adhesives. Primarily used for the lining of landfills.

6. Geocells

Geocells are 3-dimensional honeycomb-like structures, made of strips of polymer sheet.



Characteristics-

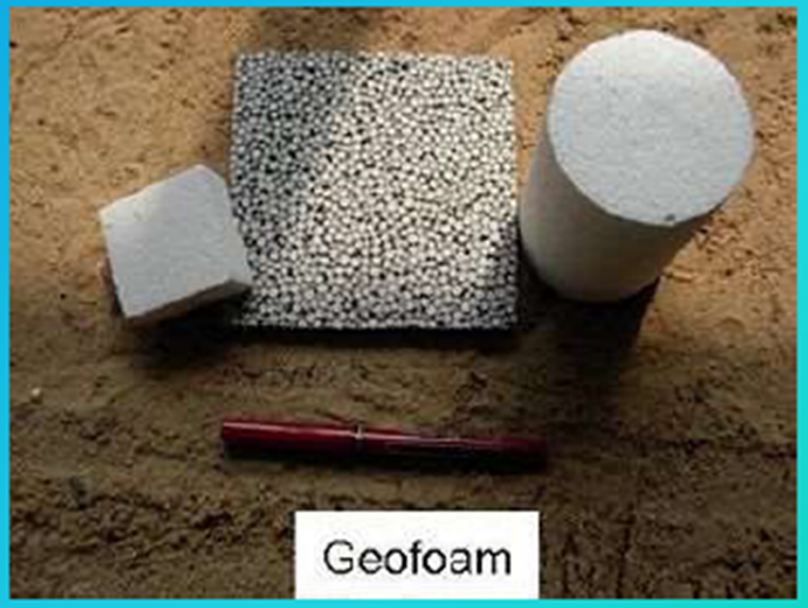
- Similar to geotextiles or geogrids but have depth.
- provides both a physical containment of a depth of soil and a transfer of load through
- Allow water through it.
- Used in slopes with soft sub-grade
- Used in erosion control in channels

Use of Geocell in Erosion Control

7. Geofoams

Geofoam is manufactured into large lightweight blocks by polymeric expansion process. They are large but extremely light materials with gas filled cells.

- Low density/ high strength: Geofoam is 1% to 2% the density of soil with equal strength.
- Quick to install and can be installed during any type of weather.
- If geofoam comes in contact with a petroleum solvent, it will immediately turn into a glue-type substance, making it unable to support any load.
- Untreated geofoam is a Fire hazard



Uses-

- within soil embankments built over soft, weak soils;
- under roads, airfield pavements and railway track systems subject to excessive freeze-thaw conditions.
- thermal insulation in storage tanks containing cold liquids.
- separation, lightweight fill, compressible inclusions,

8. Geocomposites

These are products manufactured by combining the superior features of various types of geosynthetics.

This is prepared to extract all the major properties of the geosynthetics into a single unit with minimum cost.

The various types of Geocomposites are :-

Geotextile-Geonet Composites

Geotextile –Geomembrane Composites

Geotextile –Geogrid Composites

Geomembrane –Geogrid Composite

Geotextile-Polymer Core Composite

Geocomposites

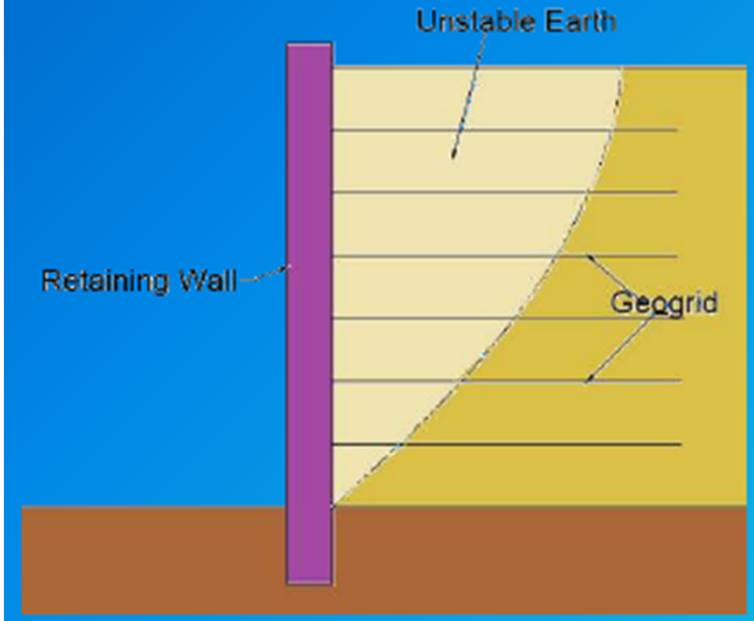
FUNCTION OF GEOSYNTHETIC MATERIALS: A Comparative Review.

Types Of Geosynthetics	Separation	Re-inforcement	Filtration	Drainage	Containment
Geotextile	YES	YES	YES	YES	
Geogrid		YES			
Geonet				YES	
Geomembrane					YES
G. Clay Liners					YES
Geocells		YES			YES
Geofoam	YES				
Geocomposites	YES	YES	YES	YES	YES

Use of Geosynthetics in Earth Retention Techniques - Retaining Walls

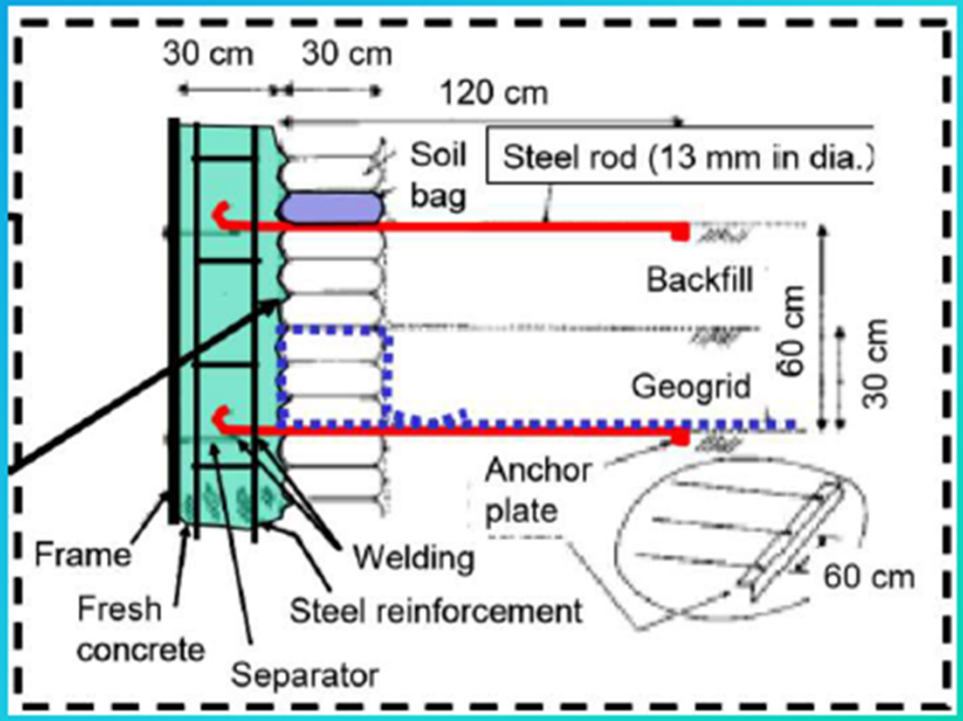
Retaining walls are structures designed to restrain soil to unnatural slopes.

For heavy loads or for greater slopes, concrete walls are placed along with the use of geosynthetic.

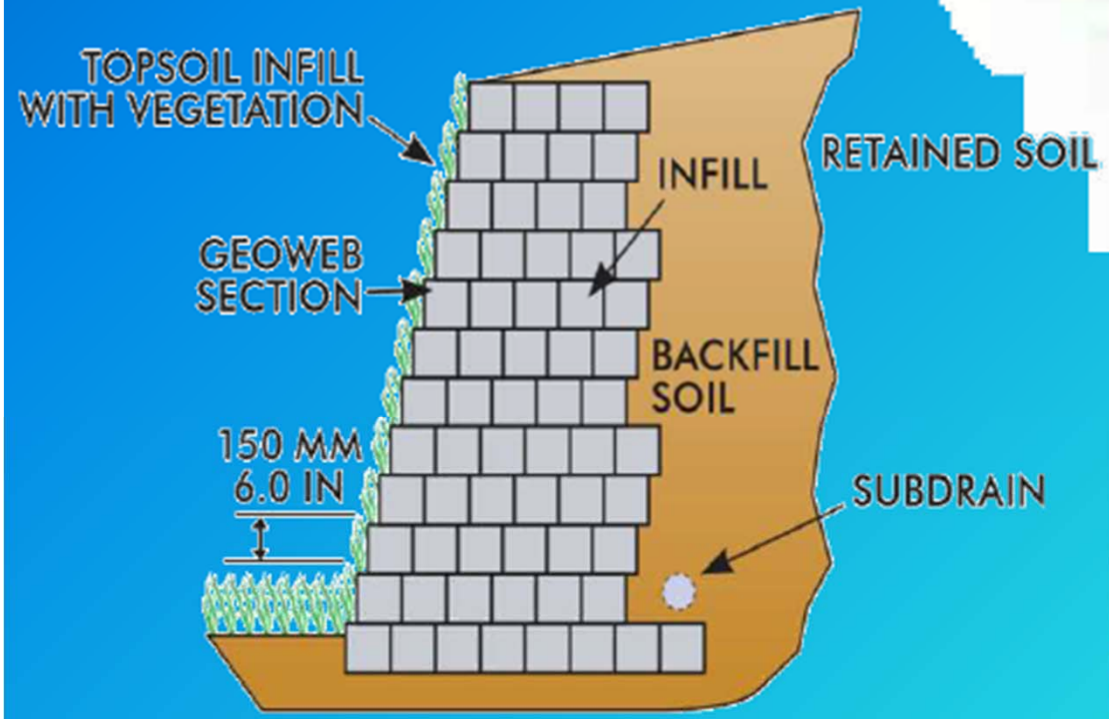


The Geogrid ties the portion of stable earth with the unstable earth

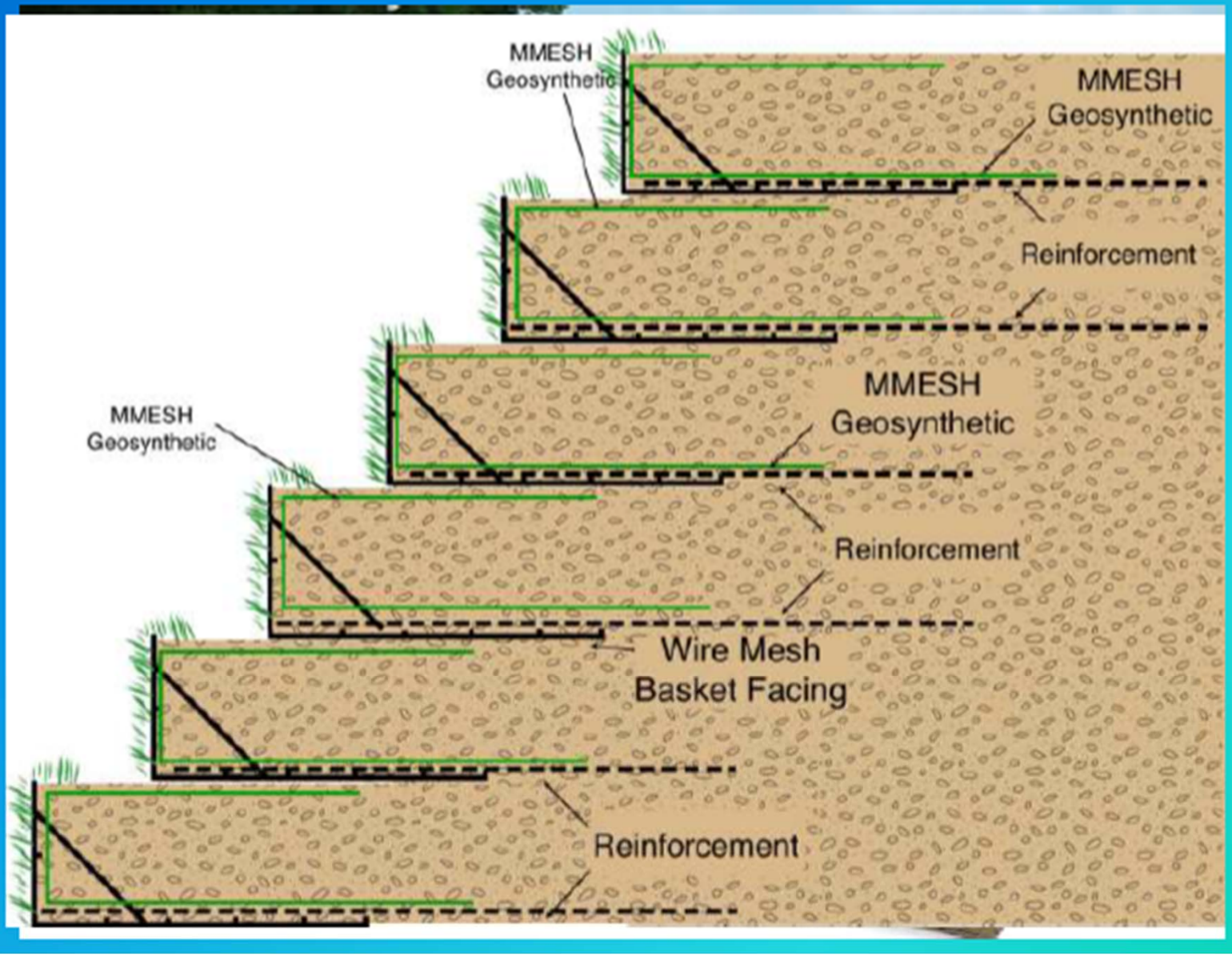
The Geogrid is layed in layers With earth fillings in between



If Geocells are used then even for steeper slopes, steel reinforcements are not necceray



For less loads or gentler slopes only layers of geogrid with steel reinforcement is used.



Such Earth Retention using only geogrid and steel reinforcement is done mostly for Embankments

IV.

Urban open spaces, urban avenue, urban forest and urban heat island.

URBAN OPEN SPACES

- In land use planning, urban open space is open space areas for "parks," "green spaces," and other open areas. The landscape of urban open spaces can range from playing fields to highly maintained environments to relatively natural landscapes.

- Generally considered open to the public, urban open spaces are sometimes privately owned, such as higher education campuses, neighbourhood/ community parks/ gardens, and institutional or corporate grounds.

- Areas outside city boundaries, such as state and national parks as well as open space in the countryside, are not considered urban open space.

- Streets, piazzas, plazas and urban squares are not always defined as urban open space in land use planning.

URBAN FOREST

- An **urban forest** is a forest or a collection of trees that grow within a city, town or a suburb.
- In a wider sense it may include any kind of woody plant vegetation growing in and around human settlements. In a narrower sense (also called **forest park**) it describes areas whose ecosystems are inherited from wilderness leftovers or remnants.
- Care and management of urban forests is called **urban forestry**. Urban forests may be publicly owned municipal forests, but the latter may also be located outside of the town or city to which they belong.
- Urban forests play an important role in ecology of human habitats in many ways: they filter air, water, sunlight, provide shelter to animals and recreational area for people. They moderate local climate, slowing wind and stormwater, and shading homes and businesses to conserve energy. They are critical in cooling the urban heat island effect, thus potentially reducing the number of unhealthful ozone days that plague major cities in peak summer months.
- In many countries there is a growing understanding of the importance of the natural ecology in urban forests. There are numerous projects underway aimed at restoration and preservation of ecosystems, ranging from simple elimination of leaf-raking and elimination of invasive plants to full-blown reintroduction of original species and riparian ecosystems.

URBAN FOREST

Benefits of urban forest

The benefits of urban trees and shrubs are many, including

- beautification,
- reduction of the urban heat island effect,
- reduction of storm water runoff,
- reduction of air pollution,
- reduction of energy costs through increased shade over buildings,
- enhancement of property values,
- improved wildlife habitat, and
- mitigation of overall urban environmental impact.

URBAN FOREST

Social, psychological, recreational, wildlife

The presence of trees reduces stress, and trees have long been seen to benefit the health of urban dwellers. The shade of trees and other urban green spaces make place for people to meet and socialize and play.

Economic benefits

The economic benefits of trees and various other plants have been understood for a long time. Recently, more of these benefits are becoming quantified. Quantification of the economic benefits of trees helps justify public and private expenditures to maintain them. One of the most obvious examples of economic utility is the example of the deciduous tree planted on the south and west of a building (in the Northern Hemisphere), or north and east (in the Southern Hemisphere). The shade shelters and cools the building during the summer, but allows the sun to warm it in the winter after the leaves fall.

URBAN FOREST

Air pollution reduction

As cities struggle to comply with air quality standards, trees can help to clean the air. The most serious pollutants in the urban atmosphere are ozone, nitrogen oxides (NOx), sulphuric oxides (SOx) and particulate pollution. Ground-level ozone, or smog, is created by chemical reactions between NOx and volatile organic compounds (VOCs) in the presence of sunlight. High temperatures increase the rate of this reaction. Vehicle emissions (especially diesel), and emissions from industrial facilities are the major sources of NOx. Vehicle emissions, industrial emissions, gasoline vapors, chemical solvents, trees and other plants are the major sources of VOCs. Particulate pollution, or particulate matter (PM10 and PM25), is made up of microscopic solids or liquid droplets that can be inhaled and retained in lung tissue causing serious health problems.

Trees reduce temperatures and smog

With an extensive and healthy urban forest air quality can be drastically improved. Trees help to lower air temperatures and the urban heat island effect in urban areas. This reduction of temperature not only lowers energy use, it also improves air quality, as the formation of ozone is dependent on temperature. Trees reduce temperature not only by directly shading: when there is a large number of trees it create a difference in temperatures between the area when they are located and the neighbour area.

URBAN FOREST

Lower temperatures reduce emissions in parking lots

Temperature reduction from shade trees in parking lots lowers the amount of evaporative emissions from parked cars.

Unshaded parking lots can be viewed as miniature heat islands, where temperatures can be even higher than surrounding areas. Tree canopies will reduce air temperatures significantly.

Although the bulk of hydrocarbon emissions come from tailpipe exhaust, 16% of hydrocarbon emissions are from evaporative emissions that occur when the fuel delivery systems of parked vehicles are heated.

These evaporative emissions and the exhaust emissions of the first few minutes of engine operation are sensitive to local microclimate. If cars are shaded in parking lots, evaporative emissions from fuel and volatilized plastics will be greatly reduced.

URBAN FOREST

Active pollutant removal

Trees also reduce pollution by actively removing it from the atmosphere. Leaf stomata, the pores on the leaf surface, take in polluting gases which are then absorbed by water inside the leaf. Some species of trees are more susceptible to the uptake of pollution, which can negatively affect plant growth. Ideally, trees should be selected that take in higher quantities of polluting gases and are resistant to the negative effects they can cause.

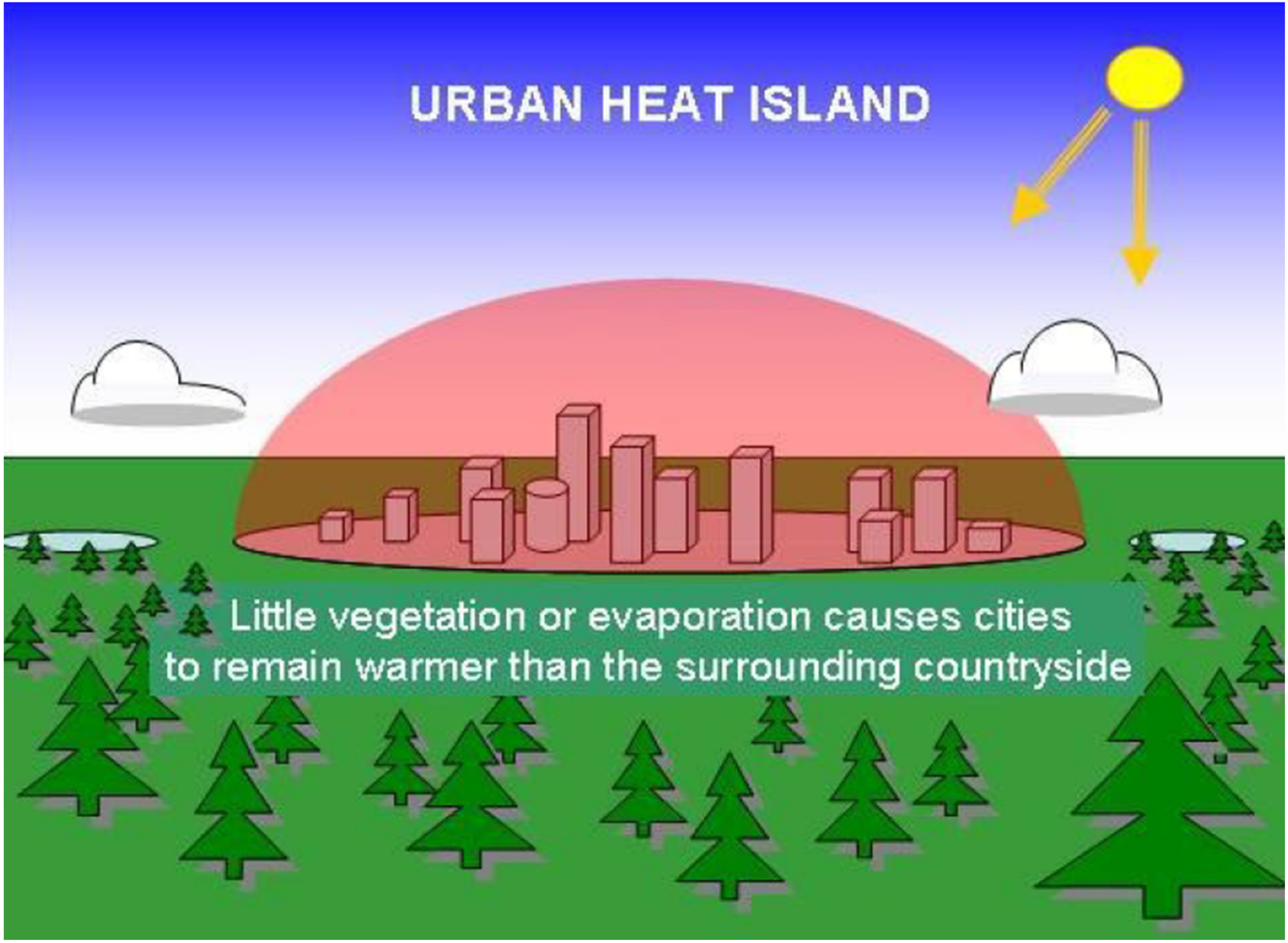
Carbon sequestration

Urban forest managers are sometimes interested in the amount of carbon removed from the air and stored in their forest as wood in relation to the amount of carbon dioxide released into the atmosphere while running tree maintenance equipment powered by fossil fuels.

Interception of particulate matter

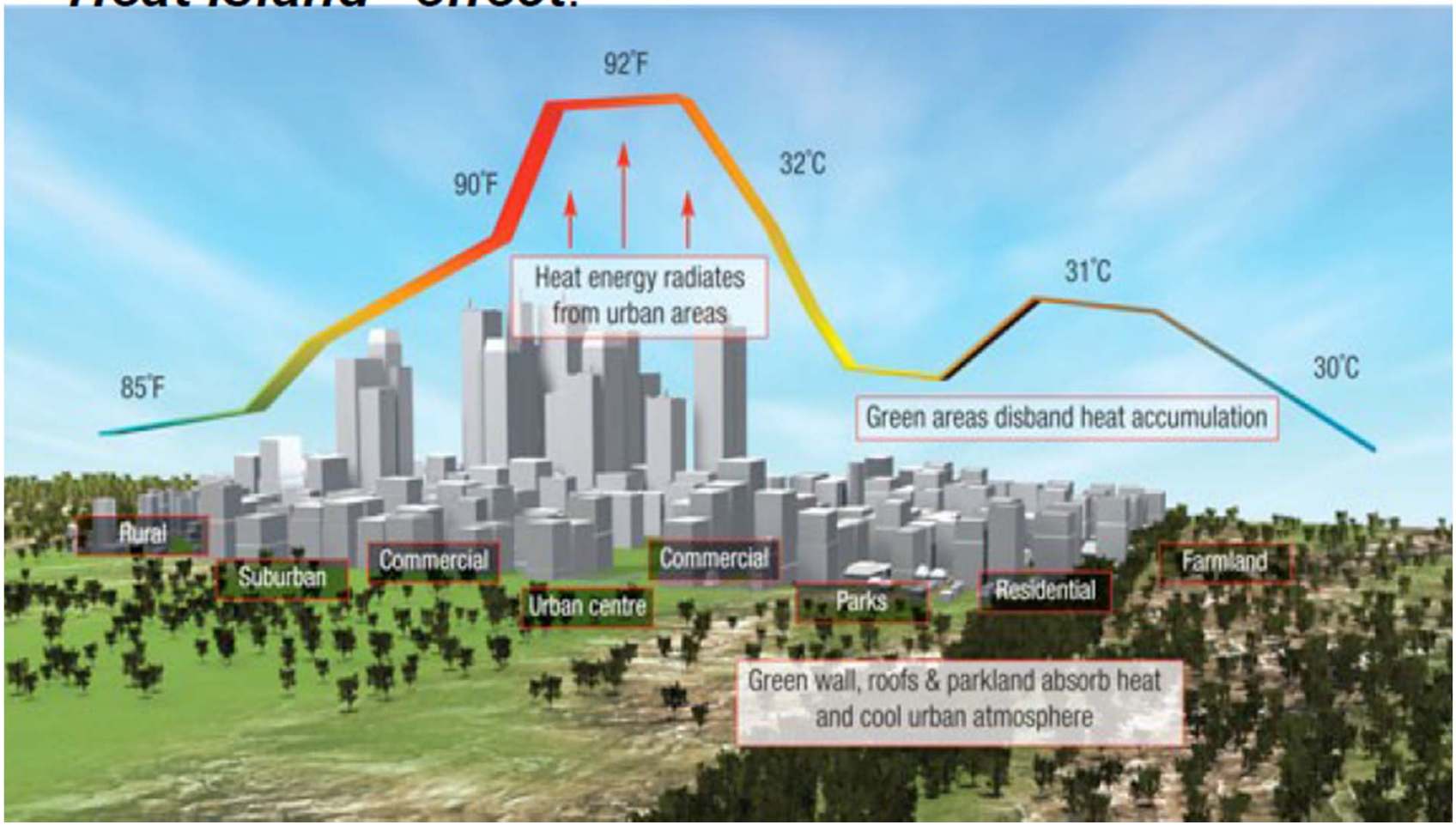
In addition to the uptake of harmful gases, trees act as filters intercepting airborne particles and reducing the amount of harmful particulate matter. The particles are captured by the surface area of the tree and its foliage. These particles temporarily rest on the surface of the tree, as they can be washed off by rainwater, blown off by high winds, or fall to the ground with a dropped leaf. Although trees are only a temporary host to particulate matter, if they did not exist, the temporarily housed particulate matter would remain airborne and harmful to humans. Increased tree cover will increase the amount of particulate matter intercepted from the air.

URBAN HEAT ISLAND

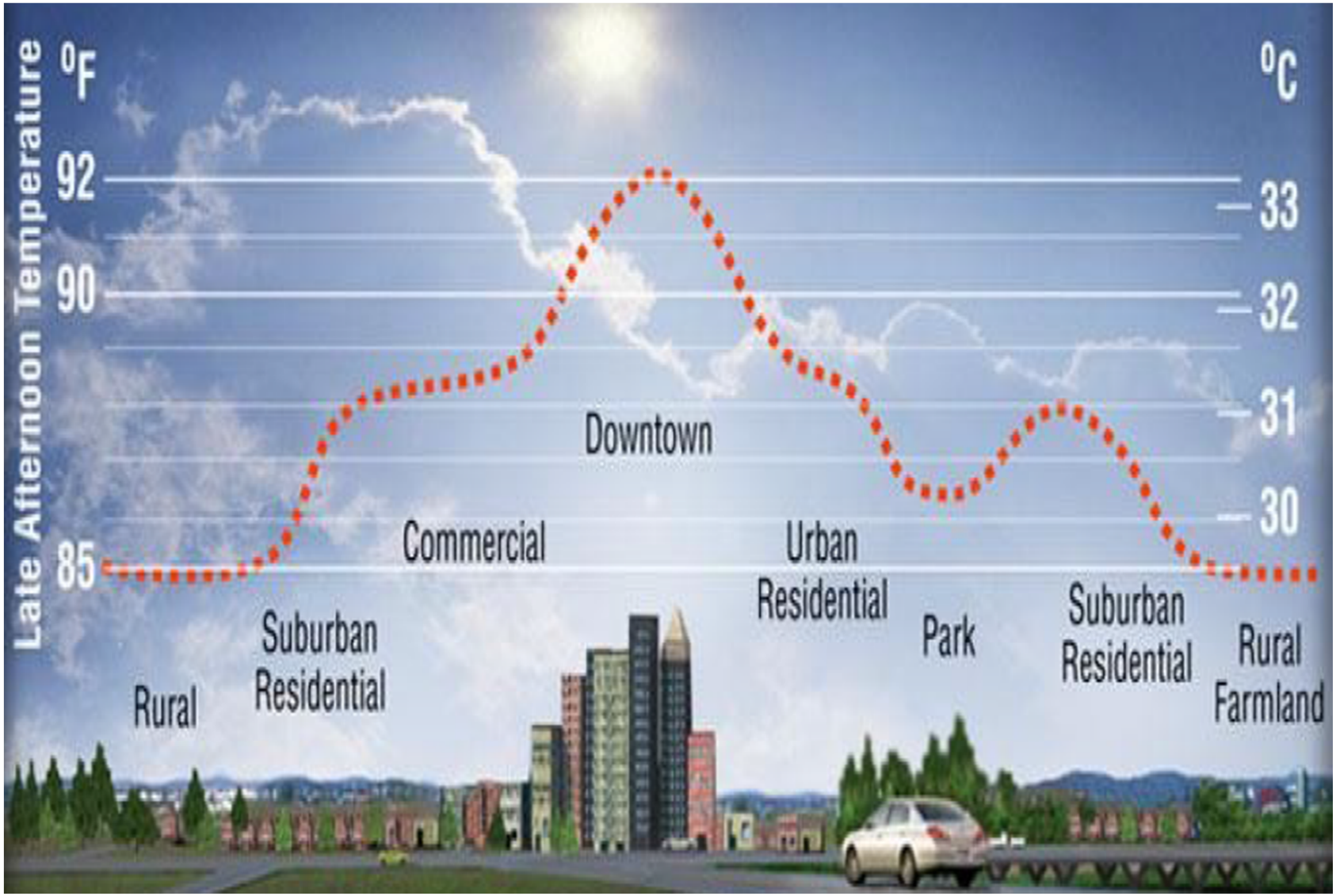


URBAN HEAT ISLAND

The temperature of urban areas can be significantly higher than that of the surrounding rural areas. This fact is known as the "Urban Heat Island" effect.



URBAN HEAT ISLAND



URBAN HEAT ISLAND

Is this Global Warming?

- No, this is a separate phenomenon where cities are 6-8°F warmer than surrounding rural areas. Global warming however could increase the impact of urban island felt in cities in the summer months.

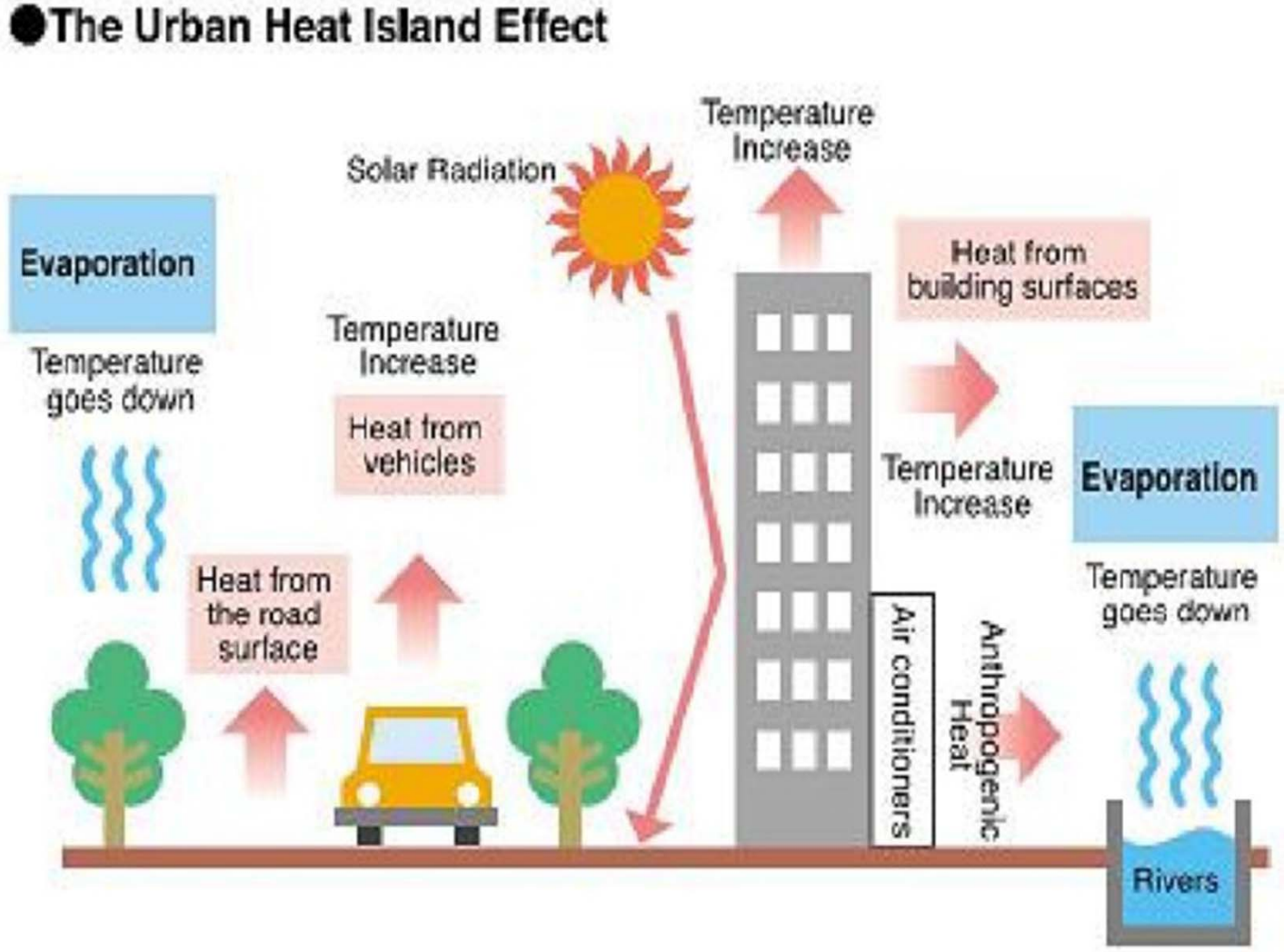
URBAN HEAT ISLAND

Factors work to promote a heat island.

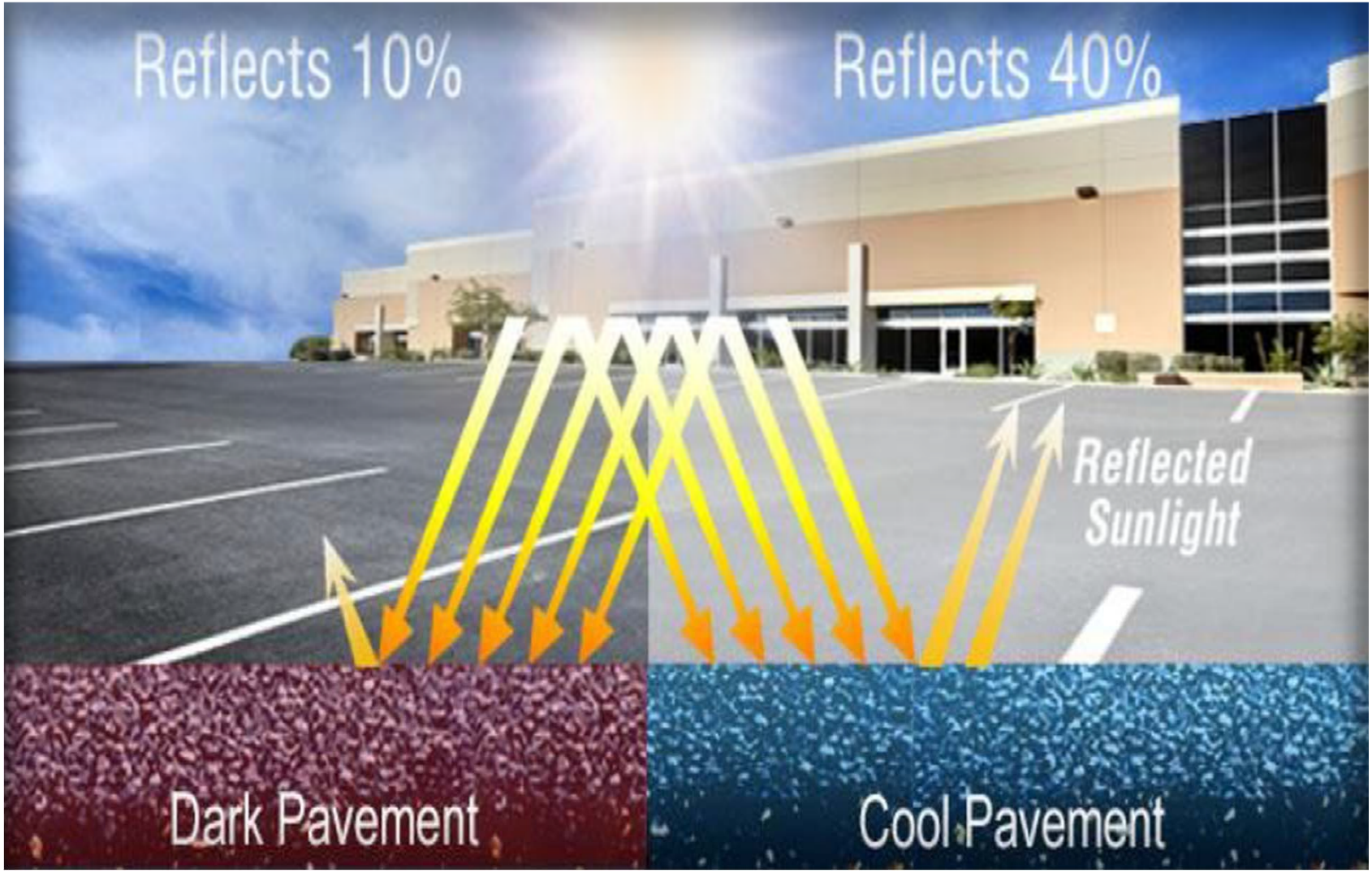
- **Concrete and man made surfaces**
- **Less water in the soil and environment**
- **Excess energy from buildings**

URBAN HEAT ISLAND

What is an Urban Heat Island?

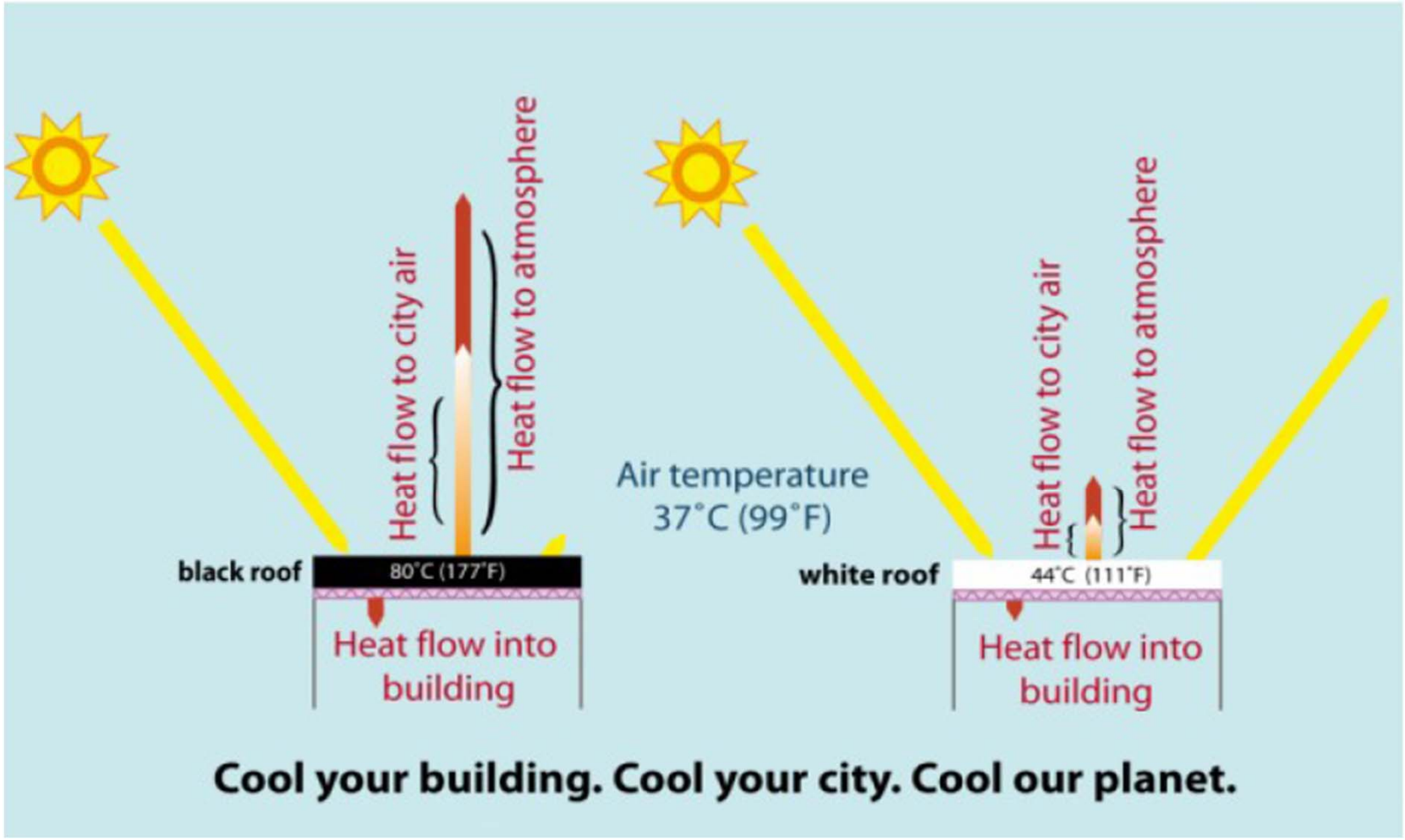


URBAN HEAT ISLAND



URBAN HEAT ISLAND

Difference b/w Black and White Materials



URBAN HEAT ISLAND

Causes

- The main cause of the UHI effect is from the modification of land surfaces, which use materials that effectively store short-wave radiation.

  Waste heat generated by energy usage is a secondary contributor.

URBAN HEAT ISLAND

During the day in rural areas, the solar energy absorbed near the ground evaporates water from the vegetation and soil(evapotranspiration). Thus, causes evaporative cooling.

In cities, where there is less vegetation, the buildings, streets and sidewalks absorb the majority of solar energy input. UHIs have been indirectly related to climate change due to their contribution to the greenhouse effect, and therefore, to global warming.

URBAN HEAT ISLAND

The principal reason for the nighttime warming is that buildings block surface heat from radiating into the relatively cold night sky.

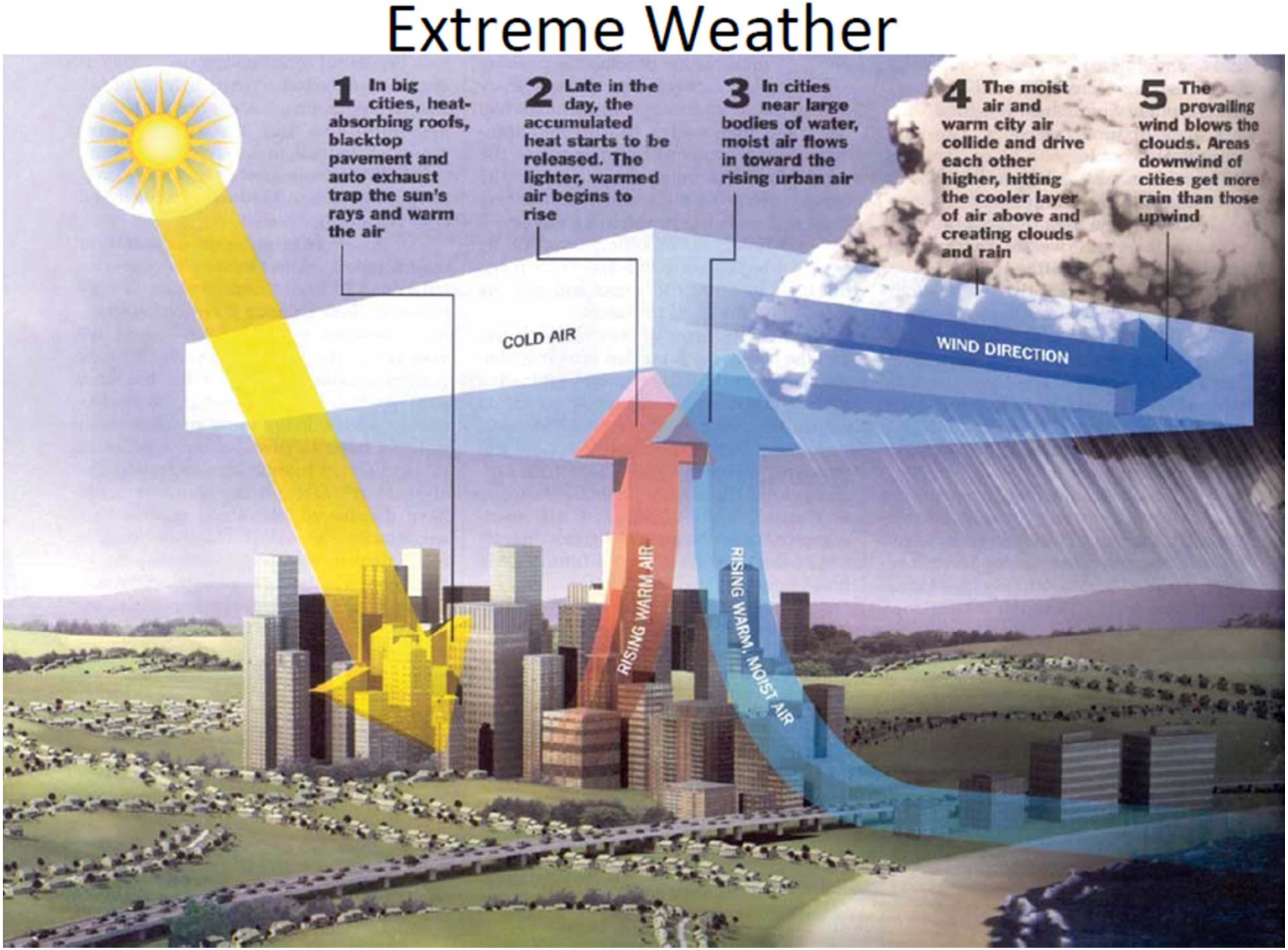
Tar, asphalt, brick and concrete absorb insolation and release it as heat, rather than reflecting it (without heat) like soil does.

URBAN HEAT ISLAND

Effects of UHI

- The extra heat from urban environments can cause extreme weather and climatic events such as ***storms, hurricanes, and floods***. Warmer air can hold more water and moisture, which results in more precipitation. For every **1°F** warming, atmospheric water vapor increases **3-4%**. Urban heat islands can cause up to **15°F** of warming, which can increase atmospheric water vapor by more than **50%**!

URBAN HEAT ISLAND



URBAN HEAT ISLAND

- Every ***1°C*** increase in air temperature, there is a ***5-10%*** increase in electricity demand this energy demand need more fossil fuels and more pollution.

  Heat islands can exacerbate the health risk of heat waves during the summer, difficulty in ***breathing in olds , heat craps, and heat strokes***.

  Impact on ecosystems, the atmosphere, and people.

URBAN HEAT ISLAND

Mitigation

1. Building green roof/wall
2. Create more city parks
3. Covers roofs and roads with light colored materials to Increase the Albedo
4. Tree Plantation and Preservation
5. Plant Trees For Energy Efficiency
6. Low Impact Development Techniques

URBAN HEAT ISLAND

Green roofs can be installed on a wide range of buildings, from industrial facilities to private residences

Green Roof

- **A green roof, or rooftop garden, is a vegetative layer grown on a rooftop. It provides shade and remove heat from the air through evapotranspiration, reducing temperatures of the roof surface and the surrounding air.**

  conventional rooftop can be up to 90°F (50°C) warmer.

Green roof Vs. Conventional

Green Walls

URBAN AVENUE

Avenue- a broad road in a town or city, typically having trees at regular intervals along its sides.

In landscaping, an **avenue**, or **allée**, is traditionally a straight path or road with a line of trees or large shrubs running along each side, which is used, as its Latin source *venire* ("to come") indicates, to emphasize the "coming to," or *arrival* at a landscape or architectural feature. In most cases, the trees planted in an avenue will be all of the same species or cultivar, so as to give uniform appearance along the full length of the avenue.