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Energy-Efficient Landscape Design

Prashanti Rao and Janmejoy Gupta

Abstract

Buildings that are carefully designed using passive strategies for natural ventilation and day lighting reduces our dependency on electrical energy meanwhile ensuring thermal comfort inside the building. Similarly, carefully planned vegetation around the building helps in reducing the urban heat island effect and electricity consumption. Methodology adopted for presenting this study as book chapter, first by understanding the concept of landscape with respect to typologies and components. Secondly discussing the physical parameters in terms of temperature, precipitations and humidity of varied prevailing climatic conditions and varied methods adopted through landscape interventions and techniques to overcome the extreme conditions throughout the year, which in turn helps in reducing the consumption of energy.

Keywords: landscaping, energy-efficiency, shading, ventilation, windbreaks, climate-specific landscape design, roof-gardens, swale

1. Landscape - an introduction

Landscape is specifically the amount of land, either countryside or cityscape, that can be seen at once in a glance by the eye in a single frame. Landscape can also be referred to as an area of either land or water, taken in aggregate. According to Norman T Newton in the forward to his “Design on the Land: The Development of Landscape Architecture” book, stated landscape architecture as “the art or the science if preferred of arranging land, together with the spaces and objects upon it, for safe, efficient, healthful, pleasant human use.”

Landscape elements include parks, turfs, golf courses, managed bio reserves, soil systems, water systems, street-furniture, outdoor spaces, side-walks, lighting features, railings, and of course, vegetation.

Landscape is a common element in most architectural works. It has many functional values even though it is largely used for its esthetic properties. It can be shading devices & evaporative coolers during the summer period, windbreaks during the winter period, and light filters throughout the year. Environmental quality within a building can be improved significantly by plants. Urban heat island is one of the most discussed phenomena in the present world. It is more evident in dense urban forms. It affects human beings as well as the environment by having both physical and physiological impacts. Some of the causes for this phenomenon are inappropriate material selection for building envelopes, improper land use, transportation & traffic, impermeable surfaces, etc. However, the landscape can improve this situation at different levels. Urban heat island can be reduced by proper planning of vegetation around the dwellings at micro and macro levels [1].

1.1 Components of landscape

Hard-scape & soft-scape are the two constituents of landscape design. Both differ in their characteristics; Hard-scape has a solid character while soft-scape is more fluid in nature. Hard-scape remains unchanged throughout time but soft-scape changes with time as they mature. Soft-scape acts as a breathing animated component of the landscape (Figures 1–3).

Hard-scape elements – walkways, driveways, rocks, paver patios, etc.

Soft-scape elements - flowers, trees, turf, plants, vines, shrubs, etc.

Some of the key advantages of landscaping are as follows:

- Reducing energy consumption, CO₂ impact & heat island effect.
- Treating nitrogen pollution in rain.
- To negate acid rain effect.
- Aesthetical value

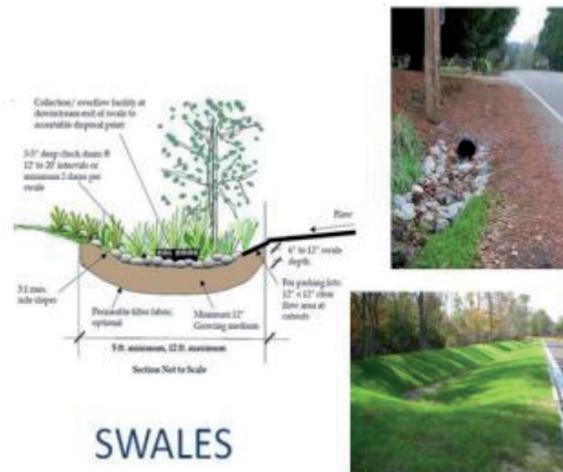


Figure 1.
Softscape (vegetated swales). Source: Co-author.

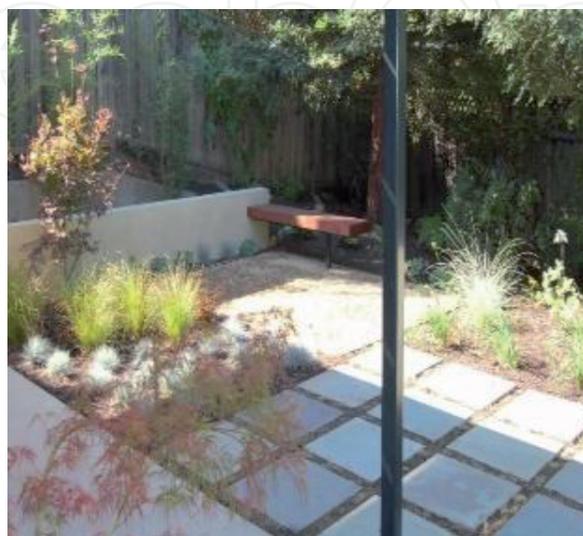


Figure 2.
Hardscape (hard paving).

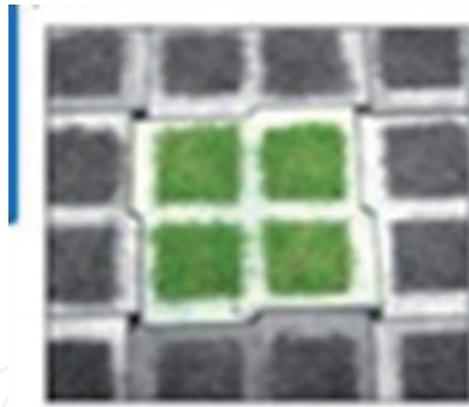


Figure 3.
Energy efficient landscape solution-combination of hard and soft paving: grass-paver blocks: Source: Co-author.

Some of the major concerns that landscape deal with are:

- Improving both outdoor & indoor environmental quality.
- Integrating man-made structures such as agriculture, forests, transport, settlements, industry etc. to the natural world.
- Composing land, water & vegetation with built elements & paving.
- Designing land, together with spaces & objects upon it, to develop a public realm.

2. Types of vegetation and its landscape-oriented benefits

Growth habits define the shape or form of the plants and play a key role in both their esthetic character and their function in the landscape. Based on growth habit, plants can be classified as trees, shrubs, groundcovers, or vines. The boundaries between these growth habit types are not always distinct, nor consistent. A plant species may fall into several categories depending upon the conditions of a particular site or its maintenance regime. Despite the shortcomings of this classification system, it is widely used in landscape design.

Herbaceous & woody plants are the main two kinds of landscape plants. Both kinds of plants differ in their characteristics. Plants that do not produce woody stems are known as herbaceous plants. They are known botanically as herbs. They can grow either in an upright, prostrate, or creeper manner. Trees, shrubs, or woody vines are different types of woody plants. It is usually difficult to find out a clear distinction between trees and shrubs. Woody plants can be further divided into evergreen & deciduous plants. Deciduous trees usually shed their leaves in autumn while evergreen trees keep their leaves. Trees are relatively larger than shrubs. Shrubs are usually taller than 0.5 m and less than 3 m in height. Plants that grow over and cover ground areas are known as ground covers. They act as the bottom layer in a planting design. Groundcover has various advantages and can be used for different purposes. It can protect from drought & soil erosion. It is also used to

improve the aesthetical value of a landscape as it fills the area between trees & large plants. Vines are climbing plants that can spread in different directions. Vines can be used to control erosion as well as for protecting horizontal & vertical planes from the summer sun (**Figures 4 and 5**).

Plants can also be classified according to their lifespan. Ecological origin, growth habit & seasonal pattern of plants are important factors that have to be considered in a landscape design. Region or place from which a plant species originated is considered as its ecological origin. Therefore, plants can be either native or non- native. Native plants usually have an integrated growth habit & pattern with its native ecology. Native plants can provide food to native insects and birds, developing an

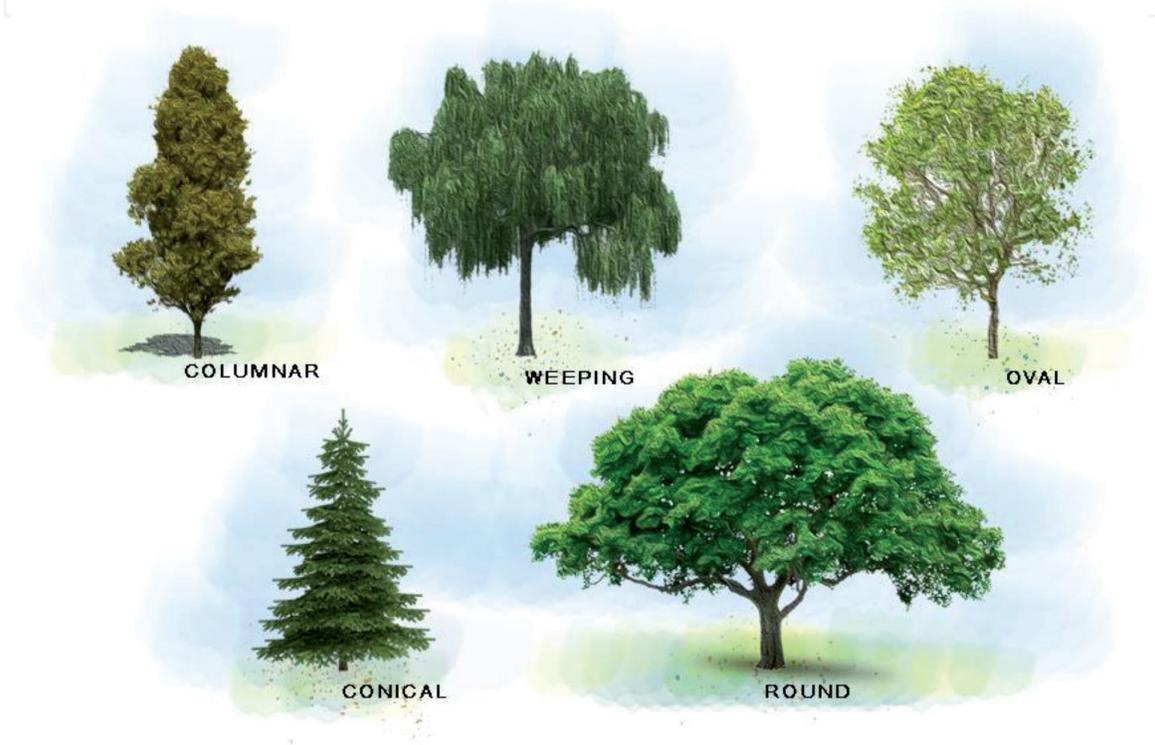


Figure 4. *Trees with different foliage columnar, oval, weeping, conical and round-spread out. Source: Authors.*



Figure 5. *Typical broad-leaved-evergreen tree with large canopy. Source: Authors.*

Sr. no.	Name	Physical characteristics	Function/benefits
1.	Ground cover	Typically grow to less 0.5 m tall or are maintained at that height. In general, they reach 15–30 cm high.	A groundcover is utilized to provide protection from erosion and drought, and to improve the esthetic appearance of a landscape by filling areas between large plants and trees.
2.	Shrubs	It can be defined as being larger than 0.5 m, but less than 3 m in height.	Used for Esthetic purpose, Buffer and fencing also sometimes
3.	Vines/Climbers	Vines are climbing & rambling plants.	They are used on man-made structures such as a trellis, a pergola, a balcony to protect from summer sun the horizontal and vertical planes. Various vines can also be used for an effective erosion control.
4.	Trees	Trees measuring 3 to 6 m is height can be classified as `small trees`, trees 6 to 9 m can be considered as `medium trees`, and trees taller than 9 m can be considered as `large trees`.	Form and Foliage persistence of the tree perform various function, in terms of shading, wind breakers, cooling, buffering and also add Esthetic value.
4a.	Deciduous	Deciduous plants are those which completely or significantly, shed their foliage during the winter or dry season. and remain bare for a period of time, followed by the growth of new leaves in the next growing season, typically spring.	These trees are helpful for shading during the w Summer season and Allowing Sun light and warmth during the winter season.
4b.	Evergreen	Evergreen plants retain foliage throughout the year.	All of these plants have special leaves that are resistant to cold and/or moisture loss. Evergreens may continue to photosynthesize during the winter or dry period.

Source: Authors.

Table 1.
 Classification of vegetation on the basis of physical characteristics and function.

inter-relation with the native ecology. They usually require comparatively lesser resources & maintenance. So that, the use of non-native plant species may not help the native ecology & also can have negative impacts in some cases.

Some plant species shed their leaves during a period of the year while some others keep their leaves throughout the year. So that annual retention of foliage is another factor that has to be considered in landscape design as this foliage retention pattern can have a larger impact on its properties such as protection from sun & wind. Landscape can implement improvements by applying principles & practices that are environmentally friendly. Some of the changes that can be made in the micro-climate of urban public green spaces, streets & housing by proper planning, implementation & management of landscape are (**Table 1**).

- Increasing the esthetic value
- Increasing the real estate value

- Decreasing the maintenance cost
- Improving energy efficiency

3. Energy-efficiency through landscaping: interventions

3.1 Introduction

Energy consumption can be reduced to a greater extent by proper utilization of landscape elements such as trees, shrubs, ground covers, or vines in strategic locations and proper quantity. Such kind of landscape systems can convert solar heat energy into moderate thermal loads. Thus, the need for mechanical cooling is reduced. Proper planning and management of landscapes help us to achieve a higher comfort level within the buildings. Landscape elements can be used to alter the microclimate around a building to regulate the heat gain in summer & heat loss in winter.

Heat exchange within a building occurs through three different processes – air infiltration, heat conduction & transmission of solar radiation. Outside air can infiltrate into the buildings through its openings in the ceilings or walls. Passage of air is also possible through cracks around doors & windows. This is the first heat exchange process. Air infiltration results in heat gain in summer and heat loss in winter. Surfaces that face wind subject to comparatively higher air pressure as the wind velocity increases and thus air enters through the openings or cracks in these surfaces. Proper planting of plants can reduce the wind velocity and thus reducing the air infiltration. Heat conduction is the second process. Heat can conduct through materials used for constructing the building. The Rate of heat conduction depends upon the insulating properties of these materials. Landscape can also reduce the heat conduction by regulating the difference between the inner & outer surfaces of the building. Landscape elements such as trees & shrubs also regulate the solar radiation receiving on the outer surfaces. Solar radiation can reduce heat loss in the winter period by increasing the temperature of outside surfaces. The Landscape system can block cold winds during the winter period to reduce conductive heat loss. Transmission of solar radiation via windows is the third process. South facing and east or west -facing glass allows an undesirable amount of solar radiation during the summer period. Glass can also heat a building in the winter period. Proper planning & planting of vegetation helps to regulate the transmission of solar radiation in different seasons. Thus landscaping & orientation on the site are two important factors that can affect the heating, cooling & lighting of a building.

- Landscape reduces air infiltration & creates air spaces adjacent to buildings. These air spaces act as insulation.
- Landscape elements can be shading devices that can reduce the total thermal heat loads on a building, especially during the summer period. Trees are better than man-made structures to provide canopy as trees do not heat up & reradiate down.
- Vegetation cools the air in contact with it by transpiration of water from the leaves and thus reducing the cooling load on buildings. It is better for the building to be surrounded by trees, rather than concrete walls.

- The advantage of using native plant species is that they are more adaptable to the local soil, climate & pathogens.
- Longwave radiations are reduced by the trees and thus regulating the natural cooling at night. Radiant cooling will be more in an open field than in a canopy.
- Vegetation can improve the quality of daylight passing through the windows and it can also moderate the light intensity & glare from the bright sky.
- Vegetated green walls are more efficient in reducing the cooling load as compared to green roofs.

Strategic designing of the landscape is required in achieving these advantages. For example, plants are more effective when they are planted adjacent to the east & west walls, as those sides are more exposed to the summer sun. The north side requires comparatively lesser shading. The selection of plant species for shading the southern windows is difficult for a building that requires winter heat.

3.2 Shading through vegetation

Proper shading of building surfaces is an effective method to reduce the undesirable thermal load, especially during periods of high-intensity solar radiation, such as the summer period of the year. The effectiveness of shade is largely dependent on canopy spread, the height of the trees, and the location of trees & shrubs within the site. One of the best methods to reduce the air temperature is by providing shade to the building roof, south-west & west facing walls & windows. This also helps in hastening early evening cooling. South-facing roof & wall surfaces have to be shaded as these surfaces receive the majority of direct sunlight when the sun is higher in the sky. Proper plants have to be provided for shading the east or west-facing surfaces as these surfaces receive direct sunlight in the morning & afternoon. Deciduous trees can be used to block the sunlight during the summer period. Sun crosses the sky at a lower angle during the winter period but proper planting of tall trees or trimming up the branches helps to achieve desirable winter sunlight. The ambient temperature around the structure as well as the indoor temperature can be reduced to some degree by shading other parts of the building & its adjacent site. The landscape design of the site is also an important tool to reduce the reflected light towards a building from surrounding surfaces (**Figure 6**).

Vine covered frames or pergolas & high bushes can also be used for shading the surfaces. One main advantage of a newly planted vine is that it can provide shade much earlier than a newly planted tree. It is an effective method to cover east and west-facing surfaces by vertical vine-covered trellis while horizontal trellis can be used on any orientation. Bushes can be used on north-facing surfaces to block the low sun (**Figure 7**).

3.3 Directing wind

Evergreen plants can be used in landscape designing to protect the cold winter winds. These plants can be used on the north, east & west sides of a building. Both evergreen trees and shrubs are used for continuous shading or to block heavy winds. Trees and shrubs with low crowns are used as an effective windbreak system that can block wind, close to the ground. Key locations, a well-designed landscape system & proper selection of plants help to reduce the total expenses for winter heating & summer cooling of a building. It can be reduced as much as twenty-five percent.

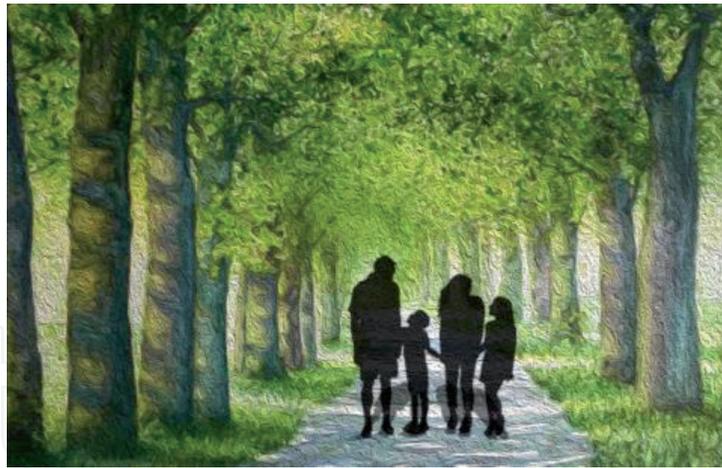


Figure 6.
Shaded alleys under canopy cover. Source: Co-author.

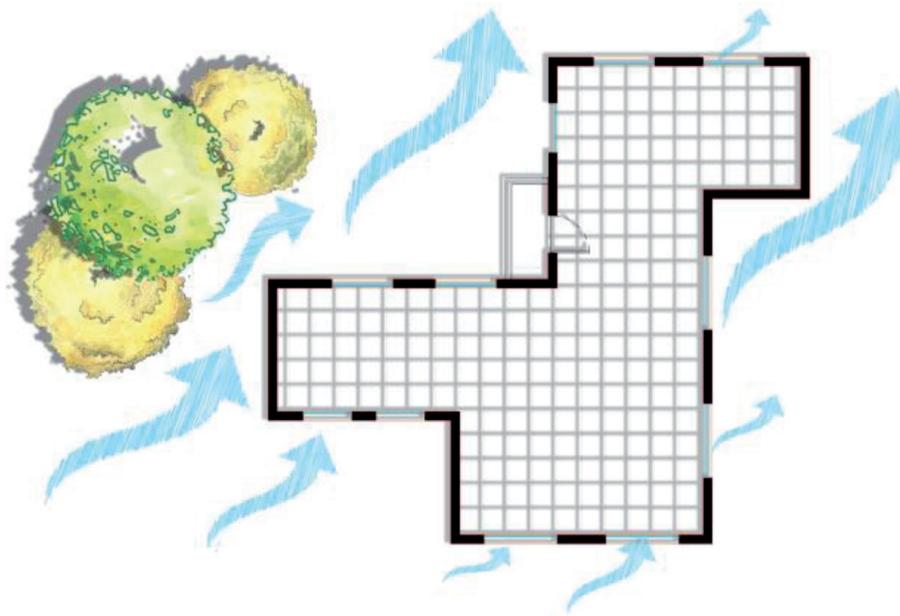


Figure 7.
Shading of west walls through landscaping. Source: Authors.

Deciduous plants are the best shading devices. They can shed their leaves in response to the change in temperature.

- Advantages - low cost & aesthetical value, glare can be reduced, these plants have the ability to cool the air via transpiration.
- Disadvantages - limited height, diseases can affect growth & slow growth

The east, south-west & south-east sides of a building are usually considered as proper locations for deciduous plants. Deciduous plants may also cause more harm during winter than good in the summer if those plants are not carefully placed on the southern side of a building.

3.4 Windbreaks

The Wind is an important climatic factor that has to be considered in a landscape design. The Windbreak is an effective system used in a landscape to control

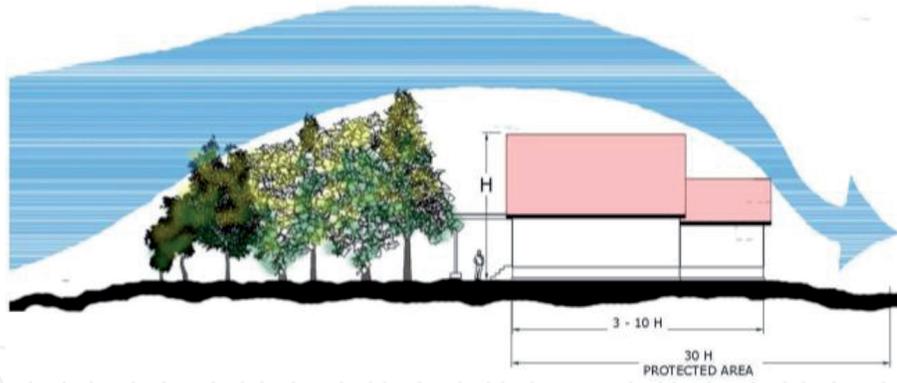


Figure 8.
Wind-shadows created by landscaping. Source: Co-author.

wind & its impacts. These shelter belts, formed by rows of trees and shrubs can reduce the wind speed or redirect its movement. Properly planted windbreaks in a cold climate can regulate the heat loss & air infiltration by reducing the wind velocity around the building. Plants that can withstand the winter climate conditions have to be selected for windbreak systems. It is an effective technique to use evergreen species as the major constituent of a windbreak composition. They occupy a significant portion of the system as these plant species retain wind-blocking mass in winter. These species can divert cold winds from the buildings & thus reducing the expense for heating. Distance between the tree and building depends upon the tree height. The Optimum distance is usually taken as 1 to 3 times the windbreak height. Distance up to which the wind can be reduced depends upon the height of the tallest row. It is considered to be 30 times the height. The effective distance of a windbreak system is generally indicated based on the windbreak multiplier, which is measured from the middle of the outermost layer of vegetation, downwind, along a line following wind direction. Components of a windbreak system have to be closely spaced to act as a continuous barrier against the wind. It is necessary to consider the final form that plant species will achieve once they get matured. A one-row windbreak system is formed by a single linear row of trees & shrubs. Evergreen plant species are densely planted in a one-row windbreak as these species retain their lower limbs & foliage. Deciduous plants with narrow crowns can be used and these plant species have to be densely planted. Two-row & twin-row windbreaks are composed of two linear rows of trees or shrubs. A single species, a set of 2 species, or a mixture of species can be used to form this windbreak system. Each row of the windbreak has to be densely planted in the same way as in a one-row windbreak. Three-row windbreaks are composed of 3 rows of trees or shrubs. It should include at least one row of dense evergreen trees. Other rows can be either deciduous or evergreen plantings. Shrubs can also be used as a front-row to catch the snow, if necessary. The three-row system provides additional sheltered spaces and there is a possibility for greater diversity. Thus, the three-row windbreak system has more wildlife value than a single or double-row system (**Figure 8**).

4. Energy-efficiency through landscaping - techniques for different climatic zones

The mature size of plant species has to be considered in designing the landscape. The growth rate is thus an important factor. Fast-growing plant species may not be a good choice as most of these species have poor strength even though some vines are effective fast-growing species that can be used in landscaping. Man-made

structures such as a pergola, framework, wall, etc. can be used for supporting vines. Vines can also act as shading devices. Properly designed and executed landscape consisting of trees, shrubs, vines & man-made structures can regulate the micro-climate around a building and thus reducing the heat gain in the summer and heat loss in the winter. Vegetation can guard buildings from the cold winds during winter. It also provides shade from the summer sun and controls the solar radiation during different periods of the year. Thus, landscape strategies can be used for solar, thermal & wind control, according to the climate types.

4.1 Hot and humid climate strategies

The climate of hot-humid zones is characterized by high rainfall and high humidity. The temperature range is relatively high at around 30–35°C and is fairly even during the day and throughout the year. Due to minimal temperature differences, winds are light or even non-existent for longer periods. However, heavy precipitation and storms occur frequently.

Landscape design strategies can be used to maximize the shade throughout the year and improving the air movement, thus increasing thermal comfort. Deciduous vines covering the wide trellises on the north & south sides of a building act as shading devices. These can provide comfortable outdoor areas and solar protection. Planting beds that require frequent watering have to be avoided in areas adjacent to the building. Plant species that allow penetration of low-angle winter sun have to be used for shading the buildings and outer spaces (**Figure 9**).

Deciduous trees with high-canopy can be used on the east & west sides of a building to improve its solar protection in the morning & afternoon. These trees allow the movement of air underneath the canopies. Low vegetation has to be kept away from the building. This allows breezes to pass through and also prevents dampness. Proper landscape placements & deflection techniques help to channel prevailing winds and thus increasing the air movement. Glare & heat absorption can be reduced by light-colored materials that are paved around the building (**Figure 10**).

Other strategies which shall be adopted to minimize the discomfort occurred due to hot and humid climatic conditions like buildings should be separated with large, free spaces between them. This allows airflow which provides ventilation for cooling and a hygienic environment. Certain species of trees (e.g. rain trees) form



Figure 9. *In buildings it is possible to have vines/creeper covered trellises which provides shading in summer, allows diffused sunlight. Source: Created by Nivedhitha Ravichandran.*



Figure 10.
Channeling prevailing winds with appropriate landscaping. Source: Authors.

an extraordinary outdoor space by creating a canopy effect. They should not be planted too far from each other, so that the crowns form a wide hall-like space, creating a comfortable microclimate. An un-shaded pavement should be avoided as far as possible and air should not be allowed to pass over such hot surfaces before reaching buildings. High bushes, however, should be avoided near buildings because the space between the ground vegetation and the high crowns of the trees should remain open, providing free access for the wind at the level of the living spaces.

4.2 Hot and dry climate strategies

The hot and dry climate, it is imperative to control solar radiation and movement of hot winds. The design criteria should therefore aim at resisting heat gain by providing shading, reducing exposed area, controlling and scheduling ventilation, and increasing thermal capacity. Hence, strategy should be such that it should prevent formation of dry dusty air due to overheating. It should maximize filtered air movement in summer. Vegetation is desirable as a radiation absorbent surface and for it has evaporative and shade giving properties.

The main aim of landscape design should be to provide maximum shade during the late morning & late afternoon hours. Forestation can be avoided on the north & south sides of the building and landscape elements such as shrubs, deciduous trees, vines, etc. can be used at the eastern & western sides. More shade-providing trees can be used at the east & west sides of the building. This helps to improve shade. Solar heating of the southern walls can be regulated by using shade trees or trellis structures with vines.

Vines help to cool the air adjacent to it via transpiration. Vines growing on vertical structures can also protect the east & west sides from heat gain during the morning & afternoon. Water features are also effective landscape tools that can cool the air in a hot dry zone. The Cooling effect is produced when hot, dry winds pass across the water body. This generates required moisture. It is better to reduce the use of paving materials and provide vegetation as much as possible. This reduces the glare as well as the potential for heat absorption by the paving materials. Light-colored paving material is an effective choice. Courtyard & garden walls are the other tools that can keep out the hot winds and conserve moist air. By planning narrow winding alleys and streets, which are shaded and relatively cool and break stormy winds, but allow through-ventilation and adequate natural lighting.

4.3 Composite climate strategies

The Composite climate is characterized by three seasons. A hot and dry season, usually the longest period, is followed by a wet and warm season, the monsoon period. In the third season, the winter time, depending on the altitude, temperatures can drop far below the comfort level, especially at night, whereas daytime temperatures are moderate and the solar radiation intense.

It is necessary to maximize the shade throughout the year as well as improving the air movement. Proper humidity levels have to be maintained in dry seasons. These are the main objectives for landscape design in a composite climate zone. Some of the landscape design interventions that should be used in a composite climate zone are as follows:

- Water features are effective strategies for cooling effect during dry seasons in a composite climate zone.
- Deciduous trees with high canopy & terrace gardens can be used on the west & east sides of a building. This provides solar protection during morning & afternoon. It also allows air movement underneath the canopies.
- Light-colored paving materials can be used around the building as this reduces the glare & heat absorption. Channeling prevailing winds with wind channeling & deflection techniques helps to maximize the air movement.

Wide trellises with deciduous vines can be used as shade structures on the north & south sides of a building to provide additional help for solar protection. It also develops comfortable outdoor spaces (**Figures 11 and 12**).

4.4 Temperate climate strategies

Temperate climates are generally defined as environments with moderate rainfall spread across the year or portion of the year with sporadic drought, mild to warm summers and cool to cold winters.

It is necessary to consider more substantial seasonal variations to effectively accommodate the climatic conditions of temperate regions. It is a good method to increase shade during the summer and the warming effect of the sun in winter. Winter winds should be prevented while summer winds have to be directed towards the buildings. Some of the elements that can be used in a prototypical landscape design for these climate regions are:

- Use of high-canopy deciduous trees with high branches on the west & east sides. This allows penetrating warming rays from the lower sun in the winter as well as it protects from the high summer sun.
- Use of low-branching evergreen tree clusters to block cold winds from north-west or north-east during the winter.
- Dense evergreen shrubs can be used on the north, west, and east sides of a building to create an insulating air space between the building & vegetation. This helps to reduce heat loss during the winter.
- Distance between the building and windbreak on the north side should not be more than four times the height of the windbreak



Figure 11.
Window shaded by trellises with deciduous vines. Source: Co-author.



Figure 12.
Deciduous trees cutting off summer solar radiation. Source: Co-author.

- An overhead trellis with deciduous vines can be provided adjacent to the southern façade as it adds additional shade to the building. It also creates a shaded outer space for summer use.
- Light-colored outdoor paving materials reduce the heat absorption and cooler air temperature can be maintained during the warm weather climate. It also reduces glare.
- It is necessary to channel prevailing winds with wind channeling & deflection techniques.
- Low vegetation has to be kept away from the building to prevent dampness & allow breezes to pass through.

4.5 Very cold climate strategies

Regions that lie in the cold climate zone are situated at high altitudes. The temperatures range between 20 and 30°C in summers, while in winters, it can range from -3°C to 8°C, or less.

Landscape design in a cold climate region has to consider the protection of the building from norther winds in winter. Windbreaks can be densely planted to prevent these cold winter winds. Overheating from the direct summer sun can be a problem and this can be avoided by providing shade to the south & west surfaces of the building. Dense evergreen shrubs can be planted at the northern sides of the building to create dead air spaces. This acts as insulation during the winter and summer. The speed of cold winter wind can be regulated by planting dense rows of evergreen trees and forming an earthen berm on the north & northwest sides. Low shrubs & grass should be applied in the southern windbreaker. Deciduous trees can be used in the south-west and south-east directions away from the building.

Earth sheltering is also an effective landscape tool in cold climates. It can be used if the building site is located on a south-facing slope that receives sufficient sunlight. Deciduous trees and shrubs can be used on the southern side of a building, as it helps to provide summer shading when required. It also allows low winter rays.

Advantages of using deciduous high canopy trees on the east & west sides are:

- It allows warm winter rays, provides summer shade, and maximize summer breezes.

A sunken terrace with light-colored reflective material can be incorporated into the southern side of the structure to further capture low winter sun & reflect its warmth to building interiors. Darker paving materials can be used around the building to capture warmth & promote snowmelt.

4.6 Roof garden - an energy-efficient landscaping technique

Lightweight soil medium is used in green roof gardens (**Figure 13**). A drainage layer & a high-quality impermeable membrane is provided beneath the soil medium to prevent the seepage of water. Plant species are selected that can withstand severe, dry roof temperature and resist short bursts from heavy rains [2].

4.7 Swales - an energy-efficient landscaping technique

Swales are constructed wetland systems. They are mainly used for managing storm-water runoff. These systems are used to maximize the removal of pollutants from the storm-water runoff and it is carried out through settling, uptake & filtering by proper vegetation planted. Some of the advantages of using swales are [3]:

- reduce peak runoff rates
- help in rainwater harvesting efficiency
- contribute to the green goals of the site & project

5. Conclusion

Plants are immensely useful in the heating, cooling, and lighting of buildings. Simple strategies utilizing landscape planting elements such as trees, shrubs,

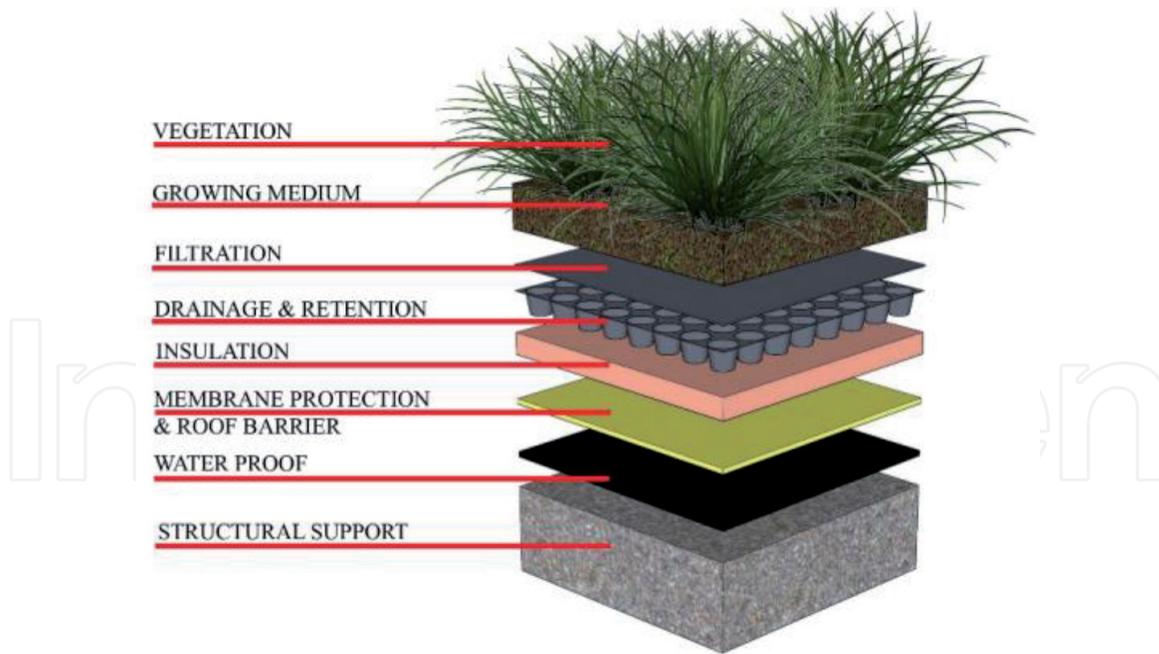


Figure 13. Schematic cross section of a green roof. Source: Redrawn by Co-author, reference from American Wick Drain: <https://www.awd-usa.com/drainage-applications/green-roof>.

groundcovers or vines in key locations and in proper quantities can greatly reduce energy consumption. In certain circumstances, carefully positioned trees and shrubs can save up to 25% of the energy a typical household uses. Appropriately utilized landscape elements and systems can deflect and diffuse sunlight or dissipate solar heat energy to moderate thermal loads and reduce requirements for mechanical cooling. Energy efficient landscaping has additional benefits such as lower maintenance costs, a reduction in water use, a cleaner air.

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