

# Paradigm of Landscape Gardening in the era of Climate Change

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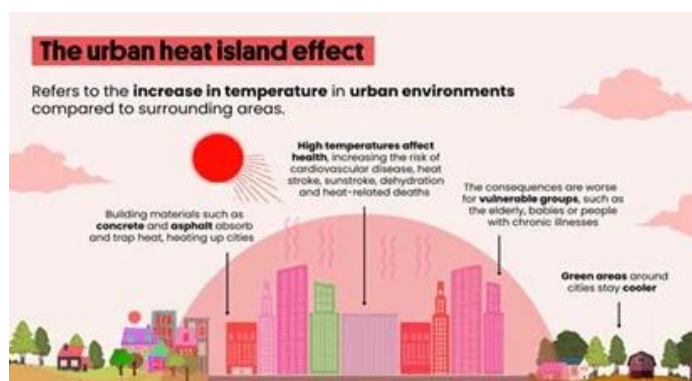
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## Abstract

Earth is warming up each year and rise in temperature will have its effects on the earth's inhabitants. Pollution of air, water and soil is another problem not just in cities, but also in the areas where urbanization has not taken its toll yet. Land-use change, management practices, pollution and human demography shifts are all drivers of environmental/climate change either directly or indirectly. In other words, cities demonstrate greater temperature in its center than the surrounding rural areas, which is known as Urban Heat Island effect. Depending on the size of urban areas and nature of vegetation in rural areas, the UHI can raise the temperature of cities up to 5°C. There are different ways and means such as landscape gardening, creating an urban forest, etc., which helps to mitigate the environmental pollution. Designing the highways with dense plant coverage not only beautifies the area but also reduces noise pollution rising from roads traffic. Planting of both evergreen or deciduous trees and shrubs gives an aesthetic appeal as well as helps in abatement of pollution and improvement of environment is an effective way for fighting against the climate change. The constant rise in urban environmental pollution has made it necessary to reevaluate urban landscaping as a whole and its orientation in order to achieve both pollution mitigation and bio-aesthetics. For the bioremediation of urban environmental pollution, appropriate planning and planting schemes should be carried out based on the extent and kind of pollution. pollution-tolerant and dust-scavenging trees and shrubs should be selected. Landscaping, is the only concept by which vegetation in the cities can be increased and maintained. The planning should therefore be done keeping in view the long-term effects of climate change because of global warming since landscaping may be best long-term investment in reducing heating and cooling costs while also bringing other improvements to the community.

## Introduction

In the last few decades, significant urbanization has occurred in cities across the world, which is due to the rise in automobiles and building infrastructure. The land surfaces which were once covered by vegetation have now been replaced with impermeable and high emissivity surfaces. Such surfaces tend to absorb most of the solar radiation and emit it later, which causes an increase in the overall temperatures. Consequently, the urban areas observing higher temperatures compared to their rural counterpart. Therefore, it is commonly observed that the temperature in the core of most major cities is greater than that of the suburbs or the surrounding area. This phenomenon is known as “Urban Heat Island (UHI)” effect. This Urban Heat Islands (UHI) can lead to health problems, a rise in ground level ozone, deterioration of the living environment, and an increase in building energy demand. As a result of the micro climate created by the UHI, the demand for energy to cool buildings increases (Adina et al. 2009). Additionally, more power must be generated to fulfil the demand, which raises greenhouse gas emissions and contributes to climate change.



According to the report of IPCC the average temperature of the earth has increased by around 1.5°C during the 21<sup>st</sup> century and is expected to rise from 1.5 to 6.4°C by the year 2100 while CO<sub>2</sub> concentration might increase to 850 ppm and the sea level has risen 3 mm per annum for the past 15 years. Pollution, global warming, rise in the sea level, extinction of species, depletion of ozone layer, soil erosion, etc. are some of

the commonly heard problems of the environment due to the changing climate and they all seem to be interrelated.

Therefore, there is an urgent need to tackle this problem to keep our surroundings green, healthy and ecofriendly. Therefore, one of the major solutions to these problems can be the idea of landscape gardening. Landscaping gardening refers to decorating a tract of land with trees, plants, and other garden materials to produce a picturesque and naturalistic effect in an area. Trees breathe, much like us. However, where people breathe in oxygen and expel carbon dioxide, trees do the exact opposite: their leaves absorb carbon dioxide, water, and solar energy to convert into sugars that the tree needs to survive. In one year, a mature tree can absorb a half a Metric ton of carbon dioxide equivalent.

According to Bailey, Landscape gardening is the application of garden forms, methods, and materials to the improvements of the landscape and the landscape in this connection is any area large or small on which it is desirable to develop a view or design. It is also a source of pleasure, recreation, peace, freshness, enjoyment, and purification.

#### Impact of climate change on the environment

Factor	How we are tracking?	Prediction
<b>Global temperature</b>	The past 30 years have been the warmest of the past 200 years	Suggests that temperature rises will be at or above the worst-case scenario of 6–8°C
<b>Sea levels</b>	Have risen by 3mm per annum for the past 15 years	Consistent with higher sea level predictions
<b>Atmospheric CO<sub>2</sub> levels</b>	These are above the predicted	This suggests atmospheric temperature rises of 6–8°C
<b>Safe atmospheric CO<sub>2</sub> levels</b>	The environmentally safe level seems to be about 350ppm, and for the past 200,000 years they have	Atmospheric CO <sub>2</sub> levels are likely to rise to between about 500 and 1000 ppm, which could cause a major extinction event

	been at about 280ppm	
<b>Melting polar ice caps</b>	Melting more rapidly	Only 3% of the extra energy absorbed in global warming has gone into heating the atmosphere. Most has gone in melting the ice caps
<b>Plant and animal life</b>	6% of insects, 8% of plants, 4% of vertebrates are losing their life	18% of insects, 16% of plants, 8% of vertebrates will lose their life

#### Importance of landscape gardening

- To create an aesthetically pleasing harmony, landscape gardening entails considering the entire surroundings of any new development and then sculpting it with natural components like trees, plants, water, and landforms.
- These plants help to reduce the pollution of the environment such as purification of air, prevents soil erosion, minimizing noise pollution as well as minimizes some of the effects of heat, sound, wind, etc.
- Plants with thick foliage also trap pollutants which are later washed by rains.
- Some indoor plants, such as spathyphyllum, Sansevieria, palms, dracaena etc., absorb toxic material from the environment they are in.
- Winds can be guided, diffused, blocked, or channeled by plants. They can be directed by plants to remove pollutants from the air.
- Plants reduce radiated heat thereby bringing down temperature thus helping to modify the microclimate of an area where they have been planted.
- In addition to their utility, plants have aesthetic values too.
- Acts as a shelter for wildlife especially birds.
- They increase the property value of an area and also provides privacy.
- Planting of plants and trees on walls, channels, boundaries, in parks etc., also helps to hide the attractive areas of the house or buildings.

- Contributes to the improvement rather than the destruction of environment.
- It can be a place of recreation and enjoyment.

### Various components of landscape gardening and their importance:

1. **Trees and Shrubs:** They are an essential feature in landscape garden. These are the one that helps us in fighting the effect of climate change in long run and so their selection criteria is very important.
2. **Annuals, biennials and bulbous plants:** These plants are mostly affected by the change of climate and hence can be selected according to purpose and season.
3. **Lawns:** can be defined as a green carpet of a landscape. Is a source of charm, pride and reduces tension of the mind after a day's hard work in this materialistic world.
4. **Climbers:** They can be used to cover the bare walls thereby reducing the heat.
5. **Palms and cycads:** these are useful for decorating the entrance of a house, the veranda, and the landings of staircase, for display in shade gardens and also in a conservatory.
6. **Cacti and succulents:** they are quite hardy and easy to cultivate and can be planted in a xeriscape garden.
7. **Aquatic plants:** Plants like *nymphaea*, water lilies can be used in a water garden and the presence of water in a garden also helps in maintaining the microclimate of an area.
8. **Water bodies:** Increased amount of water bodies may reduce temperature due to their evaporative action and enhanced wind speed is the opinion of Robitu *et al.* (2006). The presence of water bodies in a garden or on traffic island adds beauty to the surrounding areas and at the same time also reduces the heat of the surroundings.

### Importance of landscape plants

- **Produce oxygen:** Plants supply oxygen during photosynthesis or food preparation, they send out oxygen. Hence, the more the plants, the more the supply of oxygen to the environment.
- **Control noise pollution:** landscape plants play an important role in deadening unwanted noise. Sound waves are absorbed by their leaves,

branches, and twigs. Studies suggest that belts of trees 100' wide and 45' long can cut highway noise to half.

- **Reduce water runoff:** Leaves and branches temporarily hold rain on their surfaces. This reduces run off volumes and slows soil erosion. Tree roots help rain soak into the soil and increase total amount of rain that the soil can absorb.
- **Source of food:** These plants may also serve as a food for many of the birds, humans as well animals.
- **Act as windbreaks:** Windbreakers and shelterbelts fulfil essential microclimatic functions in rural and urban environments.
- **Increase property values:** Research comparing sales prices of residential properties suggests that people are willing to pay 3 to 7 percent more for properties with many trees versus properties with few or no trees.
- **Act as head light glare on roads:** This helps to reduce traffics and accidents.
- **Improve air quality:** Leaves intercept and hold small particles on their surfaces like dust, ash, pollen, and smoke and absorb gaseous air pollution. Ground-level ozone formation is reduced because air temperatures in tree-filled areas are cooler.
- **Reduce atmospheric CO<sub>2</sub>:** Plants directly sequester CO<sub>2</sub> in their stems and leaves while they grow. Plants near buildings can reduce the demand for heating and air conditioning, thereby reducing emissions associated with power production.
- **Healthier communities:** Plants filled neighbourhoods report lower levels of domestic violence, are safer and more sociable, reduce stress of body and mind, decrease need for medication, and speed recovery times.
- **Save energy and money:** Energy savings come from shading buildings, lowering ambient air temperatures, and reducing wind speed. Trees and other vegetation can lower air temperatures 5 °F compared with outside the tree-covered area. One well placed large tree provides average savings of \$31 in home heating costs each year.

- **Lower heating and cooling costs:** Plants have demonstrated the ability to reduce heating and cooling costs and counteract the “heat island” effect in urban environments. Proper plantation can cut heating and cooling costs by as much as 12 % and reduce overall power demand.
- **Trees (barriers):** Barriers formed with plants are needed in landscape for screening the unpleasant views, for dividing up the landscape into spaces, for providing shelter from wind, for protection against pollution, for defining boundaries and for assisting in the creation of beautiful landscape.

#### Selection of trees based on forms which may vary a/c to elevation and purpose

Sl.no	Forms	Purpose	Examples
1.	Oval	Frame/ screen	<i>Populus alba</i> , <i>Cassia fistula</i>
2.	Vase	Above the large shrubs or small trees.	<i>Melia azadirachta</i> , <i>Saraca Indica</i>
3.	Pyramidal	Accent	Evergreen trees – such as spruces, pines and firs
4.	Round	Lawn specimen.	<i>Plumeria alba</i> , <i>Chorisia speciosa</i>
5.	Columnar	Frame the views and structure in the landscape setting.	<i>Grevilea robusta</i>
6.	Weeping/ Fan	Focal point	<i>Callistemon lanceolatus</i> , <i>Salix babylonica</i>
7.	Round to spreading	Creates grove effect.	<i>Dalbergia sisso</i> , <i>Ficus glomerata</i> , <i>Delonix regia</i>

#### How landscape gardening helps us to mitigate ill effects of climate change-

- **Urban forests, cities ‘answer to climate change. (Andrea Barolini)**

Urban forests are the local answer to global problems. Their benefits are numerous and affect areas such as the climate, biodiversity, health, tourism.

Even though cities occupy only three per cent of the Earth’s surface, they currently consume 78 per cent of the total energy used in the world. They are also responsible for 70 % of global greenhouse gas emissions. Therefore, urban spaces are an important starting point to make changes with a positive impact not only on their populations but also to fight against global warming. They absorb CO<sub>2</sub> contribute to the elimination of polluting agents study-planting-trees, they’re a source of nutrition, improve energy and hydrological safety, restore degraded soil, and prevent droughts and flooding.

- ❖ Beijing is one of the major cities that have launched the greatest reforestation programme in 2012.
- ❖ Many industries were moved just outside the city in order to make space for new trees. This is an attempt to make green areas reach 42 % of the total urban sprawl.

Trees play an important role in reducing emissions and smog in big cities. There are species that are more advisable than others which helps us to mitigate ill effects of climate change.

S. No	Name of the tree	Its role
1.	<b>European Hackberry</b> ( <i>Celtis australis</i> )	Store 3,660 kg of CO <sub>2</sub> in 20 years and effectively absorb and capture pollutants.
2.	<b>Elm</b> ( <i>Ulmus minor</i> )	It can turn 3660 kg of CO <sub>2</sub> into biomass and has a medium high potential for the absorption of pollutants.
3.	<b>Common ash</b> ( <i>Fraxinus excelsior</i> )	Fast-growing especially in the early years and it can store over 3 tonnes of CO <sub>2</sub> in 30 years.
4.	<b>Wild linden</b> ( <i>Tilia cordata</i> )	This variety excellently captures CO <sub>2</sub> and effectively reduces smog



5.	<b>Norway maple</b> ( <i>Acer platanoides</i> )	It has a high capacity to store CO <sub>2</sub> 4,807 kg in 30 years.
6.	<b>Turkey oak</b> ( <i>Quercus cerris</i> )	Absorbs large amounts of CO <sub>2</sub> 4,000 tonnes both if it's planted in a city or a park
7.	<b>Ginkgo</b> ( <i>Ginkgo biloba</i> )	Excellent capacity of cleaning up the air and absorbing CO <sub>2</sub> .
8.	<b>Broad-leaved linden</b> ( <i>Tilia platyphyllos</i> )	High capacity to reduce urban smog.

#### ➤ Noise pollution

Noise pollution, also known as [environmental noise](#) or sound pollution, is the propagation of noise with harmful impact on the activity of human or animal life. It is responsible for causing:

- Hypertension
- Sleepiness disorder
- Hearing loss
- Increases stress levels
- Interferes with our day-to-day activities

#### Buffer guidelines for noise reduction along roads

<b>Moderate Speed roads (&lt; 40mph)</b>	Plant 20-50-foot-wide buffer with the near edge of the buffer within 20-50 feet of the centre of the nearest traffic lane
<b>High speed roads (&gt; 40 mph)</b>	Plant 65–100-foot-wide buffer with the near edge of the buffer within 50-80 feet of the centre of the nearest traffic lane

#### ➤ Windbreaks

Windbreaks are linear plantings of trees and shrubs designed to enhance crop production, protect people and livestock, and benefit soil and water conservation.

#### Advantage of wind breaks:

- Reduction of wind velocity
- Block, diffuse, guide or channel winds
- Protect the crops from harmful effect of high winds
- Prevents soil erosion
- Reduces the evaporation losses from soil.

#### Few species suitable for wind breaks

##### a) For Dry and Arid Regions

*Ailanthus excelsa* (Maharukh)  
*Albizia lebbbeck* (Siris)  
*Azadirachta indica* (Neem)  
*Casuarina equisetifolia* (Beef- wood)  
*Dalbergia sissoo* (Sheesham)  
*Eugenia Jambolana* (Jamun)  
*Grevillea robusta* (Silver oak)  
*Peltophorum ferrugineum* (Cooper pod)  
*Tamarindus indica* (Imli)  
*Pongamia glabra* (Indian beech)

##### b) For Coastal Area

*Anacardium occidentale* (Cashew)  
*Ailanthus malabarica* (Alston)  
*Cassuarina equisetifolia* (Beef-wood)  
*Pongamia glabra* (India beech)  
*Sesbania aculeate* (Sesban)  
*Thevetia peruviana* (Yellow oleander)  
*Thespesia populnea* (Indian Tulip)

Since we are all aware of the fact that the phenomena of climate change is a long term and therefore it should not be overlooked and hence, for fighting the ill effects of climate change the trees and shrubs that we are planting should be hardy and resistant. Few of them are:

##### List of hardy trees

*Pongamia pinnata*  
*Azadirachta indica*  
*Ficus benghalensis*  
*Ficus religiosa*  
*Michelia champa*  
*Ficus racemosa*  
*Butea monosperma*  
*Dalbergia sissoo*  
*Casuarina equisetifolia*

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*Butea monosperma*  
*Dalbergia sissoo*  
*Casuarina equisetifolia*

However, planting of few trees like Eucalyptus and Acasia is banned in Karnataka since, 2016 because of the following reasons:

- Water absorption by eucalyptus plantations in three years was greater than the actual rainfall in Bengaluru.
- 20 years of eucalyptus plantation deepened borewells by 90 to 100 m in Kolar district of Bangalore.
- Water requirement of each eucalyptus plant ranges from 50 litre a day per to 90 litre a day

In 2023, The government of Gujarat and Telangana has banned the plantation of *Conocarpus* trees in the "forest and non-forest regions" due to its adverse impacts on the environment and human health"

Whereas planting of trees like Himalayan Oak/ Banj Oak (*Quercus lamellosa*) should be taken into consideration which is one of the most endangered species. This tree is basically found in the hills of Uttarakhand and therefore its cultivation can also be taken up in hilly areas of our country. The benefit of planting this tree is:

- The Banj oak leaves contain high degree of nutrients which enrich the soil.
- It helps in soil formation and replenishing crop land fertility;
- Helps in maintaining the health of mountain streams and regulating the hydrological regime
- Aims to stabilize local and regional climate through direct influences
- It builds up a moisture regime favourable to wild species.

#### ➤ **Bio-aesthetic planning**

The concept was given by Prof. Lancelot Hogben, which means "proper utilization of available flora and fauna in the beautification of the surroundings". In India, the theme was propagated by Dr. M.S. Randhawa who gave a practical shape to it in planning Chandigarh along with the famous architects Le Corbusier and Pierre Jeanneret. The aim behind this concept is to plant ornamental flowering trees along roads, in parks, house compounds, public places along with the beautiful flora. The older congested cities and towns should be retrieved from their present state by using this concept. Thus, planting of greenery around

can also play a significant role in reducing the harmful impacts of climate change.

#### **Various types of garden types to mitigate the ill effects of climate change**

These different garden forms are less affected by the change in climate because they are mostly indoor planted. The choice of the plants in these gardens depends upon individual's choice, preferences and seasonal variations.

- **Container gardening:** this involves growing of various ornamental plants like small ferns, palms etc in troughs, dishes, bowls and trays.
- **Vertical gardening:** A vertical garden also referred to as plant walls, bio walls, green walls or living walls is a garden that grows vertically using a trellis or other support system, rather than on the ground and are attached to the exterior or interior of the building.
- **Roof top gardening:** A roof garden is a garden on the roof of a building. Besides the decorative benefit, roof plantings may provide food, temperature control, hydrological benefits, architectural enhancement, habitats or corridors for wildlife, recreational opportunities, and in large scale it may even have ecological benefits. "If widely adopted, rooftop gardens could reduce the urban heat island
- **Window gardening:** refers to growing of plants within the room just opposite or close to the window or on the window sill outside and this method is ideally suited for congested cities and flat dwellers.
- **Hydroponic:** is a method of growing plants without soil by using mineral nutrient solutions in a water solvent
- **Aeroponics:** is the process of growing plants in an air or mist environment without the use of soil or an aggregate medium.
- **Indoor gardening**

Indoor gardening is concerned with the growing of houseplants within a residence or building, in a conservatory, or in a greenhouse. This does not only help us to beautify the surrounding area but also helps us to reduce the temperature and provides a cooling effect. Common indoor plants may provide a valuable weapon in the fight against rising levels of indoor air

pollution & are very useful in absorbing potentially harmful gases and cleaning the air inside modern buildings and provide a natural way of helping combat “Sick building syndrome”

### • Therapeutic garden

It is an outdoor garden space that has been specifically designed to meet the physical, psychological, social and spiritual needs of the people using the garden as well as their care givers, family members and friends. Various types are:

- ✓ Alzheimer's Gardens
- ✓ Healing Gardens
- ✓ Rehabilitation Gardens
- ✓ Restorative Gardens
- ✓ Senior Community Gardens
- ✓ Cancer Gardens
- ✓ Enabling Gardens
- ✓ Meditation Gardens



Vertical gardening



Indoor gardening



Indoor gardening



Therapeutic Garden

### Top indoor air purifying plants as recommended by NASA

S.No	List of the plants	Benefits
1.	Areca Palm ( <i>Dypsis lutescens</i> )	Removes formaldehyde, xylene, and toluene
2.	Bamboo Palm ( <i>Chamaedorea seifrizii</i> )	Effective at removing formaldehyde, benzene, trichloroethylene, and xylene.
3.	Rubber plant ( <i>Ficus elastica</i> )	Removes formaldehyde.

4.	English Ivy ( <i>Hedera helix</i> )	Effective at removing formaldehyde, benzene, xylene, and toluene
5.	Peace lily ( <i>Spathiphyllum</i> )	Removes formaldehyde, benzene, trichloroethylene, xylene, and ammonia
6.	Boston Fern ( <i>Nephrolepis exaltata</i> )	Removes formaldehyde and xylene
7.	Dracaena ( <i>Dracaena spp</i> )	Removes formaldehyde, benzene, trichloroethylene, xylene, and toluene
8.	Money Plant ( <i>Epipremnum aureum</i> )	Removes formaldehyde, benzene, xylene, and toluene.
9.	Snake Plant ( <i>Sansevieria trifasciata</i> )	Effective at removing formaldehyde, benzene, xylene, toluene, and nitrogen oxides.
10.	Aloevera ( <i>Aloe barbadensis miller</i> )	Known for its ability to remove formaldehyde and benzene
11.	Philodendron ( <i>Philodendron spp.</i> )	Effective at removing formaldehyde.
12.	Spider plant ( <i>Chlorophytum comosum</i> )	Known for its ability to remove formaldehyde, xylene, and toluene
13.	Weeping Fig ( <i>Ficus benjamina</i> )	Removes formaldehyde, xylene, and toluene.
14.	Chinese Evergreen ( <i>Aglaonema</i> )	Known its ability to remove formaldehyde and benzene.

### Conclusion

Landscaping is the only concept by which vegetation in the cities can be increased and maintained.” It may be best long-term investment in reducing heating and cooling costs while also bringing other improvements to the community. The planning should therefore be done keeping in view the long-term effects of climate change because of global warming. Area and plant specific landscaping should be given

importance to mitigate the ill effects of climate change. However, cities where tree plantation and landscape gardening in large scale is not possible, the shrubs planting with specific characteristics, bio-aesthetic planning, green roofs, water bodies, and other forms of gardening should be adopted to mitigate ill effect of climate change.

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