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Carbon Sequestration Potential of Flowering Plants and Ornamental Trees

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ABSTRACT

Climate change and rising atmospheric carbon dioxide (CO_2) levels have become major global environmental concerns due to rapid industrialisation, urbanisation, deforestation, and excessive fossil fuel use. Carbon sequestration through plants is an effective natural method for reducing atmospheric CO_2 and mitigating climate change. Flowering plants and ornamental trees play an important role in this process by absorbing carbon dioxide through photosynthesis and storing it in their biomass and the surrounding soil. Besides their aesthetic value, ornamental plants contribute to urban greening, biodiversity conservation, air purification, temperature regulation, and ecological sustainability. Large ornamental trees with dense canopies and long lifespans act as significant carbon sinks, while flowering plants, shrubs, and turfgrass improve soil organic carbon and microclimatic conditions. Indoor ornamental plants such as Snake Plant, Areca Palm, Spider Plant, and Peace Lily also help reduce indoor air pollutants and improve environmental quality. Urban landscaping practices, including green belts, roadside plantations, rooftop gardens, and vertical gardens, enhance carbon storage and help reduce the urban heat island effect. However, factors such as limited urban space, pollution stress, poor maintenance, and deforestation reduce the efficiency of urban green

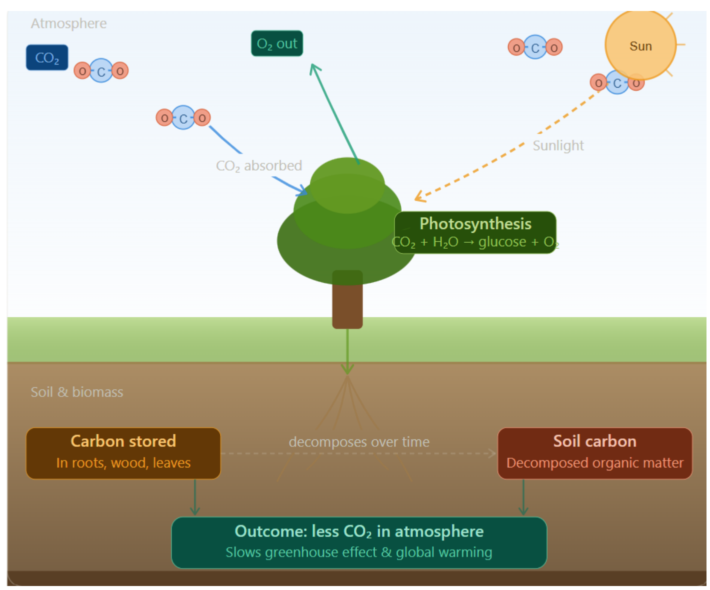
carbon storage. Sustainable ornamental landscaping, community participation in tree planting, and conservation of urban green spaces are essential for improving carbon sequestration potential and promoting climate-resilient cities. Therefore, flowering plants and ornamental trees are valuable tools for environmental protection and sustainable urban development.

INTRODUCTION

Climate change and global warming have become major environmental concerns across the world due to the continuous increase in atmospheric carbon dioxide (CO_2) levels. Rapid industrialization, urbanization, deforestation, and excessive use of fossil fuels have significantly contributed to greenhouse gas emissions, leading to rising global temperatures and environmental imbalance. In this context, carbon sequestration has emerged as an effective natural strategy to reduce atmospheric CO_2 and mitigate climate change.

Plants play a crucial role in carbon sequestration through the process of photosynthesis, where they absorb carbon dioxide from the atmosphere and store it in their biomass such as leaves, stems, roots, and surrounding soil. Among various plant groups, flowering plants and ornamental trees are gaining attention not only for their aesthetic and landscaping value but also for their environmental benefits. These plants contribute significantly to urban greening, biodiversity conservation, air purification, temperature regulation, and carbon storage.

Ornamental trees with large canopy cover and long lifespan can store substantial amounts of carbon over many years, while flowering plants and shrubs help improve microclimatic conditions and enhance green cover in urban and residential areas. Parks, gardens, roadside plantations, institutional landscapes, and home gardens planted with ornamental species collectively act as small but effective carbon sinks.



With increasing urban expansion and reduction of natural forests, the integration of flowering plants and ornamental trees into urban landscapes has become essential for sustainable environmental management. Understanding their carbon sequestration potential can help promote eco-friendly landscaping practices and encourage the development of greener cities for a healthier future.

IMPORTANCE OF FLOWERING PLANTS AND ORNAMENTAL TREES

ROLE IN URBAN ECOSYSTEMS

Rapid urbanisation has resulted in increased pollution, loss of green spaces, and rising temperatures in cities. In such conditions, flowering plants and ornamental trees serve as vital components of urban ecosystems. Parks, avenue plantations, gardens, green roofs, and roadside landscapes create green infrastructure that improves the quality of urban life.

Ornamental trees provide shade and reduce the impact of heat in densely populated areas. Their root systems stabilize soil and improve groundwater recharge. Urban green spaces planted with ornamental species also support urban wildlife and create healthier living environments for people. Furthermore, these plants reduce noise pollution by acting as natural sound barriers and contribute to psychological well-being by reducing stress and enhancing mental health.

CONTRIBUTION TO AIR PURIFICATION AND COOLING

Flowering plants and ornamental trees play an important role in improving air quality by absorbing harmful gases and trapping dust particles from the atmosphere. Leaves act as natural filters that capture pollutants such as carbon monoxide, sulfur dioxide, nitrogen oxides, and particulate matter. This helps reduce respiratory problems and promotes healthier urban environments.

In addition to air purification, ornamental trees contribute significantly to cooling effects in urban areas. Through shading and transpiration, plants lower surrounding temperatures and reduce the urban heat island effect. Large canopy trees can decrease surface and air temperatures by several degrees, making cities more comfortable and energy efficient. Green landscapes also reduce the need for excessive air conditioning, indirectly lowering energy consumption and greenhouse gas emissions.

MECHANISM OF CARBON SEQUESTRATION IN PLANTS

PHOTOSYNTHESIS - THE CARBON CAPTURE ENGINE

Inside every green leaf cell are organelles called chloroplasts. Photosynthesis happens in two linked stages. First, the light-dependent reaction uses sunlight energy to split water molecules, releasing oxygen and producing energy carriers (ATP and NADPH). These carriers then power the Calvin cycle, which pulls CO_2 molecules from the air and assembles them into glucose ($C_6H_{12}O_6$). The overall equation: $6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$. This is the moment carbon moves from a gas in the atmosphere into solid organic matter.

CARBON IS STORED IN LEAVES AND STEMS

Glucose doesn't sit idle. The plant converts it into three main structural compounds: cellulose (the primary material of cell walls, making up roughly 40% of plant dry weight), starch (a compact energy store held in leaves and other tissues), and lignin (the tough polymer that makes wood rigid and resistant to decay).

All three contain carbon atoms extracted from CO_2 - so every gram of plant biomass represents CO_2 removed from the air. Above-ground biomass is the most visible carbon store and the first to be lost if a plant burns or is cut down.

CARBON IS TRANSPORTED TO THE ROOTS

Plants are not passive they actively pump sugars downward through tubes called the phloem. In the root zone, some of this carbon becomes root biomass itself, some is exuded into the surrounding soil as organic acids and sugars (feeding the microbial community and encouraging soil carbon formation), and a small fraction is re-released as CO_2 through root respiration. The net flow is still strongly downward roots and the soil they modify represent one of the largest terrestrial carbon stores on Earth.

LONG-TERM STORAGE IN WOOD AND SOIL

Two processes make carbon sequestration genuinely long-term. First, as a tree grows, its inner wood (heartwood) dies and becomes essentially inert no living cells, no respiration, just densely packed cellulose and lignin holding carbon for centuries. A large old-growth tree can store several tonnes of carbon in its trunk alone.

Second, when roots and leaf litter decompose, microbes partially break them down, leaving behind stable compounds collectively called humus. Humus resists further decomposition and can keep carbon locked in soil for decades to over a thousand years. A healthy forest ecosystem, therefore, sequesters carbon continuously not just while the trees are alive, but long afterwards through its soil.

ESTIMATION OF CARBON SEQUESTRATION POTENTIAL OF TREES

Direct method

- The direct method involves destructive sampling of trees.
- The tree is cut and separated into stem, branches, leaves, and roots.
- Each component is weighed to record fresh weight.
- Samples are oven-dried (65–105°C) to obtain dry weight.
- Total dry biomass is calculated by summing all components.
- Carbon content is estimated as 50% of dry biomass.
- Dry Biomass = Fresh Weight × (Dry Sample Weight / Fresh Sample Weight)
- Carbon Stock = Biomass × 0.50

Indirect method – that is calculated through the above-ground biomass and below-ground biomass method, without cutting the tree

- DBH (Diameter at Breast Height): Measured using a diameter tape at 1.3 meters above the ground
- Above-ground biomass (dry biomass) = Volume X Specific wood density
- Volume=πr^2h
- For getting the value of the radius from the girth of the tree
- C = 2 π r or r = C / 2 π
- C = circumference of the tree trunk

Carbon Sequestration Potential of Ornamental Trees

Crop	Above Ground Carbon	Below Ground Carbon	Total Carbon Sequestration
Scholars tree	**3496.10 kg**	**524.42 kg**	**4020.52 kg**
Plumeria	3339.43 kg	500.91 kg	3840.34 kg
May Flower	3097.49 kg	464.63 kg	3562.11 kg
Bottle bush	586.78 kg	88.02 kg	674.80 kg
Cassia fistula	301.77 kg	45.27 kg	347.04 kg
Pride of India	179.40 kg	26.91 kg	206.31 kg
Copper pod	108.87 kg	16.33 kg	125.20 kg
Bauhinia	149.40 kg	22.41 kg	171.81 kg
Butea	**0.06 kg**	**0.02 kg**	**0.08 kg**

Trees for Pollution Control

Pollutants	Tree species for remediation
Gaseous pollutants	*Pongamia pinnata, Albizia lebbeck, Polyalthia longifolia, Alstonia scholaris, Acacia auriculiformis*
Suspended particulate matter	*Pongamia pinnata, Albizia lebbeck, Polyalthia longifolia, Alstonia scholaris, Acacia auriculiformis, Terminalia arjuna, Kigelia pinnata, Cassia siamea*
Automobile exhaust pollutants / dust	*Pongamia pinnata, Albizia lebbeck, Polyalthia longifolia, Alstonia scholaris, Acacia auriculiformis, Ficus benghalensis, Tectona grandis*

ROLE OF FLOWERING PLANTS IN CARBON CAPTURE

Fast-growing ornamental shrubs and flowering plants are highly effective in capturing carbon because of their high photosynthetic activity and quick biomass accumulation. Species such as Hibiscus, Bougainvillea, Ixora, Rose, and Tecoma absorb carbon dioxide continuously during their growth period and convert it into plant tissues such as leaves, stems, flowers, and roots.

TURFGRASS AND CARBON SEQUESTRATION

CARBON STORAGE PROCESS

The carbon sequestration process in turfgrass systems mainly occurs through continuous root growth and decomposition. Turfgrass roots, whether annual or perennial, constantly grow, die, and regenerate. As older roots decompose, they release organic matter into the soil, increasing soil organic carbon (SOC) content.

The dense fibrous root network of turfgrass enhances below-ground carbon accumulation and improves soil structure. In addition, regular mowing of turfgrass contributes indirectly to carbon recycling. Small grass clippings left on the lawn decompose naturally and return nutrients and organic carbon back to the soil and canopy system.

Another important component is the thatch layer, which consists of living and dead plant material located between the green grass canopy and the soil surface. When decomposed gradually, thatch contributes to soil organic matter (SOM) formation and enhances long-term carbon storage capacity in the soil.

LONG-TERM CARBON STORAGE

Turfgrass is managed as a perennial system, and sod can remain undisturbed for decades. Unlike agricultural land, it faces less soil disturbance, allowing stable carbon accumulation.

CARBON SEQUESTRATION RATES

Average sequestration rate: 0.3–1.4 Mg carbon ha^{-1} $year^{-1}$

Fertilizer application has little effect on carbon storage.

Studies show consistent soil organic carbon (SOC) accumulation under turfgrass systems.

Turfgrass in urban landscapes acts as a stable and long-term carbon sink, contributing significantly to soil carbon storage and climate change mitigation.

ORNAMENTAL PLANTS CONTRIBUTING TO CARBON EMISSION REDUCTION

Snake Plant has the ability to improve indoor air quality. It helps reduce carbon monoxide (CO) levels in enclosed spaces by absorbing harmful gases and releasing oxygen. This natural air-purifying ability, it is considered one of the most effective ornamental plants for indoor environments.

Spider Plant. This plant can reduce carbon monoxide (CO) levels by about 41.47%, showing a strong ability to improve indoor air quality. Due to its effective air-filtering capacity.

The Ti plant is capable of absorbing gases such as carbon dioxide (CO_2) and carbon monoxide (CO). Helps reduce the presence of certain heavy metals in the environment.Contributes to cleaner air in residential areas.

Areca Palm is considered one of the most effective indoor ornamental plants because of its excellent air-purifying ability. It absorbs carbon dioxide, releases large amounts of oxygen, and removes pollutants such as xylene and toluene from enclosed spaces. Its dense foliage also helps maintain indoor humidity and improves the overall carbon balance of indoor environments.

Peace Lily is well known for its strong air-cleaning capacity. It absorbs carbon dioxide and harmful volatile organic compounds (VOCs), thereby improving indoor air quality and reducing pollutant accumulation. The decomposition of fallen leaves also contributes organic matter to the soil, supporting soil carbon enrichment.

Rubber Plant possesses broad leaves with high photosynthetic efficiency, enabling it to absorb carbon dioxide effectively and store carbon in its woody tissues. Its long lifespan supports long-term carbon storage while also reducing indoor pollutants and improving oxygen availability in living spaces.

Money Plant is a fast-growing ornamental climber with good carbon absorption capacity. It helps remove indoor air pollutants and enhances oxygen production, making it suitable for homes, offices, and urban indoor environments. In addition, it contributes to better indoor microclimatic conditions.

Bamboo Palm is highly effective in absorbing carbon dioxide and purifying indoor air. It removes harmful gases such as benzene and formaldehyde, while its continuous biomass production supports long-term carbon accumulation. This plant is widely used in offices and residential interiors for sustainable greenery.

Ficus benjamina is a woody ornamental plant capable of storing carbon in its stems, branches, and roots over extended periods. It effectively reduces indoor and outdoor air pollution while also providing cooling and shading effects in landscapes.

Dracaena is a popular ornamental foliage plant valued for its air-filtering properties. It absorbs carbon monoxide and carbon dioxide from indoor environments and helps maintain cleaner and healthier surroundings. Its low maintenance requirement makes it suitable for urban landscaping and indoor decoration.

Aloe vera contributes to carbon sequestration through efficient photosynthesis and carbon dioxide absorption. It also helps improve indoor air quality and stores carbon-rich organic compounds within its succulent leaves.

Boston Fern is an effective ornamental fern that improves indoor air quality by capturing airborne pollutants and increasing humidity. Its dense foliage contributes to carbon fixation and makes it suitable for eco-friendly indoor decoration.

Croton contributes to carbon capture through active photosynthesis and dense leaf biomass production. Besides improving environmental quality, it also supports oxygen release and pollution reduction in ornamental landscapes.

Golden Cypress is a woody ornamental conifer with high long-term carbon storage potential. Its evergreen foliage continuously absorbs atmospheric carbon dioxide, making it highly suitable for avenue planting, urban greening programs, and climate change mitigation efforts.

URBAN LANDSCAPING AND CLIMATE CHANGE MITIGATION

GREEN BELTS IN CITIES

Green belts are areas of vegetation developed around or within cities to improve ecological balance and environmental health. These green spaces consist of ornamental trees, flowering plants, shrubs, grasses, and avenue plantations that function as natural carbon sinks. Green belts absorb atmospheric carbon dioxide through photosynthesis and store carbon in plant biomass and soil organic matter.

ROADSIDE PLANTATION BENEFITS

Roadside plantations are important components of urban landscaping and climate change mitigation programs. Ornamental and shade trees planted along roadsides absorb carbon dioxide, release oxygen, and trap airborne pollutants such as particulate matter, sulfur dioxide, and nitrogen oxides. These plantations help reduce traffic-related air pollution and improve environmental quality in urban areas. Common roadside ornamental trees such as Neem Tree, Rain Tree, Gulmohar, and Ashoka Tree are highly effective in carbon sequestration and urban cooling.

Species	Biomass (tons)
Peltophorum pterocarpum	101.7
Pongamia pinnata	71.62
Swietenia mahagoni	43.31
Tabebuia rosea	32.49
Albizia lebbeck	20.70

FACTORS AFFECTING CARBON SEQUESTRATION

PLANT SPECIES

Different plant species vary greatly in their carbon sequestration ability. Trees and ornamental plants with rapid growth, larger canopy size, dense foliage, extensive root systems, and higher biomass production generally store more carbon than smaller or slow-growing species.

Ex, Silver Maple is known for its rapid growth and large canopy, which helps absorb and store considerable amounts of carbon dioxide. Likewise, White Swamp Oak possesses dense woody biomass and a long lifespan, making it highly effective for long-term carbon sequestration and environmental sustainability.

ROOT DEPTH

Root depth is an important factor affecting carbon sequestration in ornamental trees. Deep-rooted ornamental trees tend to sequester more carbon because their roots penetrate deeper layers of the soil and store carbon securely for longer periods. These roots transfer organic carbon into the soil profile, where it remains stable and less prone to loss through erosion or environmental disturbances. Examples of ornamental trees with effective deep root systems include Ashoka Tree, Golden Cypress, Rain Tree, and Neem Tree, which are widely used in urban landscaping and avenue plantations for their high carbon sequestration potential.

AGE AND DIAMETER

The age and diameter of ornamental trees greatly influence their carbon sequestration potential. Long-lived ornamental trees continue to absorb and store carbon dioxide over many decades. As trees grow older, their trunk diameter, canopy spread, and biomass increase, resulting in greater carbon storage capacity.

Trees with larger trunk diameters store more carbon in woody tissues such as stems, branches, and roots. Mature ornamental trees, therefore, function as long-term carbon reservoirs and provide continuous environmental benefits. Species such as Oak Tree, Pine, Rain Tree, and Neem Tree are known for their long lifespan, large diameter growth, and high carbon sequestration potential.

ROOT TO SHOOT RATIO

The root-to-shoot ratio is an important factor influencing carbon sequestration in ornamental trees. Trees with a higher proportion of biomass allocated to roots can contribute more effectively to soil carbon sequestration. Extensive root systems transfer large amounts of organic carbon into the soil through root growth, root exudates, and decomposition of dead roots. Since soil carbon is often more stable and long-lasting than above-ground carbon, trees with greater root biomass play a significant role in long-term carbon storage and climate change mitigation.

TREE HEIGHT

Taller trees with more biomass store more carbon in both above- and below-ground tissues.

TREE SHAPE AND FORM

Larger, denser canopies capture more sunlight, leading to more photosynthesis and greater carbon sequestration.

Suitable ornamental trees with large and dense canopy structures that enhance carbon sequestration include Gulmohar, Neem Tree, Copper Pod Tree, and Indian Almond Tree. These ornamental trees possess broad crowns, dense foliage, and large leaf surface areas that capture more sunlight and promote higher photosynthetic activity. As a result, they absorb greater amounts of atmospheric carbon dioxide and store more carbon in their biomass and soil. Their wide canopy also provides shade, reduces urban temperatures, improves air quality, and contributes significantly to urban landscaping and climate change mitigation.

CHALLENGES IN URBAN GREEN CARBON STORAGE

LIMITED URBAN SPACE

One of the major challenges in urban green carbon storage is the limited availability of land for planting trees and ornamental vegetation. Expansion of buildings, roads, industries, and infrastructure reduces open spaces and restricts the development of parks, gardens, and green belts. In densely populated cities, the shortage of planting areas limits the number and size of trees that can be grown, thereby reducing overall carbon sequestration potential. Small planting pits, compacted soils, and a lack of root space also hinder proper growth and biomass accumulation in ornamental trees. As a result, urban vegetation often cannot achieve its full carbon storage capacity.

POOR MAINTENANCE

Improper maintenance of urban landscapes significantly affects plant growth and carbon sequestration efficiency. Lack of irrigation, inadequate nutrient management, poor pruning practices, and insufficient protection from pests and diseases weaken ornamental plants and reduce their photosynthetic activity.

POLLUTION STRESS

Urban plants are continuously exposed to environmental pollutants generated from vehicles, industries, construction activities, and domestic emissions. High concentrations of dust, smoke, heavy metals, sulfur dioxide, nitrogen oxides, and ozone can damage plant tissues and interfere with photosynthesis.

Pollution stress reduces leaf efficiency, slows plant growth, and decreases the ability of ornamental trees and flowering plants to absorb atmospheric carbon dioxide. Sensitive species may experience premature leaf fall, reduced flowering, poor root growth, and shortened lifespan under polluted urban conditions.

DEFORESTATION AND LAND CONVERSION

Deforestation and conversion of green spaces into residential, industrial, and commercial areas are major threats to urban carbon storage. Removal of trees and vegetation leads to the release of stored carbon back into the atmosphere, contributing to increased greenhouse gas concentrations.

The destruction of urban forests, roadside plantations, and gardens not only reduces carbon sequestration capacity but also affects biodiversity, air quality, and urban climate regulation. Continuous land conversion without adequate replanting programs weakens the ecological balance and reduces the long-term sustainability of urban green infrastructure.

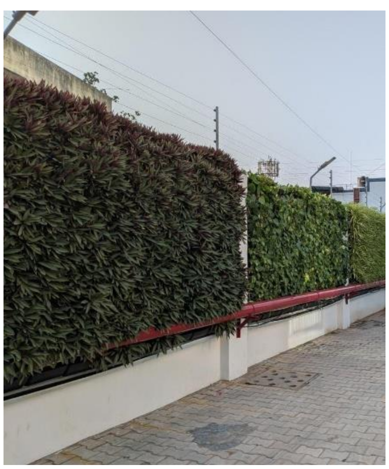
Therefore, proper urban planning, conservation of green spaces, regular maintenance, pollution control, and large-scale tree planting programs are essential for improving urban green carbon storage and strengthening climate change mitigation efforts.

FUTURE SCOPE AND SUSTAINABLE PRACTICES

VERTICAL GARDENS AND ROOFTOP GARDENS

Vertical gardens and rooftop gardens are innovative approaches to increasing green cover in areas with limited land availability. These systems utilize building walls, terraces, balconies, and rooftops for growing ornamental plants, flowering species, climbers, and turfgrass.

Vertical greenery absorbs atmospheric carbon dioxide, reduces heat absorption by buildings, improves insulation, and lowers indoor temperatures. Rooftop gardens help mitigate the urban heat island effect, improve air quality, and increase urban biodiversity. In addition, these green systems enhance aesthetic appeal and create healthier urban living spaces.



Ornamental plants such as Money Plant, Boston Fern, Bougainvillea, and Spider Plant are commonly used in vertical and rooftop gardens because of their adaptability and efficient air-purifying ability.

COMMUNITY PARTICIPATION IN TREE PLANTING

Public awareness and community participation are essential for successful urban greening and carbon sequestration programs. Active involvement of local communities, schools, colleges, environmental organisations, and residential associations in tree planting campaigns can significantly increase urban green cover. Community-based plantation programs encourage environmental responsibility and create awareness about the role of ornamental trees and flowering plants in climate change mitigation. Proper care and maintenance of planted trees by local residents ensures better survival rates and long-term carbon storage benefits. Government initiatives, awareness campaigns, and eco-clubs can further strengthen public participation in urban afforestation and sustainable landscaping programs.

SUSTAINABLE ORNAMENTAL LANDSCAPING

Sustainable ornamental landscaping focuses on designing eco-friendly landscapes that conserve natural resources while maximising environmental benefits. The use of native and drought-tolerant ornamental plants reduces water consumption and maintenance requirements. Organic mulching, composting, rainwater harvesting, and efficient irrigation practices help improve soil health and support carbon sequestration. Sustainable landscaping also promotes mixed planting systems with ornamental trees, shrubs, flowering plants, turfgrass, and climbers that enhance biodiversity and ecological stability. Green landscapes not only improve aesthetic beauty but also function as effective carbon sinks that reduce atmospheric carbon dioxide and improve urban environmental quality.

CONCLUSION

Flowering plants and ornamental trees play a vital role in reducing atmospheric carbon dioxide and improving environmental quality through natural carbon sequestration processes. Their ability to absorb carbon, purify air, regulate temperature, and enhance biodiversity makes them essential components of sustainable urban ecosystems. Ornamental trees with large biomass and long lifespans serve as effective long-term carbon sinks, while flowering plants, shrubs, turfgrass, and indoor ornamental species contribute significantly to improving both outdoor and indoor environmental conditions. Urban green infrastructure, such as parks, roadside plantations, rooftop gardens, and vertical gardens, further strengthens climate change mitigation efforts by increasing green cover and reducing urban heat stress. Although challenges such as urbanisation, pollution, and limited planting space affect carbon storage potential, proper urban planning, sustainable landscaping practices, and active community participation can greatly enhance urban carbon sequestration. Integrating ornamental plants into environmental management strategies is therefore essential for creating greener, healthier, and more sustainable cities in the future.