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CARBON SEQUESTRATION BY NATIVE TREE IN INDIAN METROPOLITAN CITIES: MECHANISMS, CO-BENEFITS, BIODIVERSITY, AND URBAN AFFORESTATION STRATEGIES

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ABSTRACT

Native tree species in Indian metropolitan cities offer substantial and quantifiable carbon sequestration potential that, when strategically deployed, can simultaneously address air pollution, urban heating, biodiversity loss and climate vulnerability across Delhi, Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Pune and Ahmedabad. Based on published research across these cities, this paper finds that species selection by growth rate is critical to balancing immediate carbon uptake with long-term storage: fast-growing species such as *Dalbergia sissoo* sequester up to 3.80 Mg CO_2/ha/year, while slow-growing species like *Manilkara hexandra* and *Ficus benghalensis* accumulate total carbon stocks exceeding 1,000 Mg C/ha over their lifespans. Mixed-species plantations combining both categories therefore represent the most effective urban afforestation strategy.

Beyond carbon, native urban trees deliver measurable co-benefits, removing up to 126.89 tonnes of air pollutants annually in a single Delhi biodiversity park, reducing ambient temperatures by 2.5–4.2°C, and attenuating noise by 8–12 dB. These same species anchor urban biodiversity: *Ficus religiosa* alone supports 23 bird species in Delhi, while *Ficus* trees serve as host plants for butterfly species including the Common Crow and indirectly sustain the Common Jezebel through parasitic mistletoe associations. India's existing policy infrastructure particularly the Nagar Van Yojana (620 city forests established) and the Miyawaki dense-planting method, provides a scalable delivery mechanism, but success

requires shifting from ornamental to native species selection, protecting urban wetlands and tailoring species mixes to each city's unique climate and soil conditions.

KEYWORDS: Biodiversity, Vulnerability, Carbon, Nagar Van Yojana, Miyawaki.

1. INTRODUCTION

India's metropolitan cities are experiencing rapid urbanization, population growth and escalating carbon emissions that pose serious threats to environmental quality and public health. Cities such as Delhi, Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Pune and Ahmedabad collectively house hundreds of millions of people and contribute significantly to the nation's greenhouse gas emissions. In this context, urban trees and green spaces serve as critical nature-based solutions for climate change mitigation. Trees fix atmospheric carbon dioxide (CO_2) through photosynthesis and store it as biomass, making urban forestry one of the most accessible and cost-effective strategies for carbon sequestration in densely populated areas (Nowak & Crane, 2002).

Native tree species are particularly important because they are well-adapted to local climate and soil conditions, require less maintenance, support local biodiversity, and provide a wide range of ecosystem services beyond carbon storage. Studies conducted across Indian cities have documented that species such as *Ficus benghalensis* achieve the highest biomass and carbon density among urban trees (Chaudhary & Singh, 2021), while fast-growing species like *Dalbergia sissoo* can sequester approximately 3.80 Mg CO_2 per hectare per year (Kumar et al., 2025). Despite this potential, Indian metros continue to lose green cover to infrastructure development, Bengaluru's forest cover declined from over 68% in the 1970s to less than 15% by the 2010s and Chennai's green cover stands at only 14.9%.

This paper presents a comprehensive review of carbon sequestration by native and suitable tree species across eight major Indian metropolitan cities. It examines the biological mechanisms of carbon capture, categorizes species by growth rate and sequestration potential, evaluates environmental co-benefits including air pollution removal and urban heat island mitigation, documents the biodiversity supported by these trees, with special emphasis on butterfly species and provides actionable afforestation strategies tailored to each city's unique conditions.

2. Rationale of the Study

Indian metropolitan cities face a convergence of environmental crises: deteriorating air quality, rising temperatures due to the urban heat island effect, loss of biodiversity,

groundwater depletion, and increasing vulnerability to climate change impacts such as flooding and heat waves. Delhi's air quality regularly reaches hazardous levels, while cities like Chennai have lost approximately 85% of their wetlands and Mumbai approximately 71%. Native tree species that once anchored urban biodiversity are being replaced by fast-growing ornamental trees that fail to sustain local ecosystems (Times of India, 2026).

While individual studies have examined carbon sequestration rates of specific species or the ecosystem services of particular urban forests, there is a significant gap in integrated assessments that combine carbon sequestration data, co-benefit quantification, biodiversity value, and city-specific afforestation recommendations into a single framework. This study addresses that gap by creating published research across multiple Indian cities and providing a holistic evaluation that can guide urban planners, policymakers and environmental managers in making evidence-based decisions about native species selection and urban greening strategies.

3. Aim

The aim of this study is to identify, evaluate and recommend native and suitable tree and plant species for maximizing carbon sequestration and associated environmental co-benefits in eight major Indian metropolitan cities such as Delhi, Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Pune, and Ahmedabad while simultaneously supporting urban biodiversity and climate resilience.

4. Objectives

The specific objectives of this study are as follows:

1. To identify and categorize high carbon-sequestering native tree and plant species by their growth rates (fast, medium and slow) with quantitative sequestration data.
2. To explain the biological and ecological mechanisms through which urban trees and ecosystems sequester carbon, including photosynthesis, biomass accumulation, soil carbon storage, biochar and wetland sinks.
3. To evaluate the co-benefits of native urban trees, including air pollutant removal (PM2.5, NOx, SO_2, O_3), noise attenuation, urban heat island mitigation and groundwater recharge, with quantitative data from Indian studies.
4. To identify fauna species particularly butterfly species along with birds, mammals, and insects that benefit from native urban trees as habitat and food sources.

5. To provide city-specific, actionable suggestions for urban afforestation strategies that enhance climate resilience across the eight target metropolitan cities.
6. To synthesize these findings into a comprehensive framework that supports integrated urban greening policy in India.

5. Literature Review

Research on urban carbon sequestration in India has grown substantially over the past decade. A landmark study at the National Zoological Park (NZP) in Delhi found that *Ficus benghalensis* achieved the highest biomass, carbon density, and CO_2 equivalent among the species studied, with a total mean carbon density of 43.61 Mg C per hectare across the site (Chaudhary & Singh, 2021). *Azadirachta indica* (neem) ranked third in carbon density at the same location. In Kolkata, a study of eight urban tree species ranked *Ficus bengalensis* highest in carbon storage, followed by *Neolamarckia cadamba* and *Mangifera indica* (Roy & Mukherjee, 2019).

A comprehensive campus-level study in Chandigarh assessed 92 tree species and found that *Manilkara hexandra* was the top contributor with a total carbon stock of 1,239.20 Mg C per hectare, while *Ficus benghalensis* contributed 1,072.24 Mg C per hectare (Kumar et al., 2024). In Gujarat's tropical dry deciduous forests, *Tectona grandis*, *Butea monosperma*, and *Diospyros melanoxylon* dominated total carbon sequestration of 448 tonnes (Sharma et al., 2019). Research from Visakhapatnam in Andhra Pradesh documented that *Pongamia pinnata* achieved the highest total carbon sequestration of 139,272 kg, with an increasing trend with tree age (Rao et al., 2021).

At the ecosystem services level, a study of Delhi's Aravalli Biodiversity Park using the i-Tree Eco model estimated that approximately 202,100 native trees store about 8,360 Mg of carbon (valued at ₹11.34 crore), sequester approximately 1,236 Mg C per year, and remove around 126.89 tonnes of air pollutants annually (Patel et al., 2026). Global meta-analyses have confirmed that urban vegetation can reduce particulate matter concentrations by 16.5–26.7%, NOx by 13.9–36.2% and SO_2 by 20.5–47.8% (Li et al., 2023).

On the policy front, India's Nagar Van Yojana, funded through the National CAMPA at Rs 895 crore for 2020–2025, has established 620 Nagar Vans (city forests) across 28 states and 3 Union Territories as of December 2025 (Ministry of Environment, Forest and Climate Change [MoEFCC], 2025). The Miyawaki method of dense native planting has been deployed in Delhi, Chennai, and Ahmedabad with documented success in increasing biodiversity and mitigating urban heat island effects. Research from IISc Bengaluru estimates

that an average urban tree sequesters approximately 6 kg of carbon annually (Ramachandra, n.d.).

6. Mechanisms of Carbon Sequestration

6.1 Photosynthesis and Biomass Carbon Storage

The fundamental mechanism of carbon sequestration by trees is photosynthesis, through which plants fix atmospheric CO_2 and convert it into organic carbon compounds. Most native Indian urban tree species, including *Ficus*, *Azadirachta indica*, and *Terminalia*, use the C3 photosynthetic pathway, which is the dominant pathway in tropical broadleaf trees (Nowak & Crane, 2002). The fixed carbon is stored in above-ground biomass (AGB) comprising trunks, branches, and leaves and below-ground biomass (BGB) in root systems. Carbon is exchanged in both organic and inorganic forms in the soil-plant-atmosphere continuum.

A 2026 study across four urban forest sites in the Delhi-NCR region found that AGB-based carbon density ranged from approximately 15.87 Mg C per hectare at Aravali Biodiversity Park in Gurugram to 50.01 Mg C per hectare at Sanjay Van, with below-ground biomass estimated using fixed root-to-shoot ratios (Singh et al., 2026). The wide variation reflects differences in species composition, tree age, canopy density and management practices. According to Kaul et al. (2010), fast-growing species can achieve net annual carbon sequestration rates of 6–8 Mg C per hectare per year, moderate growers like teak approximately 2 Mg C per hectare per year, and slow-growing species approximately 1 Mg C per hectare per year.

6.2 Soil Organic Carbon Dynamics

Urban soils represent a significant but often overlooked carbon pool. Carbon enters the soil through leaf litter decomposition, root turnover, and root exudates, accumulating through humification processes. Globally, soils contain more carbon than all terrestrial vegetation and the atmosphere combined. However, urban soils face unique challenges, compaction from foot traffic and construction, coverage by impervious surfaces, and routine litter removal all reduce soil organic carbon (SOC) inputs (Nowak & Crane, 2002). Despite these challenges, well-managed urban green spaces with native tree cover can maintain substantial SOC stocks.

6.3 Biochar as a Carbon Sequestration Strategy

Biochar, a carbon-rich material produced by pyrolysis of organic matter offers a promising avenue for long-term carbon storage in urban soils. Research has shown that biochar produced from urban green waste and crop residues can store an estimated 30 tonnes of carbon per hectare in urban blue-green infrastructure soils, with residence times spanning

centuries to millennia (Thakur et al., 2023). Studies on biochar from Indian crop residues confirm that it improves soil fertility while achieving long-term carbon sequestration, offering a sustainable alternative to crop-residue burning (RSC Advances, 2018). Biochar applications can increase SOC stocks by approximately 26–33% (Verma et al., 2026), making it a valuable complement to tree planting in urban carbon management strategies.

6.4 Blue Carbon: Wetlands and Mangrove Sinks

Urban wetlands and coastal mangroves represent powerful but underutilized carbon sinks in Indian cities. The East Kolkata Wetlands, a Ramsar site, sequester approximately 1.9 Mg C per hectare per year, mitigating at least approximately 118 Gg of atmospheric CO_2 per year, with harvested fish crops contributing an additional approximately 61 Gg CO_2 per year in carbon uptake. Mangroves and seagrasses can sequester carbon up to four times faster than tropical rainforests (Blue Carbon Ecosystems in Indian Deltas, 2024), and blue carbon ecosystems, despite covering less than 2% of the total ocean surface, account for nearly 50% of carbon burial in marine sediments (Observer Research Foundation [ORF], 2025). However, these ecosystems face severe degradation in Indian cities, Chennai has lost approximately 85% and Mumbai approximately 71% of their wetland areas, underscoring the urgent need for wetland conservation as part of urban carbon strategies.

7. Native Tree and Plant Species for Carbon Sequestration

Native and suitable tree species for carbon sequestration in Indian metropolitan cities can be categorized into three groups based on their growth rates and carbon accumulation patterns. The following tables summarize key species with their quantitative sequestration data and suitability for specific metro cities.

7.1 Fast-Growing Species

Fast-growing native species offer the advantage of rapid carbon uptake in the early years after planting, making them ideal for new afforestation projects where quick results are desired.

Table 1: Fast-Growing Native Species for Carbon Sequestration in Indian Metros.

Species	Common Name	Carbon Sequestration Rate	Suitable Metro Cities	Source
Dalbergia sissoo	Shisham / Indian Rosewood	3.80 Mg CO_2/ha/yr	Delhi, Ahmedabad, Pune	Kumar et al., 2025
Albizia lebbeck	Siris / Woman's Tongue	6 Mg C/ha/yr	Delhi, Ahmedabad, Pune	Kaul et al., 2010
Pongamia	Karanj / Indian	Highest total sequestration	Chennai,	Rao et al.,

Species	Common Name	Carbon Sequestration Rate	Suitable Metro Cities	Source
pinnata	Beech	(139,272 kg); increasing with age	Hyderabad, Mumbai	2021

Dalbergia sissoo is a hardy deciduous rosewood tree native to the Indian subcontinent that thrives in semi-arid conditions, making it well-suited for Delhi, Ahmedabad and Pune. It recorded the highest mean carbon sequestration of 3.80 Mg per hectare among species studied in urban parks (Kumar et al., 2025). *Pongamia pinnata* is particularly notable because its carbon sequestration capacity increases with tree age (Rao et al., 2021), making it a valuable long-term investment for coastal and semi-arid cities like Chennai, Hyderabad and Mumbai.

7.2 Medium-Growing Species

Medium-growing species balance reasonable growth rates with substantial long-term carbon storage and broad adaptability across Indian climatic zones.

Table 2: Medium-Growing Native Species for Carbon Sequestration in Indian Metros.

Species	Common Name	Carbon Sequestration Rate	Suitable Metro Cities	Source
Tectona grandis	Teak	Approx. 2 Mg C/ha/yr	All 8 metros	Kaul et al., 2010
Azadirachta indica	Neem	Approx. 2 Mg C/ha/yr; 3rd highest C density in Delhi	All 8 metros	Chaudhary & Singh, 2021; Kaul et al., 2010
Syzygium cumini	Jamun / Java Plum	1.5–2.5 Mg C/ha/yr	Delhi, Kolkata, Bengaluru	Kaul et al., 2010
Terminalia arjuna	Arjun Tree	1.5–2.5 Mg C/ha/yr	Delhi, Kolkata, Bengaluru	Kaul et al., 2010

Azadirachta indica (neem) is perhaps the most versatile species for Indian urban forestry. It is highly adaptable to diverse soil and climate conditions, ranked third in carbon density at Delhi's NZP (Chaudhary & Singh, 2021), and is suitable for planting across all eight target metros. *Tectona grandis* (teak), modeled at approximately 2 Mg C per hectare per year (Kaul et al., 2010), is a well-established timber species that also provides significant carbon benefits in urban plantations.

7.3 Slow-Growing, High Carbon Stock Species

Slow-growing species may have lower annual sequestration rates, but their long lifespans and massive canopies result in exceptionally high total carbon stocks over time. These species are the backbone of mature urban forests.

Table 3: Slow-Growing, High Carbon Stock Native Species for Indian Metros.

Species	Common Name	Total Carbon Stock / Annual Rate	Suitable Metro Cities	Source
Manilkara hexandra	Khirni	1,239.20 Mg C/ha total stock	Chennai, Bengaluru, Hyderabad	Kumar et al., 2024
Ficus benghalensis	Banyan	1,072.24 Mg C/ha total stock; highest CO_2 eq. in Delhi	All metros	Kumar et al., 2024; Chaudhary & Singh, 2021
Ficus religiosa	Peepal	Approx. 1 Mg C/ha/yr; high total stock	All metros	Roy & Mukherjee, 2019; Kaul et al., 2010
Mangifera indica	Mango	3rd in AGB carbon among urban species	Mumbai, Chennai, Kolkata, Bengaluru	Roy & Mukherjee, 2019
Tamarindus indica	Tamarind	Moderate annual rate; high long-term stock	Mumbai, Chennai, Kolkata	Roy & Mukherjee, 2019
Mimusops elengi	Bakul	High total stock over long lifespan	Chennai, Bengaluru, Hyderabad	Roy & Mukherjee, 2019
Butea monosperma	Palash / Flame of the Forest	Among top 3 in Gujarat dry deciduous forest	Delhi, Ahmedabad	Sharma et al., 2019

Manilkara hexandra recorded the highest total carbon stock of 1,239.20 Mg C per hectare among 92 species studied in a Chandigarh campus (Kumar et al., 2024), while *Ficus benghalensis* contributed 1,072.24 Mg C per hectare at the same site. These Ficus species are particularly valuable because their expansive canopies also provide substantial cooling, habitat, and air purification benefits.

8. Co-benefits of Urban Trees

8.1 Air Pollutant Removal

Urban trees in Indian cities provide substantial air quality improvements beyond carbon sequestration. A comprehensive study of Delhi's Aravalli Biodiversity Park, which contains approximately 202,100 native trees, estimated that these trees remove around 126.89 tonnes

of air pollutants every year including PM2.5, NOx, SO_2 and O_3 generating environmental benefits valued at approximately ₹1.89 crore (New Indian Express, 2026). An earlier phase of the same study had reported pollution removal of 14.63 tonnes per year worth ₹1.8 crore (Times of India, 2023).

At a broader scale, a global meta-analysis published in *npj Urban Sustainability* found that urban vegetation can reduce particulate matter (PM) concentrations by approximately 16.5–26.7%, nitrogen oxides (NOx) by 13.9–36.2%, and sulfur dioxide (SO_2) by 20.5–47.8% (Li et al., 2023). However, the same study noted that urban vegetation may not significantly mitigate ground-level ozone (O_3), with concentrations potentially increasing by 5.1–25.9% due to volatile organic compound (VOC) interactions. Research on tropical tree species in Indian urban environments showed response sensitivity of 34–72% for NO_2, 16–64% for PM2.5, and 3–31% for O_3, confirming that trees are considerably sensitive to the combined effects of both particulate and gaseous pollutants (Medscape, 2020).

8.2 Urban Heat Island Mitigation

Native tree species play a critical role in reducing the urban heat island (UHI) effect in Indian cities. High-performing species such as *Ficus benghalensis*, *Azadirachta indica*, and *Samanea saman* have demonstrated maximum temperature reductions of 2.5 to 4.2°C, especially in compact, low-rise, and mid-rise urban zones (Sinha et al., 2026). A broader assessment of nature-based solutions in Delhi, Mumbai, and Chennai found that urban green spaces, rooftop gardens, and wetland restoration can reduce ambient temperatures by 2–5°C, though barriers like land scarcity and fragmented governance hinder scalability (Sinha et al., 2026). Given that Indian metros regularly experience summer temperatures exceeding 40°C, even a 2–4°C reduction can significantly improve thermal comfort and reduce heat-related health risks.

8.3 Noise Attenuation

Dense vegetation belts in urban settings provide meaningful noise reduction. According to acoustic simulation studies, dense vegetation belts can achieve average noise reductions of 8–12 dB (ISPRS Annals, 2026). *Polyalthia longifolia* (false ashoka or mast tree) has been identified as particularly effective for noise reduction and is recommended as the most suitable species for green belt development in Indian cities such as Thiruvananthapuram (Rawat et al., 2018). This species is already widely planted as an avenue tree across Indian metros, making it a practical choice for noise barrier plantations along highways and arterial roads.

8.4 Groundwater Recharge and Ecosystem Service Valuation

Urban trees contribute significantly to groundwater recharge by facilitating rainwater infiltration. Delhi's Aravalli Biodiversity Park retains nearly 3 million litres of rainwater annually, significantly reducing flood risks and aiding groundwater recharge (Economic Times, 2026). The water rechargeable by the park's trees is approximately 110,977 cubic feet per year, valued at Rs 5.9 lakh (Times of India, 2023). The park's total ecosystem service portfolio including carbon storage of 8,360 Mg (Rs 11.34 crore), annual carbon sequestration of approximately 1,236 Mg C per year (Rs.1.7 crore), and air pollutant removal, demonstrates the substantial economic value of urban native tree plantations (Patel et al., 2026).

9. Fauna and Butterfly Benefits

9.1 Butterfly Species and Their Host and Nectar Plants

Native urban trees support a rich diversity of butterfly species by serving as larval host plants and adult nectar sources. The following table summarizes butterfly-tree associations documented in Indian urban areas.

Table 4: Butterfly Species and Their Host/Nectar Plant Associations in Indian Urban Areas.

Butterfly Species	Host Plant Trees/Shrubs	Nectar Plants	Important Notes
Common Mormon (*Papilio polytes*)	*Citrus* spp., *Murraya koenigii*, *Aegle marmelos*, *Glycosmis pentaphylla* (Rutaceae)	Lantana, Ixora, Jatropha, Mussaenda	Thrives in urban gardens with citrus trees
Blue Mormon (*Papilio polymnestor*)	*Citrus* spp., *Atalantia* spp. (Rutaceae)	*Mussaenda frondosa*, *Ixora coccinea*, *Jasminum* spp.	Found in wooded urban areas with Citrus cultivation
Common Jezebel (*Delias eucharis*)	*Dendrophthoe falcata*, *Loranthus* spp. — parasitic mistletoes on Ficus, Neem, Mango	Various garden flowers	Indirectly benefits from Ficus and Neem trees hosting mistletoes
Plain Tiger (*Danaus chrysippus*)	*Calotropis* spp. (milkweed), *Asclepias* spp. (Apocynaceae)	*Nerium oleander*, *Bauhinia purpurea*, *Crotalaria juncea*	Common in open urban areas with milkweed patches
Common Crow (*Euploea core*)	Apocynaceae, Moraceae (*Ficus* spp.), Rubiaceae	*Crotalaria*, *Heliotropium* (males for pheromones)	Directly benefits from Ficus trees as host plants
Tailed Jay (*Graphium agamemnon*)	*Polyalthia longifolia* (Annonaceae)	Lantana, Ixora, Mussaenda	Very common in urban areas due to widespread planting of *P. longifolia*

The Tailed Jay (*Graphium agamemnon*) is now very common at low elevations and regularly seen in gardens and urban areas specifically because its food plant, *Polyalthia longifolia* (false ashoka), is widely used as an ornamental tree in Indian cities (Wikipedia, n.d.). Similarly, the Common Jezebel (*Delias eucharis*) benefits indirectly from large native trees like Ficus and Neem because its host plants, parasitic mistletoes of the genus *Loranthus* and *Dendrophthoe* grow on these trees. The Common Crow (*Euploea core*) feeds on plants of the families Apocynaceae and Moraceae, including *Ficus* species (Wikipedia, n.d.), making Ficus trees doubly valuable for both carbon sequestration and butterfly conservation.

9.2 Bird Diversity on Native Urban Trees

Native trees support remarkably high bird diversity in Indian cities. A study in Delhi found that *Ficus religiosa* (peepal) supported the highest bird diversity at 23 species, making it the single most connected node in the bird-tree network (STM Journals, 2025). *Azadirachta indica* (neem) hosted 20 species, reflecting both its abundant canopy insects and year-round foliage. *Bombax ceiba* (semal) attracted 11 species during spring flowering, while *Ficus virens* (pilkhan) and *Ficus benghalensis* (banyan) supported 8 and 5 species respectively, confirming the pan-tropical importance of the genus *Ficus* in sustaining urban wildlife. Key bird species recorded on these trees include Coppersmith Barbet, Brown-headed Barbet, Indian Grey Hornbill, Asian Green Bee-eater, Red-vented Bulbul, Red-whiskered Bulbul, Rufous Treepie, and House Crow (STM Journals, 2025).

9.3 Mammals and Insects

The Indian Flying Fox (*Pteropus medius*), a keystone frugivorous bat, roosts on large trees including *Ficus* species, *Terminalia arjuna*, and *Ficus religiosa* in urban areas, with Ficus species being the most important foraging trees (Urban Ecosystems, 2024). Nearly 70% of the seeds found in Indian Flying Fox guano are of the banyan tree, highlighting the critical role of this bat in seed dispersal and forest regeneration. Indian palm squirrels (*Funambulus* spp.) are also commonly associated with Ficus, Neem, and Peepal trees in urban settings.

Among insects, fig wasps (family Agaonidae) are obligate pollinators of all Ficus species, with each fig species relying on specialized wasp species for pollination. Several *Euploea* (crow butterfly) caterpillars and the Plain Tiger feed on Ficus leaves, while the citrus long-horned beetle (*Anoplophora chinensis*) larvae feed on Ficus wood. These intricate ecological relationships underscore why native Ficus trees are irreplaceable in urban ecosystems.

10. Suggestions for Urban Afforestation and Climate Resilience

10.1 National Programs and Policy Framework

India has several national programs that support urban afforestation. The Nagar Van Yojana (NVY), funded through the National CAMPA at Rs 895 crore for 2020–2025, targets the establishment of 1,000 city forests (Nagar Vans) and city gardens (Nagar Vatikas) by 2027, with 620 already established across 28 states and 3 Union Territories (MoEFCC, 2025). The Ministry of Environment, Forest and Climate Change (MoEFCC) promotes urban forestry through multiple schemes including NVY, CAMPA, the National Afforestation Programme (NAP), the Green India Mission (GIM under NAPCC), and the School Nursery Yojana, involving local communities, NGOs, and educational institutions (MoEFCC, 2025). The Miyawaki method of dense native planting has emerged as a particularly effective approach for rapidly establishing biodiverse urban forests on small plots of land.

10.2 City-Specific Afforestation Recommendations

Delhi

Delhi operates in a semi-arid climate with alluvial and sandy soils and extreme temperature variations. The city benefits from its Ridge forests and six Biodiversity Parks including the Aravalli, Yamuna, Neela Hauz, Northern Ridge, and Tilpath Valley parks. Recommended strategies include protecting the Ridge ecosystem, expanding Miyawaki forests on vacant plots (the Delhi government announced 17 new urban forests totalling 177 acres in 2025, including 2 Miyawaki forests), and prioritizing species like neem, peepal, pilkhan, and arjun that are proven performers in Delhi's conditions.

Mumbai

Mumbai has a tropical wet climate with laterite and basalt soils and is prone to monsoon flooding. The Sanjay Gandhi National Park (SGNP), home to over 1,000 plant species and 251 bird species, and Aarey Forest are critical green assets. Strategies should focus on mangrove restoration along the coast, protecting SGNP ecological corridors, and planting native deciduous species suited to the Western Ghats bioregion.

Kolkata

Kolkata experiences a tropical wet-dry climate with alluvial and clay soils and frequent waterlogging. Its green spaces include the Maidan, Eco Park, and Rabindra Sarobar. Recommended approaches include planting banyan, neem, and rain trees, establishing riparian buffers along the Hooghly River, and conserving the East Kolkata Wetlands, which sequester approximately 1.9 Mg C per hectare per year.

Chennai

Chennai has a tropical savanna climate with clay and sandy coastal soils and is cyclone-prone, with green cover at only 14.9%. The Guindy National Park and Pallikaranai wetland are key assets. Strategies should include planting copper pod, Indian beech, neem, and tropical almond, deploying Miyawaki urban forests (already initiated by Chennai Smart City Limited), and restoring degraded wetlands.

Bengaluru

Bengaluru sits at approximately 900 metres elevation with red laterite and loamy-clay soils in a tropical savanna climate. Despite having iconic green spaces like Cubbon Park, Lalbagh, and Turahalli forest, the city has experienced dramatic green cover loss from over 68% in the 1970s to less than 15% by the 2010s. Priorities include lake-edge restoration with native riparian species, halting tree felling for infrastructure projects, and expanding native dry deciduous plantations.

Hyderabad

Hyderabad has a semi-arid tropical climate with red and black cotton soils. The Kancha Gachibowli urban forest is a notable green asset. Telangana's Haritha Haram program provides a strong framework, using multiple planting models, avenue, block, institutional, homestead, and agro-forestry with native species like neem, neredu (jamun), arjuna, and kanuga (pongamia).

Pune

Pune has a tropical wet-dry climate with laterite and basalt soils and hilly terrain. The Baner-Pashan Biodiversity Park, a proposed 200-hectare protected region under development by Pune Municipal Corporation, represents a significant opportunity. Strategies should prioritize native Western Ghats species, hill conservation, and biodiversity park expansion.

Ahmedabad

Ahmedabad has a hot semi-arid climate with sandy and alluvial soils and extreme heat. While green cover is expanding, native species that anchor biodiversity are declining, being replaced by ornamental trees (Times of India, 2026). The city should prioritize native species such as varuna, pilu, and pachunda over ornamental trees, deploy Miyawaki forests for heat mitigation (the method's efficacy has been confirmed in Ahmedabad), and focus on drought-resistant native plantings.

10.3 Cross-Cutting Recommendations

Across all eight metros, several cross-cutting strategies can enhance climate resilience. Urban planners should prioritize native species over exotic ornamentals in all public planting

programs, as native species support local biodiversity and are better adapted to local conditions. Mixed-species plantations combining fast-growing species (for immediate carbon uptake) with slow-growing, high-stock species (for long-term carbon storage) should be the standard approach. Community engagement through school nursery programs, citizen science biodiversity monitoring, and neighbourhood-level green space management can build public support and ensure long-term maintenance. Integration of biochar from urban green waste into soil management can enhance SOC stocks by 26–33% (Verma et al., 2026). Finally, protecting and restoring urban wetlands and mangroves should be treated as a priority equal to tree planting, given their exceptional carbon sequestration capacity.

11. CONCLUSION

This review demonstrates that native tree species in Indian metropolitan cities offer substantial carbon sequestration potential alongside a wide range of environmental, ecological, and social co-benefits. Fast-growing species like *Dalbergia sissoo* (3.80 Mg CO_2/ha/yr; Kumar et al., 2025) and *Pongamia pinnata* (Rao et al., 2021) provide rapid carbon uptake, while slow-growing giants like *Manilkara hexandra* (1,239 Mg C/ha total stock; Kumar et al., 2024) and *Ficus benghalensis* (1,072 Mg C/ha total stock; Kumar et al., 2024) serve as long-term carbon reservoirs. Medium-growing species such as *Azadirachta indica* and *Tectona grandis* (2 Mg C/ha/yr; Kaul et al., 2010) offer a practical balance for widespread urban planting.

Beyond carbon, these trees remove significant quantities of air pollutants, up to 126.89 tonnes per year in a single biodiversity park (Patel et al., 2026), reduce urban temperatures by 2.5–4.2°C (Sinha et al., 2026), attenuate noise by 8–12 dB (ISPRS Annals, 2026), and recharge groundwater. They also support rich biodiversity, with peepal trees alone hosting 23 bird species (STM Journals, 2025) and Ficus species serving as host plants for multiple butterfly species including the Common Crow and Common Jezebel.

India's national programs like the Nagar Van Yojana and the Miyawaki method provide strong frameworks for scaling urban afforestation (MoEFCC, 2025). However, success depends on prioritizing native species over ornamentals, protecting existing green assets like wetlands and ridge forests, and integrating carbon sequestration goals with biodiversity conservation and climate adaptation planning. Each of the eight metropolitan cities examined has unique climatic, soil and infrastructure conditions that demand tailored species selection and planting strategies. By adopting an integrated, evidence-based approach to urban

greening, Indian metros can significantly enhance their climate resilience while improving the quality of life for hundreds of millions of urban residents.

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