GreenariA
Go Green, Learn Green
An Agricultural Monthly e-Magazine

Volume 03, Issue 06, 2025
ISSN: 2584-153X
Article ID: G-25-0619

URBAN FORESTS: NATURE'S ANSWER TO GROWING CITY CHALLENGES

Dhanush M[1*], Ravi Raja Simman P[2], Ravaliselshiya S[3], Ashick Rajah R[4] and Ashish Kerketta[1]

[1]Ph.D. Scholar (Agricultural Extension Education), Department of Agricultural Extension, College of Agriculture, Kerala Agricultural University, Thrissur, Kerala, India

[2]PG Scholar (Silviculture & Agroforestry), Forest College and Research Institute, Mettupalayam, Tamil Nadu, India

[3]Ph.D. Scholar (Silviculture & Agroforestry), Department of Silviculture & Agroforestry, Rani Lakshmi Bai Central Agricultural University, Jhansi, India.

[4]Ph.D. Scholar (Silviculture & Agroforestry), Department of Agroforestry, Forest College and Research Institute, Mettupalayam, Tamil Nadu

**Corresponding Author Mail ID: dhanushphdscholar@gmail.com*

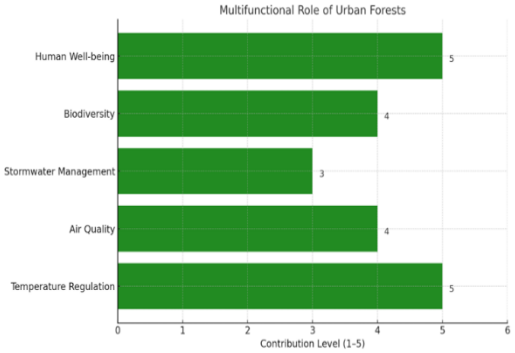
Introduction

Urban forests include a wide range of vegetation types and green spaces situated within urban landscapes, encompassing elements such as roadside tree plantings and afforestation activities initiated at the community scale. Due to the rapid rate of urbanization over the last 30 years, which is expected to reach approximately 70 percent in 2050, cities are increasingly experiencing several environmental burdens, including urban heat islands, ambient pollution, and floods. Contemporary researchers regard urban forests as vital components of multifunctional green infrastructure, playing a significant role in advancing sustainable development (Haase et al., 2014; Nowak et al., 2014). This article provides an in-depth overview of the benefits of urban forests, alongside the scientific assessment tools, design strategies, policy frameworks, and illustrative case studies from both international and Indian contexts. Aimed at an informed audience—including students, researchers, urban planners, and policymakers—it bridges empirical research with practical application.

Urban forests play a critical role in mitigating the urban heat island effect through the dual processes of shading and evapotranspiration. Meta-analyses have shown that tree-rich urban parks can decrease afternoon temperatures by approximately 0.9 to 2 °C, whereas zones with dense, mature tree canopies can locally reduce air temperatures by as much as 3 to 6 °C (Bowler et al., 2010). The region's streets shaded by trees were already up to 5.6ºC cooler than non-shaded streets in Bengaluru. Besides, big tree patches result in a major decrease of surface temperatures, e.g., in Sacramento, temperature reductions beneath tree canopies have been observed to range between 11°C and 25°C. Thus, urban forests serve as an effective strategy for mitigating the impacts of urban heat waves. The trees eliminate the pollutants through deposition and stomatal uptake (Nowak, 2006; Escobedo et al., 2011). While their impact on city-wide pollutant concentrations may be limited, urban forests contribute to improved public health by reducing levels of particulate matter (PM) and gaseous pollutants. As an example, it is possible to mention that U.S. urban forests in 2010 avoided 850 premature deaths and saved 6.8 billion dollars in health costs (Nowak et al., 2014), and Europe is also enjoying cities with high canopy density (Nowak et al., 2015; Liu et al., 2024). Yet, it is essential to choose the species, as some of them release pollen and biogenic VOCs (Abhijith et al., 2017; Baldauf & Nowak, 2014). Rainfall in cities is captured on the canopy of trees and improved by roots. Green systems are more cost-effective, nutrient filtering, and pose a lesser risk of floods than grey infrastructure. The Subhash

Bose Park in Kochi has 339 trees, which absorb stormwater, leading to less than 180,000 being spent on drainage a year. Urban biodiversity is primarily supported through the presence of pocket woodlands and interconnected green corridors (Haase et al., 2014). This has been with mixed native planting, which enhances ecosystem stability and resilience. High-density native plantations, exemplified by the Miyawaki method, enable the rapid development of mini-forests that substantially enhance local biodiversity within a relatively short time frame. In Tamil Nadu, Miyawaki plantations demonstrated rapid growth, with native species reaching heights of up to 20 feet within a single year. Trees increase physical and mental well-being-limiting heat stress, increasing air quality, and lowering crime rates and social cohesion (Nowak et al., 2018). The scoping review of 201 studies revealed that three pathways of human health related to trees are as follows: reducing harm, restoring capacities, and building capacities. There are physical activations, attentional restoration, and stress reduction caused by greenspace too (Lin et al., 2025).

Quantifying Urban Forests Benefits



Indicators such as leaf area index, canopy cover density, and pollutant removal rates can be utilized to quantify the ecosystem services (EES) provided by urban forests (Nowak, 2006). The findings of the integrated analysis conducted by Wang et al. (2023) revealed that forest patches delivered nearly threefold greater cumulative ecosystem services—particularly in urban heat island mitigation, PM2.5 reduction, and carbon sequestration—when evaluated collectively, as opposed to assessing each service in isolation. Assessment tools like i-Tree Eco combine ground-based inventory data with remote sensing technologies, such as LiDAR and multispectral imagery, to evaluate the structural characteristics, ecosystem functions, and comprehensive value of urban forests. These technologies enable precise valuation and scenario modeling, thereby supporting evidence-based policymaking. Furthermore, a meta-analysis has validated the cooling effect of urban trees, highlighting species composition, canopy structure, and park geometry as key influencing factors. However, they sound a note of warning that nocturnal cooling effects might depend on tree shape and urban structure.

Planning and design of urban Forests

An urban forest is well designed ecologically, socially and prettily. Important design models are:

- **Green infrastructure networks:** Networks of green areas which bring landscape continuity (Tzoulas et al., 2007). These are greenways, linear parks and eco-bridges.
- **Pocket forests:** High density areas of native trees, usually planted to the Miyawaki method, suited to small urban plots.
- **Green belts and buffers:** Bigger informal tree belts act as ecological buffers to pollution and noise, and construction stress.

Selecting native tree species that require minimal maintenance and exhibit resilience to climatic stress is essential (Srinivas et al., 2019). Robust Indian species such as *Azadirachta indica*, *Ficus religiosa*, and *Tamarindus indica* provide extensive canopy cover, structural integrity, and ecological compatibility. In contrast, the introduction of invasive species like *Prosopis juliflora* and *Leucaena leucocephala* can lead to ecological imbalance and should be avoided. The success and sustainability of urban forestry initiatives are significantly improved through participatory approaches that actively involve local communities, non-governmental organizations, and educational institutions. The

local governments should include an inventory of trees, planting goals, and upkeep budgets within the Master Plans. In India, under the CAMPA program, City Forests have the purpose of engaging urban populations in the reconstruction of biodiversity (MoEFCC, 2020). Notable examples include urban forest initiatives implemented in cities such as Pune, Hyderabad, and Bengaluru.

Urban Forestry Governance and Policy Frameworks

There is a variety of governance lessons offered by international models, like the city in a garden concept of Singapore has the aim of tree canopy (target: 50 per cent) as an element of the planning system of the Urban Redevelopment Authority (Tan et al., 2013). Toronto Tree Bylaws require trees to be taken into consideration during construction sites and encourage the planting of trees.

There is no Urban Forestry Act on the national level, but there are a number of indirect structures, like the National Forest Policy (1988) promotes planting of trees in the urban waste lands and in institutional lands. Urban green spaces serve primarily as instruments for climate adaptation, a role emphasized under the National Mission for a Green India (GIM). Additionally, they are integrated into the Smart Cities Mission, where they function as key indicators of urban health and sustainability. However, enforcement efforts remain largely ineffective due to fragmented governance at the neighbourhood scale, as municipal bodies, development authorities, and forest departments often function in isolation without inter-agency coordination. (TERI, 2017).

Case Studies

Delhi Ridge: Urban Lung of India

Delhi ridge stretches nearly 7,777 hectares in area, it falls within the Aravalli hill system and is a source of critical ecological processes, including temperature controls, water restocking, and preservation of biodiversity. Despite this, the area is severely affected by encroachment and the proliferation of invasive species, particularly *Prosopis juliflora*.

Bengaluru and Chennai Miyawaki Urban Forests

The popularity of Urban Miyawaki forests has spread in the Indian metros. In Bengaluru, more than 75 mini forests have been established by the use of CSR and community involvement (Times of India, 2023). Although these forests are as small as 200-500 m^2, they are likely to grow up to 10 times as quickly as the traditional plantations, as well as appeal to birds, butterflies, and reptiles after two years.

The Urban Greening Model in Singapore

Singapore already has more than 7 million trees and strives to make each house within 10 minutes of a park. The program Skyrise Greenery encourages green roofs and vertical forest on the buildings, enhancing microclimate and biodiversity.

Bosco Verticale in Milan

The “Vertical Forest” in Milan is a twin residential tower that has more than 900 trees. This pioneering architectural approach has led to a 33% decrease in energy consumption, enhanced ambient air quality, and catalyzed the replication of similar design models in several other regions.

Challenges

i. Change in Urbanization and Land shortage: The rapid urbanization in India, with an annual increase of approximately 10 million urban residents (World Bank, 2022), exerts considerable pressure on open spaces. Reforestation efforts frequently prove inadequate to offset the extensive tree loss resulting from infrastructure development—a challenge that is particularly evident in Tier-2 cities.

ii. Climate Stress and Bad Maintenance: The urban trees are vulnerable to various urban stresses that include heat, drought, vandalism, space constraints of roots, and air pollution. Poor selection of species and following the planting up with no attention leads to poor survivability (down to 30-40%).

iii. Policy and institutional fragmentation: Management of urban forests is divided between departments that provide overlapping functions

and disparities, such as horticulture, public works, forests, and urban development departments.

iv. Gap in the Data: Most Indian cities do not possess comprehensive natural inventories of urban trees or detailed canopy cover maps.Valuation, monitoring, and informed planning are also negatively affected by a lack of baseline data.

Way Forward

Unlocking the transformative potential of urban forests necessitates a comprehensive strategy that harmonizes ecological principles with policy integration, participatory governance, and innovative design interventions. Master Plans and Development Plans should integrate the rational urban and green urban forestry over the long-term period. This involves compulsory Canopy cover objectives, Tree pathways to sustain ecological connectivity, and zoning arrangements of green barriers. The land use category in urban areas should classify tree-based infrastructure as a necessity and not as a decoration. To ensure the structured management and advancement of urban green spaces, Municipal Corporations and Development Authorities should consider establishing dedicated Urban Forestry Units within city administrations. Urban foresters, planners, and ecologists, as well as GIS experts, should be deployed in these units. It is all about inter-agency collaboration- connecting Forest Departments, Smart Cities Cells, Jal Boards, and Housing Authorities. Real-time forest dashboards and digital tree inventory are essential in data-driven management. It is possible to monitor the changes in the canopy, the health of species, and even the carbon stock and service delivery using satellite imagery, drone mapping, and mobile GIS apps (Nowak et al., 2018; Yang et al., 2022). Tree-adoption and citizen science ought to be expanded. Integrating urban forestry into educational curricula at both school and university levels is essential to foster foundational literacy in ecological stewardship and climate action. Urban Greening Grants may serve as effective incentives for engaging NGOs and Resident Welfare Associations (RWAs) in greening initiatives. Furthermore, activities such as tree planting, maintenance, and innovation should be supported through emerging financial mechanisms, including green bonds, carbon credit markets, and partnerships under Corporate Social Responsibility (CSR) frameworks. City forests and enriched urban space can be provided with a portion of the Compensatory Afforestation Fund (CAMPA) established in India. Ecosystem Services (PES) systems might also motivate the private sector to develop green infrastructure.

Conclusion

Urban forests are not a luxury anymore, but a necessity. In the context of rapidly urbanizing cities across India and the globe, the escalating challenges of extreme heat, urban flooding, air pollution, and declining public health have underscored the critical role of trees as integral components of urban ecological systems. It is proven in scientific terms that urban forests have multiple solutions to offer climatic, ecological, economic, and social advantages. From the Delhi Ridge to Miyawaki pocket forests in Bengaluru, the policy innovations of Singapore to the green architecture of Milan, urban forests are emerging as solutions that are both functionally effective and aesthetically inspiring. They make humans touch with nature, mend broken landscapes, and provide relief in towering jungles. However, cities need to be planned, governed, engaged, and invested in smartly to make the most out of their potential. Urban forestry extends beyond the mere act of tree planting; it encompasses the creation of larger, greener, more equitable, and more liveable urban environments. Green is the key to the road to urban resilience. The current juncture presents a critical opportunity for decisive and coordinated action.

References

1. Abhijith, K., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broderick, B., Di Sabatino, S., & Pulvirenti, B. (2017). Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments – A review. *Atmospheric Environment*, *162*, 71–86.

https://doi.org/10.1016/j.atmosenv.2017.05.014

2. *A vertical forest*. (2016). Google Books. https://books.google.co.in/books?id=gUL2zgEACAAJ
3. Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. *Environmental Pollution*, *159*(8–9), 2078–2087. https://doi.org/10.1016/j.envpol.2011.01.01
4. Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning*, *97*(3), 147–155. https://doi.org/10.1016/j.landurbplan.2010.05.006
5. Haase, D., Larondelle, N., Andersson, E., Artmann, M., Borgström, S., Breuste, J., Gomez-Baggethun, E., Gren, Å., Hamstead, Z., Hansen, R., Kabisch, N., Kremer, P., Langemeyer, J., Rall, E. L., McPhearson, T., Pauleit, S., Qureshi, S., Schwarz, N., Voigt, A., Elmqvist, T. (2014b). A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, models, and implementation. *AMBIO*, *43*(4), 413–433. https://doi.org/10.1007/s13280-014-0504-0
6. Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening*, *4*(3–4), 115–123. https://doi.org/10.1016/j.ufug.2006.01.007
7. Nowak, D. J., Hirabayashi, S., Bodine, A., & Greenfield, E. (2014b). Tree and forest effects on air quality and human health in the United States. *Environmental Pollution*, *193*, 119–129. https://doi.org/10.1016/j.envpol.2014.05.028
8. Roy, S., Byrne, J., & Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry & Urban Greening*, *11*(4), 351–363. https://doi.org/10.1016 /j.ufug.2012.06.006