Green Arteries of The Nation: Designing Avenue Plantations for Sustainable Urban and Rural Landscapes

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ABSTRACT

Avenue plantations represent a vital form of green infrastructure that integrates ecological, social, and climatic benefits within linear transportation networks. This study examines the role of scientifically designed avenue plantations in enhancing the sustainability of both urban and rural landscapes in India. Rapid urbanization and infrastructure expansion have significantly reduced tree cover, intensifying environmental challenges such as urban heat islands, air pollution, and habitat fragmentation. Avenue plantations offer a practical and scalable solution by transforming roadsides into multifunctional ecological corridors. Distinctions between urban and rural plantation strategies are discussed, highlighting the need for pollution-tolerant, space-efficient species in cities, and multipurpose, community-beneficial species in rural areas. Despite their potential, avenue plantations face challenges such as unplanned road widening, poor species selection, inadequate maintenance, and increasing climate stress. In conclusion, avenue plantations are not merely aesthetic enhancements but essential components of sustainable development. When planned and managed scientifically, they contribute significantly to environmental resilience, public health, and landscape connectivity, thereby supporting the transition toward greener and more livable ecosystems.

INTRODUCTION

Imagine driving down a road where the air feels cooler, where birds flit from branch to branch overhead, and where a canopy of interlocking leaves turns harsh afternoon sun into a dappled green light. This is the promise of avenue plantation — a concept as ancient as the Mughal shaded highways and as urgent as today's climate emergency. Roads, highways, and streets are not merely conduits of movement; they can be green arteries that pulse with ecological life, connecting fragmented habitats, cleaning the air we breathe, and making cities and villages more liveable. India is urbanising at a staggering pace. Tree cover in cities is shrinking as roads widen and concrete spreads. Meanwhile, rural highways cut through agricultural landscapes with little thought for shade, soil, or biodiversity. The time has come for planned, scientific avenue plantations to reclaim these linear spaces — for people, for nature, and for the planet.

1. What is Avenue Plantation and their Importance?

Avenue plantation is the deliberate, planned act of planting trees along roadsides, highways, streets, canals, and railway lines (Kattel & Khanal, 2021). The practice is far from modern. Travellers on India's ancient trade routes benefited from the shade of trees planted by emperors and local rulers, a tradition of comfort and care encoded into the landscape itself. The case for avenue planting has never been stronger. Cities across India regularly record temperatures several degrees higher than surrounding rural areas — the urban heat island effect — because asphalt and concrete absorb and retain solar radiation (Mandal *et al*., 2017). A well-planted tree-lined street can reduce surface temperatures significantly, offering a natural, energy-efficient remedy.

2. Design Principles for Avenue Plantation

Good avenue planting is not a matter of digging holes and dropping in saplings. It requires careful design thinking across several dimensions. Species-site matching is fundamental — the tree must suit the local climate, soil type, and annual rainfall. A species thriving in the coastal plains of Kerala will struggle in the arid interiors of Rajasthan. Root systems deserve special attention in urban contexts. Aggressive surface roots can fracture footpaths, damage utility pipes, and destabilise road surfaces. Deep-rooted or non-invasive species are preferred where underground infrastructure exists. Spacing and alignment — whether a single row or a double row planting — depends on road width and available verge. A maintenance plan covering pruning calendars, watering schedules during establishment, and protection from grazing must be built in from the outset, or even the best-designed plantation will fail.

Figure 1. Avenue designing principles

3. Criteria for Selection of Suitable Tree Species

The ideal avenue tree balances fast early growth — to deliver shade quickly — with longevity, remaining an asset for generations. It must tolerate local stressors such as pollution in cities or drought in rain-shadow regions without intensive inputs. Non-invasive root systems and non-fragile branches are non-negotiable safety criteria. Multipurpose trees

that deliver timber, fodder, or medicine alongside shade are especially valued in rural avenue contexts.

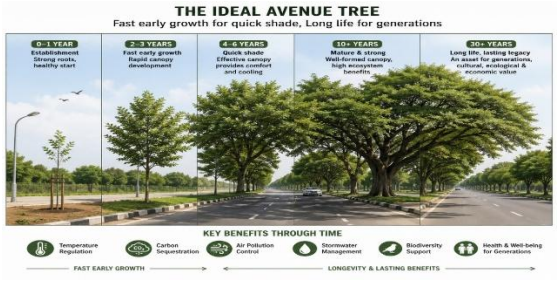

Figure 2. Species selection criteria

4. Trees Suitable for Urban Avenue Plantation

Urban roads demand species that can cope with pollution, restricted root space, and irregular maintenance (Kumar *et al*., 2019). Four species stand out across Indian cities:

Table 1. Recommended Urban Species

Scientific Name	Common Name	Key Characteristics
Delonix regia	Gulmohar	Ornamental tree with wide spreading canopy and bright seasonal flowers
Polyalthia longifolia	Mast Tree	Narrow, columnar crown; ideal for roads with limited space
Cassia fistula	Indian Laburnum	Attractive cascading yellow flowers; high aesthetic value
Neolamarckia cadamba	Kadamba	Fast-growing tree with dense canopy; provides good shade; culturally important

5. Trees Suitable for Rural Avenue Plantation

Rural roads offer more space and different priorities. Here, multipurpose trees that deliver timber, fodder, medicine, or non-timber forest products alongside shade are especially valued by local communities (Laxmanan *et al*., 2020).

Table 2. Recommended Rural Species

Scientific Name	Common Name	Key Characteristics
Azadirachta indica	Neem	Hardy, drought-tolerant; widely used in medicine and biopesticides
Tamarindus indica	Tamarind	Long-lived tree; produces fruit with strong economic and community value
Dalbergia sissoo	Shisham	High-value timber species; nitrogen-fixing; deep root system
Albizia lebbeck	Siris	Nitrogen-fixing; provides excellent shade; improves soil fertility for nearby farmland

CONCLUSION

Avenue plantations are not a luxury or an afterthought. They are green infrastructure assets as essential as the roads themselves. Every kilometre of tree-lined highway is a carbon sink, a cooling corridor, a biodiversity lifeline, and a source of beauty and well-being for the communities that live and move along it (Mandal *et al*., 2017).

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