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Urban Plant Diversity and Landscape Design: The Role of Native and Exotic Species in Sustainable Green Space Planning

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Abstract

The green city spaces are developed to support biodiversity, deliver ecosystem services, and enhance human wellbeing in rapidly urbanising areas. This review focuses on how urban plant diversity and landscape design add value to the environment and the respective roles of native and exotic species in sustainable greenspace planning. Based on landscape ecology, invasion biology, ecosystemservice assessments, and urban design studies, this paper demonstrates that plant origin strongly impacts spatial patterns like patch size, connectivity, and surrounding land use which in turn influence biodiversity and ecosystem function. Studies show that native plants supports greater native animal diversity and stronger food chains. Carefully selected, noninvasive exotic species can balance native flora by tolerating harsh urban conditions by adding diversity to structure of the ecosystem. However, invasive alien plants increase the greenness in surroundings but also lower the native species richness and leads to biotic homogenisation. A case study of Delhi-NCR shows that in rapidly urbanising cities rich native species diversity, widespread exotic species, and invasive species coexist under intense development pressure. It could be concluded that sustainable urban planning should focus on native plant species with judicial use of exotic species for multiscale landscape planning. Multifunctional ecosystem can be developed by combining robust native flora, noninvasive exotics and active invasivespecies control.

Key Words: Urban landscape, Homogenisation, Native and Exotic species, Biodiversity

Introduction

Urban green spaces are important infrastructure for both people and nature. They influence local climate, improve air and water quality, and provide soothing and healing environment under intense development pressure. The plant diversity and its distribution within these green areas determine the quality and resilience of the ecosystem. In present scenario, the concerns of relative roles of native and exotic species in sustainable greenspace planning is crucial. The question is whether we should focus on native plants only or should carefully manage mix of native and noninvasive exotic species more appropriate in stressful urban environments.

This review integrates current research on urban plant diversity, landscape patterns, and ecosystem services, with special attention to plant origin (native versus exotic). It integrates insights from landscape ecology, invasion biology, and design studies, and uses Delhi-NCR as a brief case study to ground global debates in the context of a rapidly urbanizing megacity in the Global South.

Urban biodiversity, landscape pattern, and homogenisation

Norton, Evans and Warren (2016) review how landscape ecology can guide urban biodiversity conservation, focusing mainly on European and UK cities as case contexts. The key problem identified by them is that the urban planning often treats green spaces as isolated amenities, while cityscale structure, fragmentation, and rapid landuse change drive biodiversity loss. They show that classic landscape rules (patch size, connectivity, heterogeneity) still govern species responses in cities, but are rarely applied systematically. As solutions, they propose multiscale, landscapeecologybased planning that enlarges and connects key habitat patches, integrates biodiversity with other urban functions, and uses GIS and connectivity tools in close collaboration with planners. McKinney (2006) argues that urbanization is a major driver of biotic homogenization, causing communities in different cities to become increasingly similar in species composition. He shows that standardized urban environments and frequent disturbance favour a limited set of urbanadapted species, including many nonnatives, while locally specialised native taxa decline. Empirical evidence across taxa indicates that with increasing urban intensity, native richness falls and nonnative richness and dominance rise, reducing beta diversity. McKinney concludes that conservation must openly counter homogenization by prioritising indigenous species, maintaining habitat heterogeneity along urban-rural gradients, and limiting the spread of widespread urban plant species. More recent work quantifies how surrounding landscape structure shapes diversity within individual sites. Ye et al. (2025) use street view imagery to derive plant diversity indicators for 40 green spaces and relate them to landscape metrics at multiple buffer distances around each site. They find that the composition and configuration of the surrounding urban landscape within roughly 1,000-1,500 m particularly the proportion of vegetated land and degree of fragmentation strongly influence plant diversity inside green spaces. This supports a multi-scalar view of urban biodiversity planning , species lists and planting designs at the site level are necessary but insufficient if the broader greenspace network is highly degraded or disconnected. Spontaneous vegetation adds further complexity. Ilie and Cosmulescu (2023) review the role of spontaneous (selfestablished) plants and argue that they form an integral component of urban floras, contributing to structural and functional diversity and providing ecosystem services such as soil stabilisation, pollinator support, and microclimate regulation. Spontaneous floras include both native and nonnative species, and their composition reflects management intensity, disturbance regimes, and surrounding propagule pressure.

Ecosystem services from urban vegetation

Urban plants support a wide array of ecosystem services that directly affect human health and quality of life. Saumel, Weber, and Kowarik (2016) show that roadside vegetation along urban streets like trees, shrubs, and verges provides multiple regulating, supporting, and cultural services precisely where people live and move. These include airpollution mitigation, temperature regulation, stormwater interception, noise reduction, habitat provision, and improvements in perceived safety, aesthetics, and walkability. Because street networks are dense and widely distributed, roadside vegetation has a disproportionate influence on everyday environmental quality. Broader reviews of vegetationbased ecosystem services confirm that diverse urban plant communities support microclimate regulation, carbon storage, hydrological regulation, recreation, and psychological wellbeing across

parks, streets, and other green spaces (Uppala et al., 2025). The same planting can therefore simultaneously advance climateadaptation goals and humanhealth outcomes if it is designed for multifunctionality.

However, not all vegetation contributes positively to longterm ecological resilience. Vila et. al. (2011) synthesised 199 studies in a global meta analysis and showed that invasive alien plants typically reduce the richness and abundance of native species while often increasing biomass and altering nutrient cycles. Although some ecosystem processes such as primary productivity may be enhanced, these gains often come at the cost of native community integrity and can drive long term shifts in ecosystem functioning. This shows that simply increasing green cover is not enough, the composition and ecological behaviour of plantings are critical.

Native versus exotic plant species

Native plants support richer and more stable ecological communities in urban areas because they attract more specific herbivores and maintain stronger food webs, especially for insects and birds (Kendal et al., 2012). They are well adapted to local climate and soil conditions, and once established, they usually require less maintenance and fewer inputs (Ignatieva et al., 2015). Native species also carry cultural and regional importance, which makes them valuable for sustainable landscape planning (Nassauer, 1995). For these reasons, they are often considered the foundation of urban biodiversity conservation and ecosystem service delivery (Aronson et al., 2016; Kowarik, 2011). At the same time, exotic plant species are very common in cities and are widely used in parks and ornamental landscapes, where they contribute to overall plant diversity and visual appeal (Hitchmough, 2011; Sjoman et al., 2016). In many cases, it is not practical to exclude all exotic species because urban environments require plants that can tolerate pollution, heat stress, climate change, and pest outbreaks (Sjoman et al., 2015; Alvey, 2006). Carefully selected non-invasive exotic species can provide useful functional traits, extend flowering seasons, and improve aesthetic value, which can increase public acceptance of green spaces (Kendal et al., 2012). The biggest risk is that some exotic species could become invasive, they spread rapidly and destroy native biodiversity while affecting ecosystem processes (McKinney, 2006; Vila et al., 2011; Pysek et al., 2020). These species are often difficult and costly to manage once established, and urban areas can act as sources for their spread into surrounding natural ecosystems. Some researchers argue that labelling all exotic species as harmful may create confusion in management practices, but excessive reliance on exotics can lead to biotic homogenization, where cities begin to share similar plant communities and lose ecological uniqueness (McKinney, 2006). Therefore, a balanced approach is recommended, where native species are prioritized, and non-invasive exotic species are included only when they provide clear ecological or functional benefits, supported by careful risk assessment and continuous monitoring (Sjoman et al., 2015).

Delhi-NCR as a case study

Delhi-NCR (National Capital Region) green spaces are examples of the patterns and tensions described above. Situated at the junction of semiarid and alluvial landscapes, the region hosts a rich native flora but has undergone rapid urban expansion. Around 272 plant species were documented across aquatic and terrestrial habitats, with Fabaceae, Poaceae, Asteraceae, Convolvulaceae, Amaranthaceae, and Malvaceae as dominant families (Tripathi and Sharma, 2025). Many species have medicinal and cultural significance but still face pressure from habitat loss, fragmentation, and pollution.

Bhalla and Bhattacharya (2015) compare green spaces in Lutyens' Delhi and newer settlements, revealing sharp differences in streettree diversity. Lutyens' Delhi, developed under a more generous spatial and planning regime, supports over a hundred avenue tree species and a structurally rich canopy. By contrast, Dwarka and

similar newer areas rely on a narrower palette dominated by a few hardy species, leading to more homogeneous streetscapes despite formal planning.

Field observations and local studies indicate that Delhi's parks, campuses, and residential colonies contain mixtures of native and exotic species. Native trees such *as Azadirachta indica, Ficus religiosa, Ficus benghalensis, Syzygium cumini,* and *Tamarindus indica* provide shade, nectar, fruit, and nesting sites, while also carrying strong cultural and religious associations (Bhalla and Bhattacharya ,2015, Tripathi and Sharma, 2025). At the same time, invasive alien plants such *as Lantana camara, Prosopis juliflora,* and some *Ipomoea* species have spread widely in disturbed lands and along infrastructure corridors, suppressing native understory floras and altering fire regimes and habitat structure (Tripathi and Sharma, 2025).

Delhi's biodiversity parks, established along the Yamuna floodplain and the Aravalli ridge represent deliberate efforts to restore native plant communities, remove invasives, and reestablish ecological processes. These initiatives align closely with evidence from invasion biology and landscape ecology: they prioritise native species, aim to create structurally complex habitats, and are clearly conceived as parts of broader ecological networks. In effect, they provide experimental grounds for testing nativedominated planting schemes under local socioecological constraints.

Management of greenspaces in Delhi-NCR gives opportunities and challenges to the implementation of policies in a large, resourceconstrained Global South megacity. Rich native floras and strong cultural attachment to certain species provide a foundation, but pressures from rapid development, water scarcity, and invasive species require adaptive management and sustained political commitment.

Design principles for sustainable greenspace planning

On the basis of above study, following principles for green space planning can be formed:

- **Native species should be prioritised as the structural and functional core**
  Native plants should form the majority of plantings in parks, biodiversity corridors, and ecologically sensitive areas. They tend to support higher native faunal diversity and maintain regional ecological and cultural identity.
- **Use noninvasive exotic plants strategically.**
  Nonnative plants can be valuable in harsh microclimates, for specific aesthetic goals, or where functional traits are scarce among natives. Their use should be justified, case by case, screened for invasion risk, and avoided near remnant natural habitats and biodiversity hotspots.
- **Plan at multiple scales simultaneously.**
  Site level planting design must be embedded within neighbourhood and city scale strategies that increase the amount, connectivity, and heterogeneity of green space. Surrounding landscape structure within at least 1-1.5 km of key sites should be considered in planning.
- **Spontaneous vegetation can be used wherever required.**
  Selective tolerance of noninvasive spontaneous species, particularly in lowvisibility or lowuse areas, can enhance habitat complexity and connectivity. Management should focus on early detection and removal of invasive taxa while allowing benign spontaneous floras to contribute.
- **Streetscapes should be multifunctional ecological spaces.**
  Roadside plantings should be explicitly designed for shading, pollutant capture, storm water

management, habitat provision, and human comfort, using structurally diverse, predominantly native plant palettes, especially in hot, polluted climates.

- **Socio-cultural dimensions should be looked upon while planning the greenspaces.**
  Planning must account for residents' preferences, cultural meanings of plants, and socioeconomic gradients that influence planting and maintenance. Participatory processes and public education on the benefits of native species can help align ecological and social goals.

Conclusions and future directions

Urban plant diversity and landscape design are central to reconciling biodiversity conservation, ecosystemservice provision, and human wellbeing in rapidly changing cities. The literature touches on several key points like native plants generally provide superior support for native fauna and ecological processes, noninvasive exotics can play complementary roles under certain conditions, invasive alien plants pose significant risks to native communities and contribute to biotic homogenisation, and spatial pattern patch size, connectivity, and surrounding land use strongly modulates these effects.

For regions like Delhi-NCR, these insights suggest that urban greening strategies should be built around nativedominated, structurally diverse plantings embedded within a connected greenspace network, supplemented by carefully vetted exotics, and supported by proactive invasivespecies management. Future research should prioritise longterm, experimental comparisons of native and nonnative plantings under real urban conditions, especially in the Global South, and develop practical tools for integrating plantorigin considerations into mainstream urban design and planning practice.

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