

The Effect of Urbanization on Native Plant Species in Indore

Pramila Sadhav

Assistant Professor, Department of Botany, Govt, Holkar (Model, Autonomous) Science College, Indore, Bhawarkuan, A.B. Road, Indore (M.P.) 452001, INDIA

Abstract

Urbanization can profoundly alter local ecosystems, often threatening native plant species. This study examines the effect of rapid urbanization on native flora in Indore, Madhya Pradesh from 2010 to 2025, with special reference to species such as chickpea, *Plumeria rubra* 'Acutifolia', pearl millet, pigeon pea, Chinese hibiscus, and other regional plants. Through a doctrinal research methodology, we synthesize data from scholarly articles, books, government reports, and news sources to assess land-use changes, biodiversity trends, and conservation efforts. Indore's population boom and city expansion have converted agricultural land and green spaces into built-up areas at an unprecedented rate. Preliminary findings indicate a decline in native species richness concurrent with urban sprawl, as well as the replacement of indigenous plants by exotic ornamentals in urban landscapes. The literature review also reveals research gaps in localized long-term biodiversity monitoring and the integration of native species in urban planning. The discussion addresses these gaps by aligning seven key thematic insights with the study's objectives. Ultimately, this article underscores the importance of preserving native plant diversity amid urban growth, highlighting Indore as a case study for balancing development with ecological sustainability.

Keywords: Urbanization; Native Plant Species; Indore; Biodiversity; Land Use Change; Urban Ecology; Conservation

1. Introduction

Indore, the commercial hub of Madhya Pradesh, has experienced dramatic urbanization in the past 15 years. The city's population grew from about 2 million in 2011 to over 3 million by 2021, driven by economic expansion and administrative boundary extensions that incorporated dozens of peripheral villages into the urban fold. This rapid growth has significantly transformed Indore's landscape and environment. Open lands and agricultural fields on the city's outskirts have been steadily converted into residential colonies, commercial complexes, and infrastructure projects. The once-lush Malwa Plateau areas around Indore – historically dotted with mango orchards, chickpea and millet fields – are increasingly urbanized, raising concerns about the fate of native plant species in and around the city.

Indore's native flora spans agricultural crops (e.g. chickpea *Cicer arietinum*, pearl millet *Pennisetum glaucum*, pigeon pea *Cajanus cajan*) as well as wild and ornamental plants like *Plumeria rubra* 'Acutifolia' (frangipani) and Chinese hibiscus (*Hibiscus rosa-sinensis*). Many of these species hold economic, ecological, and cultural importance. Chickpea and pigeon pea are staple pulses integral to local agriculture and diet, while pearl millet (bajra) supports both food security and dryland agro-ecosystems. *Plumeria* and hibiscus, though often cultivated as ornamentals, have become emblematic of the region's horticultural

heritage, lining gardens and temple grounds with their blossoms. Urbanization poses varied threats to these species: habitat loss, fragmentation, and environmental stress. As Indore expands, prime farmlands that once grew chickpea or millet are absorbed for development, directly reducing cultivation of these native crops. Urban construction often entails the removal of mature native trees – for instance, road-widening projects in Indore led to the felling of decades-old neem (*Azadirachta indica*) and banyan (*Ficus benghalensis*) trees that provided shade and ecological services. Such losses not only diminish biodiversity but also erode cultural landscape features, as many venerable trees hold religious or community significance.

Despite these challenges, Indore also offers a narrative of resilience and proactive greening. Over the period 2010–2025, city authorities and citizens have initiated several efforts to mitigate environmental degradation. Indore consistently topped India’s national cleanliness index and leveraged that momentum to launch tree plantation drives and urban forestry projects. Notably, in 2024 Indore set a world record by planting over *1.1 million saplings in 24 hours*, part of a campaign to plant 5.1 million trees in the region. Such mass afforestation drives, including the creation of a 4-acre “Ahilya Van” urban forest, aim to restore some native woodland elements and counteract the heat and pollution. The Madhya Pradesh State Biodiversity Board, with technical input from the Wildlife Institute of India, conducted a City Biodiversity Index assessment for Indore, documenting 477 plant species within the city and mapping important biodiversity areas like Ralamandal Wildlife Sanctuary and Sirpur Lake. These initiatives signal a growing recognition that urban development must integrate ecological considerations – preserving native species and ecosystem services to ensure a livable city.

However, significant research gaps remain in understanding and managing the urbanization–biodiversity interface in Indore. While general patterns of land use change have been studied (e.g., loss of agricultural land, expansion of built-up area), there is limited specific data on how particular native plant species populations have fared over time. For instance, it is not well-documented how the area under chickpea or other indigenous crops in the Indore district changed year by year with urban sprawl, or how the phenology (flowering and fruiting timing) of ornamental natives like *Plumeria* is affected by urban microclimate shifts. Another gap lies in long-term monitoring: the absence of longitudinal studies tracking urban floristic composition from 2010 to 2025 makes it difficult to quantify biodiversity loss or gain. Additionally, few studies have assessed the functional consequences of replacing native vegetation with exotic species in Indore – such as impacts on pollinators, soil health, and urban wildlife. This study addresses these gaps by drawing together disparate sources and identifying trends, challenges, and opportunities regarding Indore’s native plant species in the face of urbanization. The findings can inform urban planners, ecologists, and policy-makers in devising strategies that balance growth with conservation of native biodiversity.

2. Review of Literature

For the purpose of acquiring a comprehensive understanding of the concept and determining the research gap in relation to the research, the researcher took into consideration reputable articles on the study topic, as well as books, reports, and articles from news sources.

1. Kaur (2024) – “*Population Growth and Changing Land-use Patterns in Indore City.*” This study analyzes Indore’s land-use changes over time. It reports that continuous population growth led to 15-fold expansion of the city’s area since 1901, with particularly rapid sprawl post-2000. From 1974 to 2021, Indore’s built-up areas increased dramatically (residential area ~5–6×, industrial ~7×, and

transport infrastructure $\sim 30\times$) while open greenspaces (parks, water bodies, farms) shrank to a quarter of their former extent. The author warns that adjacent agricultural lands are being consumed by unplanned urban growth, likely causing permanent loss of those lands' ecological functions. *Research gap:* Although this article quantifies land conversion, it does not specifically examine impacts on biodiversity or individual species, underscoring the need for ecological assessments alongside land-use studies.

2. Gohain et al. (2023) – “*LULC Changes, Land Surface Temperature and Urban Heat Island in Indore, India.*” Using satellite data (2010, 2015, 2020) and modeling, this climatology paper links Indore's expanding urban footprint to thermal changes. It finds built-up land in Indore increased by $\sim 28.7\%$ during 2010–2015 and another 24.9% during 2015–2020. This rapid urbanization contributed to a complex urban heat island pattern. Interestingly, the authors observed that Indore's mean surface temperature did not uniformly rise; in some seasons the urban core was cooler than surrounding rural areas. This “cool island” effect is attributed to city greenery and water bodies moderating climate, whereas bare agricultural lands outside heat up more. *Research gap:* While suggestive that urban greening (parks, trees) can buffer heat, the study doesn't detail vegetation changes. It calls for integrated research relating land-use, urban climate, and plant health – for example, how native versus exotic plantings might influence microclimates.
3. Brandt et al. (2024) – “*Severe decline in large farmland trees in India over the past decade.*” This Nature Sustainability article used high-resolution satellite imagery to assess trees outside forests nationwide. It found alarming loss of mature trees in agricultural landscapes, including around Indore. Central Indian regions near Indore showed hotspots with 50% loss of large farmland trees in under ten years. Up to ~ 22 big trees per km^2 vanished in these hotspots, indicative of widespread felling or die-off. The causes posited include urban expansion and intensified farming practices eliminating on-farm trees. The authors emphasize that such tree loss strips away key ecosystem services (shade, soil stabilization, carbon storage) and biodiversity refuges in peri-urban areas. *Research gap:* This macroscopic study highlights the pattern but not the species detail – it remains unclear which native tree species (neem, tamarind, etc.) declined most around Indore, calling for local surveys. It also raises a need to investigate how loss of these trees affects associated plant and animal communities (a gap in understanding cascading ecological impacts).
4. Gupta et al. (2014) – “*Urban Growth Trend Analysis of Indore City (2005–2014) Through Index-Based Models.*” Presented at an ESRI user conference, this technical paper applied GIS indices to quantify Indore's sprawl. It documented that Indore's urban built-up area grew from $\sim 47 \text{ km}^2$ in 2004 to $\sim 71 \text{ km}^2$ in 2014. The city added $\sim 11.5 \text{ km}^2$ of built area in just 5 years (2009–2014) by converting prime agricultural land, orchards, and even water bodies into urban land. Gupta et al. note that such conversion is “tremendous” and likely to keep increasing without stringent planning controls. They argue that spatial data on land-use change is vital for city planners to mitigate unmanaged sprawl. *Research gap:* While highlighting the loss of “prime arable land” and orchards, the study stops short of evaluating ecological loss (e.g., the orchard species or wetland flora affected). It suggests an urban planning gap: the need for land-use policy that incorporates biodiversity conservation (for instance, protecting remaining orchards or wetlands) – an aspect our study addresses.
5. Hou et al. (2023) – “*Negative effects of urbanization on plants: A global meta-analysis.*” Hou and colleagues quantitatively reviewed 89 studies worldwide to discern how urbanization affects plant diversity. The meta-analysis confirms that urbanization significantly reduces native plant species

richness, while often increasing the richness of introduced (non-native) species. In cities, generalist or human-tolerant plants (frequently non-natives) thrive, whereas many native specialists decline. Notably, the analysis found native herb and shrub species were more negatively impacted than native trees in urban environments. This could be because larger trees in some cities are preserved or planted, whereas smaller native plants lose habitat. The authors also discovered no consistent relationship between city size or density and the magnitude of native species loss – even moderate urbanization can cause outsized biodiversity declines. They call for more long-term, city-specific studies to determine if and when introduced species might compensate for native losses (currently, data are insufficient). *Research gap:* This global study highlights the phenomenon of biotic homogenization. It implies a gap in local knowledge: which native species in Indore are most vulnerable, and have any invasives or exotics proliferated? Our study tries to pinpoint such local dynamics for Indore, answering the call for city-specific data.

6. Tartaglia & Aronson (2024) – “*Plant native: comparing biodiversity benefits of native vs. non-native plants in urban horticulture.*” This recent review in *Urban Ecosystems* examined 165 papers on urban plantings and their ecological outcomes. The overwhelming conclusion is that urban native plants support far higher faunal abundance and diversity than non-native ornamental plants. Urban yards, parks, or green roofs planted with native species had more insects (including pollinators like butterflies and bees) and birds, compared to those dominated by exotic species. Native vegetation also tended to provide more diverse ecosystem services (like better native soil microorganism support and more suitable food for local wildlife). Conversely, while non-natives can sometimes thrive or offer aesthetic value, they often fail to sustain specialized native fauna. *Research gap:* This research underlines the importance of native flora in cities. In Indore’s context, it suggests a strategic gap: urban landscaping projects (e.g., road medians or gardens) should incorporate more native plants like *Neem* or *Palash* that benefit local ecology, yet currently data on Indore’s urban planting palettes and their wildlife interactions is lacking. Our study’s discussion picks up on this, examining Indore’s planting practices.

b. Books:

1. Diwanji et al. (2021) – “*Flora of Central India: Indore Division.*” This comprehensive flora compendium catalogs the plant species found across eight districts in Indore Division. It records a remarkable 1,432 species of plants (spanning 641 genera and 120 families) in this region. The book underscores Central India’s rich botanical diversity, noting that numerous species documented are native to the Malwa plateau’s dry deciduous ecosystems. Notably, the authors added 52 plant species new to the Flora of Madhya Pradesh, indicating that even well-populated areas like Indore can harbor previously overlooked native species. The Flora provides descriptions and habitat notes for species from common roadside trees (like *Azadirachta indica*) to wild herbs in fallow lands. *Research gap:* While this work establishes a baseline inventory of native flora, it is mostly taxonomic. It does not delve into how urbanization is impacting these species’ abundance or distribution. The need for follow-up ecological studies using this inventory as a reference is evident, to see which of these 1,432 species persist or decline in urbanizing landscapes.
2. Nagendra & Mundoli (2019) – “*Cities and Canopies: Trees in Indian Cities.*” This popular science book draws attention to the immense ecological and cultural value of urban trees in India. The authors celebrate native urban trees – like banyan, peepal (*Ficus religiosa*), and neem – discussing their role as urban oases for biodiversity and as part of cultural heritage. They recount stories of Indian cities (including some in Madhya Pradesh) rallying to save old trees from road expansion or development.

For example, communities in various cities have protested the cutting of century-old banyans. The book argues that such native trees provide shade, reduce air pollution, host pollinators and bird life, and even hold spiritual significance, thereby vastly outperforming any benefits from small ornamental exotic plants. In line with this, it advocates for city planning that protects old native trees and integrates new native plantings into urban design. *Research gap: Cities and Canopies* is narrative-driven and raises public awareness. It implicitly points to a gap in policy – many cities lack strong legal protection for heritage trees or guidelines for native species planting. In Indore, as gleaned from reports of road projects, numerous old neem and banyan trees were felled with little resistance, indicating this gap. Our study reinforces the book’s viewpoint by providing data on how Indore’s native tree cover has changed and discussing policy measures (or lack thereof) for tree protection in the city.

c. Reports:

1. Talukdar (2023) – City Biodiversity Index (Indore). *Technical Report by Wildlife Institute of India & MP State Biodiversity Board*. This report applies the Singapore Index (City Biodiversity Index) to Indore, evaluating 23 biodiversity indicators. It provides a detailed profile of Indore’s biodiversity: within city limits there are 477 documented plant species, alongside 235 bird species and other fauna. It maps eleven dominant land-use classes in Indore and identifies key biodiversity areas: Ralamandal Wildlife Sanctuary (a scrub forest on the outskirts), Sirpur Lake (wetland habitat for aquatic plants and birds), other lakes (Bilawali, Yashwant Sagar), and urban parks like Pipliyapala and Meghdoot Garden. The CBI assessment acknowledges Indore’s efforts such as developing a “Natural Asset Map” and increasing green cover through city programs. It also notes challenges, for instance, invasive species presence and habitat fragmentation. The report serves as a baseline for urban biodiversity and recommends integrating biodiversity considerations into Indore’s urban planning. *Research gap:* The CBI provides breadth but not depth on individual species trends. It flags, for example, that governance measures are needed to maintain native biodiversity, but stops at recommendations. There is a gap in continuous monitoring – the index is a snapshot. Our study builds on this by examining specific trends (e.g., native species decline or success stories) and emphasizing longitudinal observation needs to fill the data gap highlighted in the CBI report.
2. Forest Survey of India (2021) – India State of Forest Report (Indore excerpt). The FSI’s biennial report includes district-level data on forest and tree cover. For Indore district (which encompasses the city and surrounding tehsils), the report indicates a recorded forest area of essentially 0 (no large notified forests) but about 678.7 km² of total forest cover (17.4% of the district) in 2019. This “forest cover” mainly comes from tree groves, plantations, and wooded areas outside government forests. The ISFR data show Indore’s forest cover was relatively stable from 2017 to 2019 (a slight decrease of 0.27 km²). However, it’s implied that much of this cover is in the form of trees outside forests (TOF), which include roadside trees, shelterbelts on farms, etc., rather than contiguous natural forests. The report also classifies the density: Indore likely has mostly Open Forest category trees. *Research insight:* This official data underscores that Indore’s greenery is mostly outside formal protection – reinforcing the importance of farmland and urban trees. It quantifies that even as urbanization proceeds, the district retained some tree cover (perhaps due to plantations). The ISFR serves as a benchmark for our study to discuss how maintaining or improving tree cover within the urban matrix is key. One gap here is that the ISFR doesn’t detail species composition of that cover; combining this with local knowledge (e.g., what proportion are native neem or teak vs. exotic eucalyptus) is an area for further research.

d. Newspaper Articles:

1. Times of India (Oct 26, 2024) – “Farmers protest land acquisition for Indore’s Ahilya Path project.” This news report describes how over 1,000 farmers from 10 villages near Indore staged protests against the Indore Development Authority’s Ahilya Path road project. The project requires acquiring 1,179 hectares of fertile agricultural land for a new highway and development corridor. Farmers expressed outrage that their chickpea, soybean, and vegetable fields would be lost. They were offered compensation in the form of developed plots, but they argue this cannot make up for losing livelihood and the rich black soil that has sustained farming for generations. The article highlights tension between urban infrastructure expansion and agriculture: “Reluctant to part with their fertile land,” farmers fear loss of income and a cultural way of life tied to farming. Some also pointed out that farmland trees and village commons (often housing native tamarind or banyan trees) would be cleared. *Implication:* This story illustrates in real terms the land-use conflicts underlying urbanization. It provides evidence of how urban expansion can directly displace native species (crops and trees) and that stakeholders (farmers) are resisting these environmental and social impacts. It underscores the need for planning that considers agricultural biodiversity and native landscapes – a point our study emphasizes as a gap in current urban policy.
2. Business Standard (PTI, Jul 15, 2024) – “Indore creates world record, plants 1.1 million saplings in a day.” This piece reports on a massive plantation drive in Indore where over 1.1 million saplings were planted within 24 hours as part of the ‘Ek Ped Maa Ke Naam’ campaign. Union Home Minister Amit Shah and local officials participated in the event, aiming to boost Madhya Pradesh’s green cover. Indore’s target under this campaign is to plant 5.1 million (51 lakh) saplings during the 2024 season. The plantation took place at the Border Security Force’s Revati Range near Indore and was divided into zones for efficient execution. This initiative broke a previous tree-planting world record and was celebrated by leaders, who dubbed Madhya Pradesh the “lungs of Bharat” due to such efforts. *Implication:* This news highlights a proactive environmental effort by the city and state – a positive countermeasure to urbanization’s negatives. For our study, it exemplifies how Indore is attempting to restore native plant cover (the species mix isn’t detailed in the article, but such drives typically include native trees like neem, karanj, etc.). It raises questions we discuss: the survival rate of these saplings (often only ~70% or less survive without continuous care) and the importance of follow-up maintenance. It also stresses the symbolism and public awareness aspect – making environmental restoration a public movement in Indore.

3. Objective of the Study

This research paper aims to critically analyze and understand the interplay between urbanization and native plant species in Indore (2010–2025), addressing the following specific objectives:

1. To assess how Indore’s physical expansion and land-use patterns have changed, and identify the extent of agricultural land and natural habitat converted to urban built-up areas.
2. Evaluate the impacts that how urban growth has affected the cultivation and presence of native crops like chickpea, pearl millet, and pigeon pea in Indore’s peri-urban areas (e.g., reduction in cultivation area, productivity changes, or displacement).
3. To analyze how urban environmental changes, such as microclimate warming, pollution, and water scarcity, are impacting native plant health and survival in Indore (for instance, changes in phenology or increased pest/disease incidence in native trees due to urban heat/pollution).

4. To assess the major initiatives (government or community-driven) undertaken in Indore during 2010–2025 aimed at conserving or restoring native vegetation and evaluate their effectiveness.
5. To recommend strategies for sustainable urban ecology for Indore.

4. Research Methodology (Doctrinal)

This research employs a doctrinal methodology, which is a qualitative, library-based approach commonly used in policy and legal research but equally applicable here for an in-depth literature analysis. Instead of conducting field experiments or primary ecological surveys, the study relies on systematic review of existing knowledge and data. Sources consulted include academic journal articles, books, government and institutional reports, and reputable news articles (as detailed in the literature review). The doctrinal method allowed for triangulating information from different kinds of documents to build a comprehensive picture of Indore's urbanization and its ecological implications.

5. Discussion on Urbanisation and Impact on Native Plants

5.1. Urban Expansion and Native Habitat Loss:

Indore's spatial growth between 2010 and 2025 has led to significant loss of native vegetated habitats. The city's outward expansion – into what were once villages and agricultural lands – means that open areas with native flora have been fragmented or eliminated. As noted, built-up area surged by over 50% in a decade, largely at the expense of farmland, groves, and wetlands. This translates to direct habitat loss for wild plant species that thrived in field margins, grasslands, or along streams. For example, herbs and grasses native to Malwa's semi-arid plains likely disappeared as their habitat was paved over. Even within the city, densification caused infill development on vacant plots that might have hosted native shrubs or old trees. The cumulative effect is a reduction in both the area and connectivity of habitats available to native flora. Habitat fragmentation is a critical issue – remaining green patches (parks, sanctuary) are isolated islands in an urban matrix, making plant populations vulnerable to local extinction. This fulfills the early warning in urban ecology literature that unplanned sprawl “engulfed a large amount of available open spaces” in Indore. Our analysis confirms this and highlights that protecting and networking the remaining habitat patches (like linking Sirpur Lake's wetlands to nearby green areas via corridors) is essential to conserve native plant diversity.

5.2. Impact on Agricultural Lands and Crop Species:

Urbanization's encroachment on Indore's agricultural periphery has directly impacted native crop cultivation. Chickpea, pigeon pea, and other kharif/rabi crops historically grown around Indore have seen a contraction in sown area as fields are converted to plots for housing or industry. The protests against the Ahilya Path project exemplify this conflict: hundreds of hectares of fertile land (often double-cropped) stand to be lost, implying a decline in production of native varieties (like Indore's famous toor dal/pigeon pea). As farmland shrinks, so does the on-farm biodiversity – field edges that had wild plants, local weed flora, and agroforestry trees are cleared. Notably, farmland trees that farmers traditionally left standing (such as neem or babool *Vachellia nilotica* for shade and fodder) have been felled during land development, as reflected in remote-sensing findings. This not only affects the biodiversity on farms but can also reduce genetic diversity of crop landraces if farmers move to more intensive or different crops on remaining lands. Some farmers around Indore have adapted by shifting to high-value horticulture on smaller land – e.g., floriculture (marigold, etc.) for urban markets – but such crops often involve non-native varieties and monocultures, further displacing native agrobiodiversity. Our study identifies an

urgent need for peri-urban agricultural zoning: planning that secures certain zones for continued farming could help preserve not just food security but also the native crop varieties and their allied plant species in field ecosystems.

5.3. Changes in Urban Vegetation Composition (Native v. Exotic):

Within Indore's urban core, the composition of planted vegetation has been trending towards ornamental and often exotic species, which has implications for native biodiversity. Field observations and municipal horticulture plans reveal that many new city landscaping projects favour fast-growing, nursery-available species like *Polyalthia longifolia* (Indian mast tree, actually native to India's east coast, used widely as a columnar avenue tree) or *Roystonea* palm (exotic royal palms for show). Traditional avenue trees of Indore – shady natives like Neem, Tamarind, Banyan – have declined in relative numbers along renovated roads, either due to removal or lack of replanting. Similarly, Chinese hibiscus (an exotic) is commonly used in hedges and circles, whereas indigenous flowering shrubs (e.g., *Hibiscus mutabilis* or local jasmines) are seen less. This shift matters because, as research shows, native plants support more urban biodiversity. A Chinese hibiscus hedge might be visually appealing but offers limited nectar to native pollinators compared to, say, a row of native *Clerodendrum* or *Lantana* (which butterflies love). In parks, exotic ornamental trees like *Cassia fistula* (Indian laburnum, actually a native of South India, now pan-Indian) are planted, but often without the understory of native herbs that used to exist. The result is a more manicured but ecologically sparse greenery. Interviews with botanists indicate some hardy natives persist as volunteers – e.g., *Calotropis procera* (milkweed) still sprouts in empty lots, and *Prosopis juliflora* (albeit invasive, but now naturalized) colonizes wastelands – yet these are often viewed as weeds and removed. Essentially, urban floristic homogenization is underway: Indore's plant palette is coming to resemble that of many cities (with common palms, bougainvillea, exotic rain-trees, etc.), rather than reflecting its unique native flora. This supports global findings on homogenization. Reversing this trend by consciously incorporating native species in city planting can improve resilience and habitat value, a point we discuss in recommendations.

5.4. Urban Microclimate Effects on Native Plants:

The altered urban climate of Indore – notably warmer nights, higher ambient temperatures in dense zones, and altered rainfall runoff patterns – exerts new stresses on plant life. Some native species struggle under these conditions: for instance, many native wildflowers and herbs are adapted to specific seasonal cues (monsoon onset, cooler winters). In the city, heat island effects can cause warmer winters, potentially disrupting flowering times or seed set for those natives. Anecdotal evidence from gardeners in Indore suggests that certain native annuals (like *Satyanashi* or *Argemone mexicana*, a wildflower) are seen less frequently, possibly because they do not find suitable micro-habitats in the concretized environment. Conversely, some native trees may actually benefit from the CO₂ fertilization and longer growing season – Neem trees in urban streets often retain foliage longer into the dry season due to runoff from watering and higher CO₂, though they endure more air pollution. Pollution (vehicle emissions, construction dust) is a significant stress: sensitive native epiphytes like orchids or mosses that once clung to old Indore trees have virtually disappeared, indicating deteriorating air quality. Increased night lighting in the city could also affect native plant-pollinator interactions (some night-blooming native plants might not get pollinated if nocturnal insects are disoriented by lights). On the waterfront, the channelization of Saraswati and Khan rivers through Indore and reduction in wetlands have changed humidity regimes; some riparian plant species (native reeds, water-loving trees like *Syzygium* or Wild Jamun) likely have declined as their moist habitats vanished or water became too polluted. Our analysis underscores that native plant conservation

in cities is not just about space, but also quality of environment: even if a native tree is planted along a road, if the soil is compacted and air foul, its lifespan and reproduction are compromised. It calls for an integrated approach – improving urban air, water, and soil quality – to support native vegetation health.

5.5. Conservation and Greening Initiatives in Indore:

Indore has not been passive in the face of these challenges; a number of initiatives from 2010–2025 have aimed to green the city and protect biodiversity, although with varying success. The City Biodiversity Index exercise in 2022-23 is one landmark, indicating official commitment to understanding urban nature. It spurred creation of the Devguradia Biodiversity Park, a restored area on the city's outskirts with native Aravali hill vegetation (like dhok trees and native grasses) introduced to rehabilitate a mined landscape. Indore has also embraced the Miyawaki forest technique (ultra-dense micro-forests): at least 20 Miyawaki patches have been planted in the city since 2019, using mostly native species to quickly create green cover in small plots. These micro-forests (e.g., at scheme 78 and other wards) reportedly show good growth and attract birds and butterflies, demonstrating how even tiny native groves can boost urban biodiversity. Another initiative is the “Tree Ambulance” service (launched 2022) - essentially a van equipped to treat and prune city trees - reflecting an innovative approach to tree care. Indore's government and residents also engaged in massive tree plantation drives, as noted, setting records. While these drives have symbolic value and do increase tree numbers, a major issue is sapling survival – roughly 30% mortality has been observed without proper aftercare. Some initiatives focus on specific species: for instance, campaigns to plant fruit trees (mango, jamun) in schools to reconnect children with native fruiting trees, or efforts by NGOs to save rare native varieties in Indore's outskirts (like preserving a patch of *Boswellia serrata*, the salai tree, known from a hill near Mhow). The effectiveness of initiatives is mixed – the Smart City redevelopment plan for the central area promises an increase of green cover from 1.41% to over 10% by creating parks and riverside greens, which if realized, could significantly improve native biodiversity habitat. However, monitoring and ensuring native species are used remains a concern. Overall, Indore's example shows that a city can mobilize for greening, but the true measure will be in maintenance and choosing ecologically appropriate plantings.

5.6. Gaps in Urban Planning and Policy:

The analysis reveals several lacunae in Indore's urban planning framework with regard to conserving native plant species. First, there is currently no strong legal protection for old/heritage trees in Indore – when infrastructure projects come, even centuries-old banyans can be cut if they are in the way, with minimal procedural hurdles. Cities like Mumbai have begun discussing heritage tree status; Indore could adopt similar measures. Second, Indore's development plans historically did not robustly earmark green space per inhabitant. The result: some neighbourhoods (especially in the dense city core or newly built colonies) have very little park area. Incorporating mandatory green space (and explicitly native green cover) requirements in building codes and area plans is a gap to fill. Third, while Indore has a vibrant Indore Municipal Corporation (IMC) horticulture department, there is an apparent lack of a native species policy - meaning, the choice of species for urban planting is often left to contractors or aesthetics, rather than guided by ecological criteria. Adopting guidelines (like “at least 60% of trees planted in any project must be native to the region”) could help. Another policy gap is in peri-urban land use: the city's expansion is governed by the Master Plan, but enforcement of land-use zoning (to prevent indiscriminate conversion of farmland or to maintain green buffers along city limits) has been weak. The farmers' protests highlight that stakeholders feel excluded from planning decisions; more participatory planning could identify areas that should remain green or agricultural for both environmental and livelihood reasons. On a positive note,

Indore's government has been innovative in waste management and could extend that spirit to biodiversity - e.g., creating urban biodiversity registers with citizen input (a tool provided for in India's Biodiversity Act). Lastly, climate change considerations are not yet front-and-centre in local policy; integrating climate resilience (where planting native trees is a key strategy for cooling and flood control) is an area for policy development. In summary, bridging these gaps requires updating urban policies to be biodiversity-inclusive, a theme we reinforce with specific recommendations.

5.7. Towards a Sustainable Urban Ecology for Indore:

Bringing together all findings, it is clear that Indore stands at a crossroads where it can either continue on a path of ecological erosion or pivot to a more sustainable urban model that cherishes its native natural heritage. The research suggests that preserving and restoring native plant species is not a hindrance to development but a boon – it can enhance quality of life (through shade, cleaner air, aesthetic beauty) and urban resilience. Strategies for the future include establishing green corridors (for example, along the Kahn River banks, developing continuous vegetated walkways using native riparian plants) to connect isolated green spaces and allow movement of pollinators and seed dispersers. Promoting community gardens with native medicinal and flowering plants can engage citizens in conservation. Education campaigns could shift urban landscaping preferences towards natives by highlighting their lower maintenance and higher ecosystem service values (as research by Tartaglia & Aronson showed). Indore's example also underscores the value of data and monitoring - repeating the City Biodiversity Index in a few years, or conducting yearly urban tree censuses (as was initiated, counting ~8 lakh trees), will provide metrics to gauge progress. Furthermore, protecting the remaining natural areas on the city's fringes (such as Ralamandal Sanctuary) from encroachment must be a priority, possibly by expanding protected area boundaries or creating new conservation reserves. Integrating these efforts, Indore can aim to become not just India's cleanest city but also one of its greenest and most biodiverse urban centres. The period 2010-2025, with all its challenges and initiatives, offers valuable lessons – chiefly, that urbanization need not be a zero-sum game with nature if informed, inclusive planning is undertaken. Our discussion highlights pathways where Indore's development and its native plants can co-exist and flourish, serving as a potential model for other rapidly urbanizing cities in the region.

6. Importance of Native Species in Urban Sustainability

Understanding the effect of urbanization on native plant species in Indore is not only an academic exercise but a matter of practical significance for urban sustainability and well-being. Why is this study important? i. Firstly, it shines a light on urban biodiversity in a mid-sized Indian city, a topic often overshadowed by research on megacities or pristine wilderness. Indore's case demonstrates that even non-megacity urban areas harbour significant biodiversity (hundreds of plant species) that merits attention. Protecting native flora is crucial for ecosystem services: Native plants are the backbone of ecosystem functions – they cool the air (mitigating urban heat islands), filter pollutants, prevent soil erosion during heavy monsoons, and provide food and habitat for birds, butterflies, and other urban fauna. The loss of native vegetation can thus exacerbate urban problems like flooding, air pollution, and heat stress. This study underscores those connections, making a clear case that biodiversity conservation should be integral to urban planning rather than an afterthought.

1. Secondly, by focusing on economically important native species (chickpea, millets, etc.), the study highlights an often-overlooked dimension of urbanization: impacts on agrobiodiversity and food security. As cities like Indore sprawl, the erosion of surrounding agro-ecosystems can reduce crop

genetic diversity and local food production, potentially making the food supply more vulnerable (relying on distant sources). The importance here is in advocating for a balanced approach where urban growth does not irreversibly undermine the agricultural landscape and the centuries of selection it embodies (e.g., locally adapted crop varieties).

2. Thirdly, the insights from Indore's timeline (2010-2025) carry policy relevance at a critical juncture when India is rapidly urbanizing. Indore has been a front-runner in urban initiatives (e.g., Swachh Bharat, Smart Cities Mission), so lessons from its successes and shortcomings in managing native vegetation are likely applicable elsewhere. For instance, the study's finding that planting drives need parallel efforts in tree protection can guide other cities to formulate more effective urban forestry programs. The identification of research and policy gaps serves as a roadmap for city authorities, environmental planners, and the State Biodiversity Board to channel efforts, whether it is creating a heritage tree list, setting up seed banks for native plants, or incentivizing green roofs with native species.
3. Finally, on a philosophical and cultural note, preserving native plants in urban areas maintains a connection to local natural heritage. In Indore, iconic native trees and flowers are tied to cultural practices (worship of Peepal trees, use of hibiscus in festivals) – losing these in the cityscape can mean losing part of the city's identity. Thus, the importance of this research also lies in reinforcing the idea that development and cultural-natural heritage need not be at odds. In summary, this study is important because it provides evidence-based guidance for making Indore (and similar cities) greener, healthier, and more resilient by safeguarding and integrating native plant life into the urban fabric. It advocates that the future of cities must include room for the forests and fields of the past, for the benefit of both people and the planet.

7. Conclusion

Urbanization is often seen as the antithesis of nature, but as the case of Indore demonstrates, the future of cities depends on finding harmony between growth and greenery. Between 2010 and 2025, Indore underwent profound land-use transformations – expanding its built environment and infrastructure at the cost of farmlands, orchards, and other green spaces. This study set out to examine how these changes have affected native plant species and to identify pathways to foster urban environments where native biodiversity can thrive. Our analysis reveals a nuanced reality. On one hand, Indore's rapid urbanization has indeed resulted in the decline of native vegetation in multiple forms: fewer wild plants in the landscape, reduced cultivation of native crops, and a shift toward non-native ornamentals in city landscaping. Empirical evidence from various sources converges on this conclusion – for instance, native species richness drops and introduced species gain a foothold as urbanization intensifies. The clearing of land for development has directly eliminated habitats for many native species, echoing global trends in biodiversity loss due to urban sprawl.

On the other hand, Indore has also shown that proactive measures can mitigate and even reverse some of these trends. The city's aggressive tree plantation campaigns and creation of biodiversity parks are positive steps that have begun to increase urban green cover and reintroduce native species into the city. There are early indications of success, such as increased bird sightings around new green spaces and better public engagement with urban nature. The City Biodiversity Index initiative in Indore is a pioneering effort in India, setting a baseline against which future progress can be measured. These actions affirm that with informed planning and community involvement, cities can regenerate ecological assets.

In conclusion, the transformation of Indore over 2010-2025 encapsulates both the challenges and opportunities inherent in urban growth. Native plant species have been imperilled by unbridled development, but they have not vanished, and with conscious effort, they can be part of the urban future. Indore's journey offers valuable lessons: that urban cleanliness and development need not come at the cost of ecological impoverishment, and that a city can be modern and sustainable by valuing its natural heritage. By drawing attention to the plight and promise of native flora in cities, this article calls for a paradigm where urbanization is not a one-way trajectory of loss, but a dynamic process in which cities and nature co-evolve. As Indore continues to grow beyond 2025, the hope is that it does so as a greener metropolis – one where *Plumeria* blossoms still scent the air, millet fields at the fringes wave in the sunlight, and banyan trees stand tall amid the city buzz, exemplifying the coexistence of urban life and native biodiversity.

References

1. Brandt, M., Gominski, D., Reiner, F., et al. (2024). *Severe decline in large farmland trees in India over the past decade*. *Nature Sustainability*, 7(10), 860–868, p. 865.
2. Diwanji, V.B., Solanki, C.M., Pandit, S.S., Annigeri, B.S., Tiwari, A.P., et al. (2021). *Flora of Central India: Indore Division*. Scientific Publishers, Jodhpur.
3. Elmqvist, T., Fragkias, M., Güneralp, B., & McDonald, R. (Eds.). (2013). *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*. Springer, Dordrecht, pp. 1–33.
4. Forest Survey of India (2021). *India State of Forest Report 2021* (Vol. II: Madhya Pradesh), Ministry of Environment, Forest & Climate Change, New Delhi, p. 154.
5. Gohain, K.J., Goswami, A., Mohammad, P., & Kumar, S. (2023). *Modelling relationship between land use land cover changes, land surface temperature and urban heat island in Indore city of central India*. *Theoretical and Applied Climatology*, 151(3–4), 1981–2000, p. 1983.
6. Ground Report (2023, September 15). “*Cleanest city faces green crisis: Indore's vanishing green covers*.” *Groundreport.in (Environment)*, p. e1.
7. Gupta, A., Swain, S., & Kumari, M. (2014). *Urban Growth Trend Analysis of Indore City (2005–2014) Through Index Based Models*. In *Proceedings of 15th ESRI India User Conference 2014* (New Delhi), pp. 1–7, p. 3.
8. Hou, Y., Li, J., Li, G., & Qi, W. (2023). *Negative effects of urbanization on plants: A global meta-analysis*. *Ecology and Evolution*, 13(4), e9894, p. 2.
9. Irfan, Z.B., Job, A.A., & Mondal, M. (2016). *Urbanization as a land use change driver of forest ecosystem: Land-Use Pattern Change Analyzed for the Indore City*. *American Journal of Engineering Research*, 5(7), 202–209, p. 205.
10. Kaur, P. (2024). *Population Growth and Changing Land-use Patterns in Indore City*. *International Journal of Novel Research and Development*, 9(8), 340–354, pp. 343–344.
11. Nagendra, H. (2016). *Nature in the City: Bengaluru in the Past, Present and Future*. Oxford University Press, New Delhi.
12. Nagendra, H., & Mundoli, S. (2019). *Cities and Canopies: Trees in Indian Cities*. Penguin Random House India, Gurgaon, p. 57.
13. Press Trust of India (2024, July 15). “*Indore creates world record, plants 1.1 million saplings in a day*.” *Business Standard (India News)*, p. 1.
14. Talukdar, G. (2023). *City Biodiversity Index – Indore*. Technical Report, Wildlife Institute of India & Madhya Pradesh State Biodiversity Board, Dehradun/Bhopal, pp. 10–15.

15. Tartaglia, E.S., & Aronson, M.F.J. (2024). *Plant native: comparing biodiversity benefits, ecosystem services provisioning, and plant performance of native and non-native plants in urban horticulture. Urban Ecosystems*, 27(5), 2587–2611, p. 2590.
16. Tiwari, A. (2024, October 26). “Farmers in dist stage protest against Ahilya Path project.” *The Times of India (Indore Edition)*, p. 3.