**Urban Natural Capital: A Review of Green Space Benefits, Governance Challenges, and Sustainability Pathways**

**Abstract**

Rapid urbanisation has intensified the demand for sustainable city planning, placing natural capital,particularly green infrastructure,at the forefront of resilience-oriented development. This review critically examines the multifaceted contributions of vegetated spaces across ecological, societal, and economic domains. By synthesising international and India-specific literature, including empirical studies from Delhi, Durg, Bilaspur, and Bengaluru, the paper highlights how urban landscapes regulate climate, enhance biodiversity, and support public health and fiscal stability. Key analytical tools such as carbon stock modelling, GIS mapping, and perception surveys reveal the complexity and benefits of integrating ecological systems within urban form. The review also examines governance challenges and spatial inequities that hinder equitable access and long-term viability, advocating for the operationalisation of green infrastructure, Nature-Based Solutions, and SDG-aligned planning. The findings underscore the strategic value of natural systems as actionable assets in shaping climate-adaptive and socially inclusive urban futures.

***Keywords:***Biodiversity, Climate Resilience, Ecosystem Services, Environmental Governance, Green Infrastructure, Natural Capital, Urban Planning

1. **Introduction**

Natural capital refers to the stock of natural resources, plants, soil, and water that support life in cities. The unprecedented pace of urban expansion is reshaping environmental and societal landscapes worldwide. In 2018, 55% of the world's population resided in cities, and by 2050, that percentage is expected to rise to 68%, according to the UN DESA (2018). The majority of this growth is likely to occur in developing nations, presenting both opportunities and challenges for sustainable development (Hang *et al*., 2023). Ecological degradation, increasing pollution, and the growth of slums are common outcomes of rapid urbanization (Humbal *et al*., 2023). In India specifically, 34.5% of the population resided in urban areas as of 2019, and this figure is projected to grow at a rate of 2% annually until 2050 (UNCTAD, 2020; The World Bank, 2021).

Although urbanisation fosters economic growth and innovation, it also strains natural ecosystems, leading to a host of issues for the environment, society, and public health (Bai *et al*., 2017). Permeable, vegetated surfaces are replaced with impermeable, heat-retaining materials, which drastically alter urban microclimates and exacerbate issues like air pollution, biodiversity loss, and urban heat islands (ADB, 2015; Jiang *et al*., 2018; Soltanifard, 2024).

As a result, the notion of natural capital has evolved as an essential component of sustainable urban development. The stock of ecosystems, such as plants, soil, and water, that provide a variety of products and services necessary for human well-being is referred to as natural capital. Urban forests, public parks, wetlands, gardens, green roofs, and street trees are examples of urban green spaces (UGS) and green infrastructure (GI), which are the main manifestations of this capital in urban areas (Miakhel*et al*., 2024). Beyond ecological sustainability, these landscapes offer a range of benefits, including social well-being, mental health, climate resilience, and economic vitality (Athokpam *et al*., 2024; Yi *et al*., 2025).

UGS serve as urban lungs, sequestering carbon, cooling overheated areas, filtering pollutants, and promoting biodiversity(Hansen & Macedo, 2021).Urban vegetation, for instance, can store up to 1.6 tons of CO₂ per hectare annually and lower local air pollution levels by up to 30%, according to Athokpam *et al*. (2024). Additionally, UGS can significantly lower the risks of heat-related illnesses by lowering urban temperatures by 2°C to 4°C through evapotranspiration and shade delivery (Sanju, 2025).

UGS have significant social and psychological advantages in addition to their ecological functions (Palliwoda *et al*., 2024). Particularly for children, the elderly, and marginalised groups, having access to inclusive, well-designed green spaces promotes social contact, physical activity, and stress reduction (Yi *et al*., 2025; Kasim *et al*., 2019). In addition, public areas serve as civic and cultural centres where locals interact with one another and take part in stewardship initiatives, enhancing community solidarity (Athokpam *et al*., 2024; Sen & Guchhait, 2021).

Green areas have an economic impact on property prices, tourism, and public health by reducing pollution-related illnesses and heat-induced hospitalisations (Athokpam *et al*., 2024). They also promote green employment and urban agriculture, emphasising the diverse character of urban ecosystem services.

Even with all of these benefits, UGS is still not evenly dispersed throughout metropolitan environments. High-quality green infrastructure is frequently more difficult to obtain in low-income and marginalised neighbourhoods, which exacerbates patterns of environmental injustice (Iungman *et al*., 2023). Furthermore, obstacles such as a lack of community involvement, institutional fragmentation, underfunding, and a shortage of land make it difficult to sustain and grow UGS (Paulin *et al*., 2020).

There is increasing agreement that natural capital needs to be at the heart of future-ready cities, since urban areas are becoming the frontlines of both climate vulnerability and innovation. (UN ESCAP, 2022). The strategic integration of green infrastructure into building codes, zoning policies, and resilience frameworks is a necessary step in urban planning that goes beyond ornamental greening (Nor & Shahrir, 2024; Athokpam *et al*., 2024).

While numerous global studies emphasise the ecological and social value of UGS, most overlook the India-specific governance challenges, spatial inequities, and planning gaps that hinder equitable integration. This review investigates the broad-ranging value of urban green spaces (UGS) as integral expressions of natural capital within urban environments. It focuses on three key goals: first, to assess and synthesize the ecological, social, and economic benefits of UGS; second, to investigate the mechanisms by which green infrastructure contributes to sustainable urban development, climate resilience, and public health improvement; and third, to examine the governance-related barriers, spatial inequities, and policy opportunities that influence the equitable planning, distribution, and long-term integration of UGS.

1. **India-Specific Case Studies: Insights into Urban Green Space Research**

This review explores the ecological and social dimensions of urban green spaces (UGS) as integral components of natural capital. Studies were selected through a structured review of literature focused on ecosystem services, urban sustainability, green infrastructure, and public space planning.

To represent the Indian urban context, case studies from cities such as Delhi, Chandigarh, Mumbai, Nagpur, Bhopal, Bengaluru, Ahmedabad, Bilaspur, and Durg, etc. have been included. These studies applied varied methodssuch as geospatial tools, restoration monitoring, perception surveys, and biodiversity assessmentsto examine UGS performance, accessibility, and ecological outcomes across different urban settings.

**Table 1. India-Specific Urban Green Space Case Studies: Tools, Focus, and Insights**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **City** | **Method Used** | **UGS Focus Area** | **Key Analytical Insights** | **Citation** |
| 2024 | |  | | --- | |  |   Durg | Ecological Restoration Monitoring | Wetland Biodiversity Park restoration | 66% drop in TVOCs, 58% PM10 reduction, 27,782 MT carbon stored, 398 species documented | Maitry*et al*., (2024) |
| 2024 | Delhi | i-Tree Eco Model | Roadside vegetation in industrial zones | PM2.5 and CO2  reduction; vegetation functions as urban lungs | Vashist *et al*., (2024) |
| 2023 | Bhopal | Visitor Perception Survey | Biodiversity parks and social outcomes | Positive community response; high perceived ecological value | Sirsikar (2023) |
| 2023 | Tezpur | Remote sensing & regression analysis | Urban blue-green space & UHI mitigation | NDVI ↓, LST ↑ (1993–2023); negative NDVI–LST correlation; Brahmaputra river buffers UHI | Hazarika *et al*., 2023 |
| 2022 | Bilaspur | Quadrat-Based Diversity Assessment | City-wide tree species distribution | 60 species across 22 families; Shannon Index of 3.32 signifies rich biodiversity | Singh & Tiwari (2022) |
| 2022 | Rohtak | Tree inventory and diversity indices | Campus TOF and ecosystem services | 66 species, 35K+ trees; 60% native; key services:shade, ornamental, medicinal; diversity index 2.51 | Nandal *et al*., (2022) |
| 2021 | Bardhaman | Surveys and statistical analysis | Visitor perceptions of cultural ecosystem services | CES linked to place attachment, green proximity aids well-being | Sen & Guchhait, 2021 |
| 2021 | Nagpur | POSI Framework | Public open space equity | Revealed UGS access disparity across wards | Ahirrao & Khan (2021) |
| 2020 | Mumbai | Remote sensing & GIS analysis | Spatio-temporal UGS change | Green cover declined from 46.4% to 26.7% (1988–2018); ↑ LST, ↓ NDVI & LAI | Rahaman *et al*., 2020 |
| 2020 | |  | | --- | |  |   Hyderabad | Park visitor interviews and surveys | Equity in ecosystem services access | Parks foster well-being but access is uneven; user fees and safety limit low-income/women visitors. | Basu & Nagendra, 2021 |
| 2019 | Bengaluru | Field inventory & NMDS analysis along rural–urban gradient | Tree species diversity & composition | 92 species across 23 plots; diversity ↓ with distance from city centre; urban areas richer in exotics | Jha *et al*., 2019 |
| 2019 | Ahmedabad | MODIS LST analysis & field survey | SUHI dynamics in semi-arid cities | Negative SUHI in summer daytime; rural LST > urban due to bare croplands; SUHI footprint expanding | Mohammad *et al*., 2019 |

1. **Multidimensional Contributions of Urban Green Spaces**

Urban green spaces (UGS) serve as dynamic components of natural capital, offering multifaceted benefits that span ecological balance, societal well-being, and economic resilience. This section analyses how UGS contribute across these three core dimensions, each vital to shaping climate-resilient, equitable, and livable urban environments.

**3.1 Ecological Contributions of Urban Green Spaces**

Urban green spaces are essential for ecological balance and public health, especially amid rapid urbanisation. They lower city temperatures by around 1°C, reduce air pollutants like NOx and particulate matter, and help manage stormwater, cutting runoff by up to 50%. These areas support biodiversity, act as carbon sinks, and lessen urban flooding. Psychologically, they reduce stress and depression by 20–30% while encouraging physical activity (Thompson*et al*., 2012). As cities are expected to house 70% of the population by 2050, green spaces remain vital for urban resilience(Nor & Shahrir, 2024; Athokpam *et al.,* 2024).

**3.2Social Contributions of Urban Green Spaces**

A recent study found that over 75% of residents believed green spaces helped reduce stress and improve well-being during the COVID-19 pandemic, underscoring the significant mental health benefits of urban greenery (Maurer*et al*., 2023; Noszczyk*et al*., 2022). This observation aligns with the concept of Nature’s Contributions to People (NCP), which expands the traditional framework of ecosystem services by incorporating cultural and relational values, thereby capturing the full spectrum of nature’s influence on human quality of life (Lehnen*et al*., 2021). Both the NCP and ecosystem services frameworks are interconnected and offer a comprehensive basis for conservation and policy-making (Valck*et al*., 2023)

**3.3 Economic Contributions of Urban Green Spaces**

Increased property values are one of the many economic advantages of urban green infrastructure; research shows that green areas can raise the value of neighbouring real estate by as much as 20% (Edeigba *et al*., 2024). It also creates jobs in fields like landscape management and urban forestry, while helping reduce energy expenditures.A single tree that is 8 meters tall can save 8–12% on home heating and cooling bills. Their importance in fostering social well-being is further supported by the 25% decrease in mental health-related healthcare expenses linked to access to green spaces (Oijstaeijen *et al*., 2020). These statistics demonstrate how UGI investments produce measurable financial gains in addition to co-benefits for the environment and society.

**Figure 1. Urban Green Spaces Benefits Distribution (Source:Nor & Shahrir, 2024)**

**List of Urban Green Spaces(UGS) of Benefits**

**1**

**2**

**3**

**ECOLOGICAL**

**ECONOMIC**

**SOCIAL**

* Air purification
* Carbon sequestration
* Urban heat island mitigation
* Water filtration & groundwater protection
* Biodiversity & habitat conservation
* Ecological balance maintenance
* Soil stabilization & erosion control
* Physical & mental health improvement
* Stress & obesity reduction
* Recreation and relaxation
* Social cohesion & community interaction
* Educational value
* Enhanced quality of life
* Energy savings
* Increased property values
* Job creation (green employment)
* Tourism and investment attraction
* Urban beautification & branding

**Figure 2. List of Urban Green Spaces (UGS) of Benefits (Source: Nor & Shahrir, 2024)**

1. **Mechanisms Supporting Sustainable Urban Transitions**

Urban green spaces are no longer passive landscape elements; they are actively shaping the trajectory of sustainable urban transitions. This section explores the mechanisms through which natural capital, particularly Nature-Based Solutions and Green Infrastructure, is operationalised to enhance urban resilience, mitigate climate risks, and align with global sustainability frameworks.

**4.1 Nature-Based Solutions in Urban Resilience Frameworks**

Nature-Based Solutions (NBS) represent a cornerstone of urban natural capital, offering adaptive strategies that harness ecological processes to enhance resilience. By integrating features such as urban forests, bioswales, and restored wetlands into cityscapes, NBS mitigate climate-induced risks while delivering ecosystem services (Olivadese& Dindo, 2024). Empirical studies indicate that strategic greening and canopy expansion can reduce urban temperatures by 2–4°C, while wetland restoration lowers flood risk by up to 30% (Managi *et al.,* 2023). These interventions not only buffer environmental shocks but also generate co-benefits,biodiversity enhancement, psychological well-being, and cultural valuethereby reinforcing the multifunctionality of urban green spaces as natural capital assets (Pan & Qu, 2024). Global frameworks by UNEP and the World Bank advocate for multi-scalar deployment of NBS, embedding them within broader resilience planning (Managi *et al.*, 2023).

**4.2 Integration of Green Infrastructure in Land-Use Planning**

Green Infrastructure (GI) serves as a spatial manifestation of natural capital, embedded within land-use systems to optimise ecological connectivity and urban functionality. When integrated into zoning regulations, ecological corridors, and multifunctional landscapes, GI supports the provisioning and regulating services of urban ecosystems (Chenoweth et al., 2018). Planning principles such as multifunctionality, connectivity, and participatory governance are essential for maximising GI’s value (Godoi *et al.,* 2025). Evidence from cities like London and New York demonstrates that GI integration has led to a 20–25% increase in permeable surfaces, reducing runoff and improving air quality (Sharma *et al*., 2025; Zhang & Qian, 2024). These outcomes underscore GI’s role not merely as a design intervention but as a strategic planning tool that sustains and enhances urban natural capital.(Bargah *et al.,*2024)

* 1. **Contribution to Climate Risk Mitigation and Adaptation**

Urban green spaces contribute significantly to both climate mitigation and adaptation, reinforcing their status as dynamic components of natural capital. On the mitigation front, urban vegetation, particularly mature trees and green roofs, acts as a carbon sink, with 1 hectare of urban forest capable of storing up to 30 tons of CO₂ (Rodriguez*et al*., 2022; Zhang & Qian, 2024). Simultaneously, these spaces enhance adaptive capacity by reducing flood vulnerability, moderating heat stress, and supporting food security through agroecological practices. Coastal wetlands and mangroves, with carbon storage potential exceeding 1,000 tons per hectare, exemplify high-value ecosystems that deliver both climate regulation and disaster risk reduction (Managi *et al.,* 2023). These dual functions position urban green spaces as indispensable assets in climate-resilient urban transitions.

**4.4Operationalising Urban Green Infrastructure through SDG Synergies**

Operationalising urban green infrastructure through the lens of the Sustainable Development Goals (SDGs) enables cities to align natural capital management with global sustainability targets. GI contributes to 74 of the 169 SDG targets, particularly SDG 11 (Sustainable Cities), SDG 13 (Climate Action), and SDG 3 (Health and Well-Being) (Managi *et al*., 2023; Tate *et al.,* 2024). Frameworks such as the Urban Nexus Approach facilitate cross-sectoral integration linking water, energy, land, and food systems to amplify GI’s ecosystem service delivery (Godoi *et al.,* 2025). Institutional mechanisms, including interdepartmental coordination units and performance-based indicators (e.g., green cover percentage, carbon sequestration rates), are critical for embedding GI into urban governance (Akanbi, 2025). This alignment ensures that urban green spaces are not only preserved but leveraged as measurable, multifunctional components of natural capital.

1. **Governance Architecture and Planning Challenges**

Urban green spaces constitute essential elements of urban natural capital, providing a wide range of ecological, social, and economic benefits that underpin sustainable urban development. Nevertheless, their effective governance faces significant challenges, including fragmented policy frameworks that hinder cross-sectoral coordination and reduce the efficiency of green space management (Ayele*et al*.*,* 2022). The adoption of inclusive governance models that promote stakeholder engagementencompassing local communities, civil society, and private sector actorscan enhance legitimacy, foster community ownership, and ensure the sustainable utilization of green spaces (Borrini-Feyerabend *et al*., 2013; Ababneh *et al*., 2023). Furthermore, issues related to spatial justice and equitable access remain critical, as disparities often align with socioeconomic and geographic inequalities, thereby necessitating policies that prioritise social equity and promote urban livability (Colding *et al*., 2020; Williams *et al*., 2025). Addressing institutional barriers, inadequate funding, and outdated legal instruments requires comprehensive reforms, innovative funding mechanisms, and the development of clear, enforceable legal frameworks to safeguard and manage urban green assets effectively (Deininger *et al*., 2011). Strengthening governance structures in these domains is essential to optimise the ecological functions of green spaces, enhance social cohesion, and build resilient urban environments that serve the needs of all residents (Yeshitela *et al*., 2019).

1. **Conclusion**

Urban vegetated areas are now essential resources for promoting sustainability, fairness, and resilience rather than being merely ancillary features. According to this analysis, green infrastructure has significant advantages that range from preserving biodiversity and regulating the microclimate to enhancing mental health and boosting the economy. Nevertheless, these advancements are still being weakened by disjointed governance, unequal distribution, and insufficient institutional support. Unlocking the transformative potential of natural capital requires bridging policy frameworks with on-ground implementation through community participation, performance monitoring, and inclusive planning. Future cities will continue to be resilient and habitable if ecological intelligence is given top priority in urban planning and green initiatives are coordinated with national and international sustainability goals.

**Disclaimer (Artificial intelligence)**

I hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of this manuscript

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