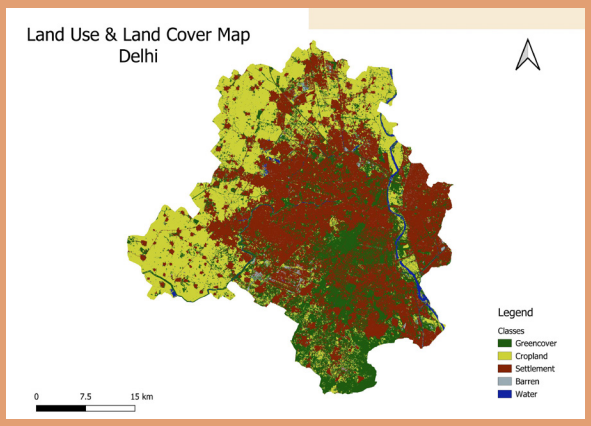
Green infrastructure and ecosystem-based solutions for climate adaptation in Indian cities

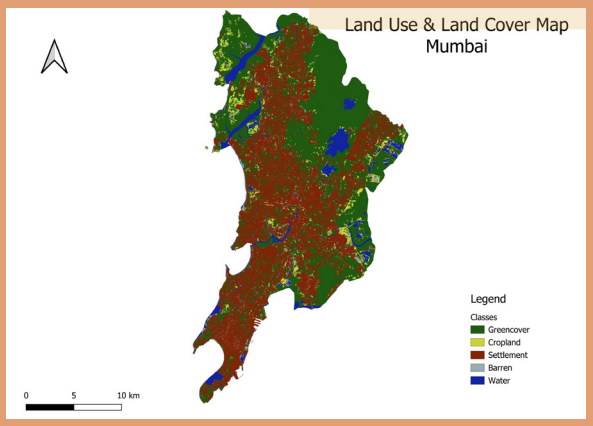
Indian cities are on a rapid growth path, attracting increased migration from across the country. Almost every city in India, from small towns to mega metropolises, is grappling with unprecedented population movement and resultant pressures on resources, both natural and man-made. City planners and administrators are challenged to develop and implement sustainable soutions to address climate change risks resulting from these pressures. To meet the demand for hard infrastructure such as housing, transportation, water and power provision, especially in high-density city regions, the provision and management of urban green infrastructure (UGI) invariably gets sacrificed.

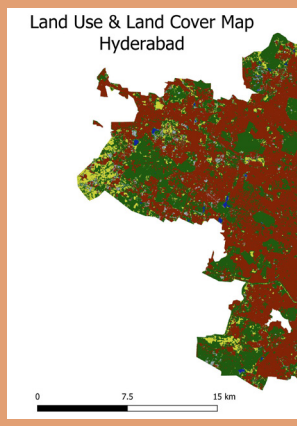
To address this challenge, integrating ecosystem-based solutions (EbS) into UGI planning is being increasingly recognised as an adaptive strategy to fulfil multiple sustainability objectives and address contemporary challenges of climate change, land degradation, biodiversity loss, and degeneration in cities that were identified as 'wicked problems'[1] even five decades ago. It presents opportunities to increase the carbon sink, enhance biodiversity, and modify microclimatic conditions as some of the tangible benefits of climate change adaptation.

The Nature Conservancy (TNC), collaborated with TERI School of Advanced Studies (TERI-SAS), to undertake a study[2] on a ward-level assessment of UGI's efficiency for climate change adaptation in five mega-city regions (Delhi, Mumbai, Hyderabad, Kolkata, and Bangalore) of India. Working at the Science-Policy-Practice Interface (SPPI), this study developed a methodological framework for application in metropolitan city regions within India. Data Envelopment Analysis (DEA), a non-parametric tool commonly used for benchmarking the relative efficiency of decision making units such as cities and wards, was applied to gain insights into the UGI

1 Rittel, H. W. J. and Webber, M. M., 1973. Dilemmas in a General Theory of Planning. *Policy Sciences*, Vol. 4, No. 2, pp.155-169.
2 Conducted by Prof Shaleen Singhal and Dr Meenakshi Kumar.







efficiency at the local level. The analysis helped to evaluate the relative efficiency of the selected cities, and contribute to the development of a multi-scalar framework of EbS strategies for UGI efficiency (see figure). Results were triangulated and discussed through a collaborative process between multiple organisations.

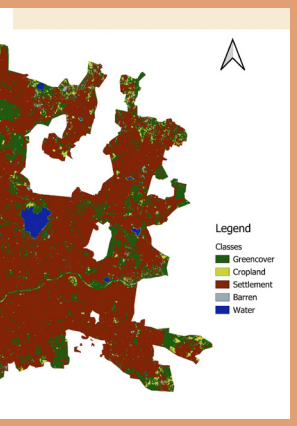
KEY LEARNINGS AND OPPORTUNITIES FOR EBS

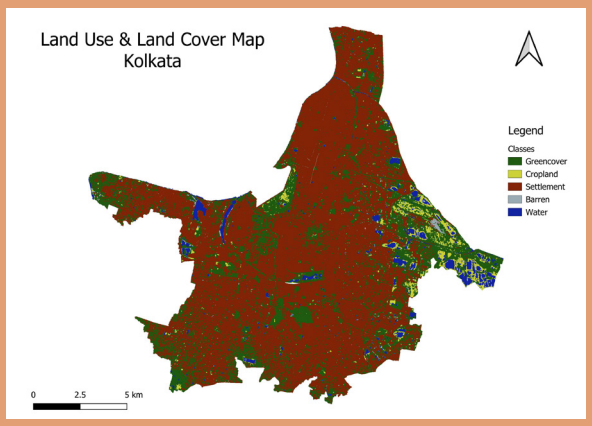
The DEA approach raises the need to integrate EbS across UGI typologies to enhance resource-based efficiency. Study findings show a higher proportion of degraded land on the outskirts of these five cities, suggesting an opportunity to expand UGI resources and promote the adoption of EbS in these specific city-regions. Further, the ward-level examination, including the analysis of Land Use Land Cover maps, DEA, and expert interviews, underscores the pressing need to improve accessibility to green infrastructure. It also highlights the importance of incorporating urban greening guidelines at the ward level within city masterplans, and incorporating such principles into the development components of national-level policies.

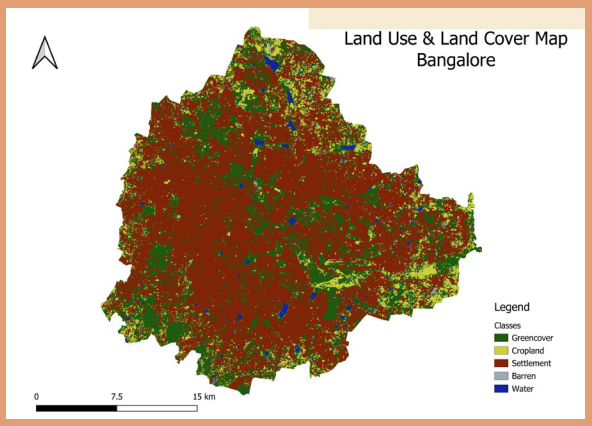
RECOMMENDATIONS

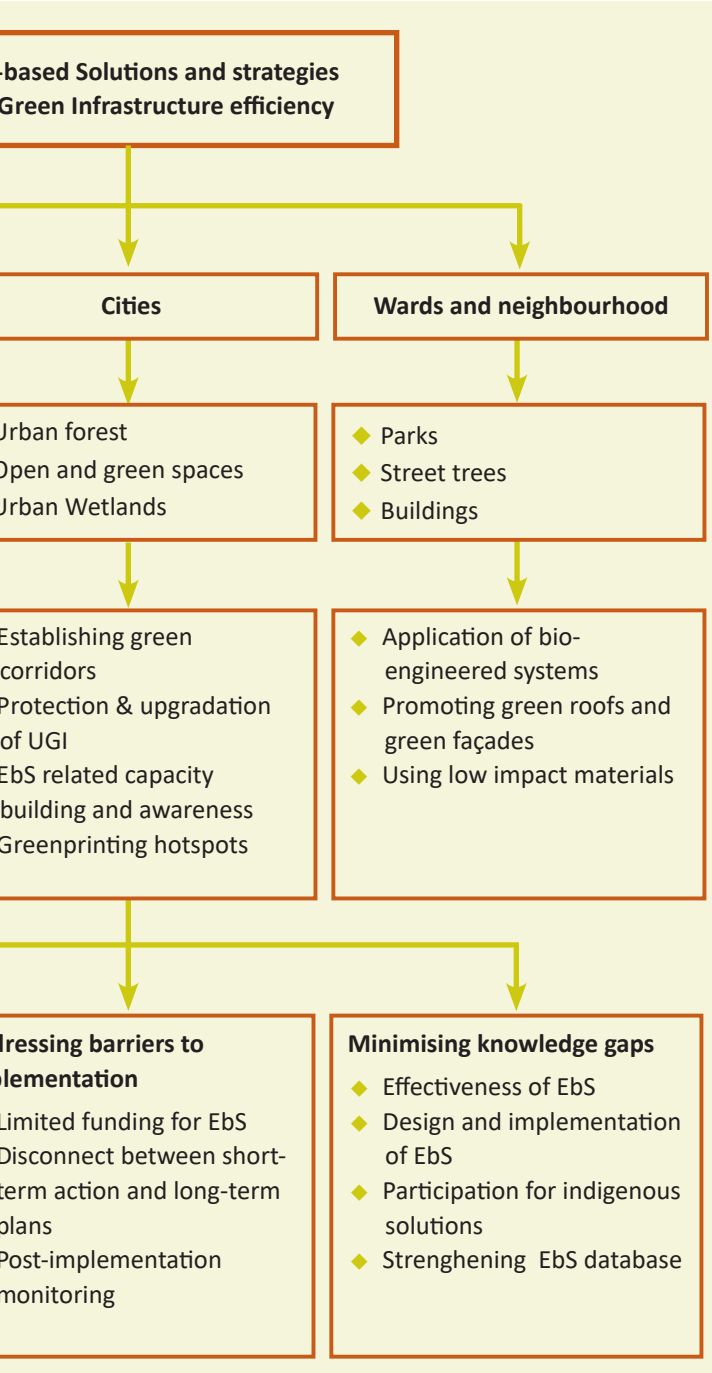
EbS presents an opportunity to effectively enhance the performance of land under UGI in high-density cities for climate change adaptation through collaborative efforts. Land and ecosystem restoration in high-density cities can increase the per capita availability of green cover, and enhance ecosystem services and benefits while providing for social and recreational opportunities.

Multi-scalar framework of EbS strategies for UGI efficiency.









1. Bottom-up approach to multi-scalar integration of EbS

A bottom-up approach exerts a substantial influence at the city level and establishes a stronger rationale for implementing EbS in urban areas. It can be achieved by formulating policy instruments rooted firmly in ward-level baseline data. For example, the city of Stuttgart in Germany promotes the greening of courtyards, roofs, and facades at the municipal level. The environmental sustainability dimension of cities has the potential to be strengthened in national missions such as the Smart Cities Mission.

2. Stakeholder coordination

Urban contexts are usually very complex and emphasise the imperativeness to foster effective coordination between multiple stakeholders – government, private sector, key academic institutions, civil society, and think-tanks – bringing together diverse expertise such as in financial planning, business modeling, and creating enabling environments. As a key strategy, multi-stakeholder collaboration, which works at the SPPI, has the potential to bridge the gap between policy development and actual implementation. For example, cities such as Indore, Coimbatore, and Delhi have restored urban lakes and water bodies using floating wetlands. In Indore, the initiative is funded by international non-profit organisations, implemented at the municipal level, and monitored by local water conservation and management committees.

3. Explore innovative financing mechanism

Financial gains estimated from ecosystem-based adaptation in cities worldwide are around $3,000 to $18,000 (₹2,40,000 to ₹14,40,000) from one

hectare of urban green space in a year. Incorporating EbS into climate change legislation to address issues related to inequitable distribution and accessibility to ecosystem services has the potential to enhance economic benefits. Access to climate finance (and carbon finance) can support UGI typologies such as urban forests, transitional ecosystems, and local nature reserves. In developing countries, carbon credits are issued as certificates. Indore is the first city in South Asia to tap carbon finance. Entry barriers that discourage the uptake of carbon credits through EbS and UGI development, such as high upfront charges and registration costs, should be addressed. A simplified and transparent methodology for carbon credit calculation in EbS sectors such as urban forestry for mitigating emissions must be developed.

4. Strengthen evidence base and knowledge sharing

Knowledge generation (and sharing) on the impacts of EbS on mitigation and biodiversity conservation will reinforce the evidence base and promote access to knowledge and co-production across organisations. Verified action research enables policymakers and urban planners to integrate this knowledge into both new and existing urban plans. Cities need to proactively engage in communicating the best practices on EbS implementation using SPPI to bridge any potential communication gaps between the city administrators and other stakeholders.

5. Integrate advanced technologies for incorporating EbS approaches

Incorporation of bio-engineered EbS for smart cities (such as constructed wetlands and root zone treatment areas) with technology can intensify the provision of ecosystem services, particularly in spheres such as the supply of clean water. Integration of green and smart urban development enhances well-being and social cohesion. UGI-based smart growth strategies promote smart environments and multifunctionality, promise resource efficiency in high-density cities.

RECOMMENDATIONS FOR DELHI-NCR

Delhi has a higher per capita green cover compared to other metropolises in India, yet it grapples with severe air quality issues and plummeting groundwater levels. Recommendations to support the uptake of EbS approaches in Delhi-NCR include:

- **Development of green corridors,** of a continuous green-blue network created by greening grey infrastructure across the city, along side natural drains and transportation routes such as railway tracks, under overhead metro tracks, and along road medians.
- **Restoration of degraded land and ecosystems,** through ongoing initiatives such as biodiversity parks to enhance UGI connectivity.
- **Integration of UGI in the built environment,** by incentivising development of green surfaces such as green roofs, and interior and exterior vertical green walls.
- **Application of bio-engineered systems for UGI efficiency,** through constructed and floating wetlands as done for the *Sanjay Van Lake* and *Hauz Khas Lake*.
- **Development of a greenprint,** through stakeholder consultations in the Delhi-NCR region. For example, the greenprint approach developed for the city of Chennai, by TNC and partners.
- **Quantification of the benefits of EbS and economic impacts of climate change,** by using models such as InVest by Stanford University.

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TNCC acknowledges financial support from Sir Ratan Tata Trust for the Indian Collaborative for Applied Sustainability Solutions (ICASS) initiative.

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