# Barriers to Mainstreaming Nature-Based Solutions in Urban India

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# Executive Summary

Floods, heat waves, and water scarcity are common across Indian cities, upending the lives of millions. Climate change has made these extreme weather events more frequent. Besides, rapid, unplanned urbanisation has made cities more susceptible to the multiple challenges posed by climate change (Khosla & Bhardwaj, 2018).

One way to deal with worsening climate stressors involves redesigning cities with nature-based solutions (NbS), that is, the use of natural processes or ecosystems, to address socio-environmental issues, or a combination of blue, green, and grey infrastructure.[1] These have helped cities in other countries (such as China and Singapore) combat flooding, heat stress, and droughts. However, mainstreaming NbS in urban India faces significant challenges.

This report utilises insights from a literature review, policy analysis, workshop, and interviews with 30 stakeholders to outline the following barriers:

1. Lack of scientific evidence establishing the efficacy of NbS in the Indian context
2. Dearth of design guidelines, tendering protocols, and technical capacity to integrate NbS into urban planning
3. Inadequate funding mechanisms and incentives, especially for the operations and maintenance of projects
4. Administrative and institutional barriers, such as the lack of coordination between government departments, regulatory and legal overlaps, and bureaucratic bottlenecks

A comprehensive approach that addresses these barriers through robust evidence generation, capacity-building, policy reforms, inclusive planning, enhanced enforcement, and public engagement can unlock the potential of NbS in urban India. This integrated strategy is key to enhancing climate resilience, promoting sustainable development, and supporting inclusive growth.

[1] *Blue infrastructure refers to water bodies and drainage systems, green to vegetation, and grey to conventional infrastructure, such as concrete pipes and sewage treatment plants.*

Chapter One

# Introduction

*Photo by aksinfo7 universe from Pexels*

While Indian cities are hubs of economic growth and development, they also have to bear the brunt of climate stressors, such as heavy rainfall leading to floods, increased heat stress due to urban heat island effects, and water scarcity. Climate change has made erratic weather a more frequent phenomenon, upending the lives of millions. Besides, rapid, unplanned urbanisation has made cities more susceptible to the multiple challenges posed by climate change (Khosla & Bhardwaj, 2018). Urban regions can become more resilient in the face of worsening climate stressors if they incorporate nature-based solutions (NbS).

The International Union for Conservation of Nature (IUCN) defines NbS as actions to protect, sustainably manage, and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide social, economic, and biodiversity benefits. This umbrella term encompasses various related approaches, such as ecosystem-based adaptation, green infrastructure, natural climate solutions, ecological restoration, ecosystem services, green farming, urban greening, and agroforestry.

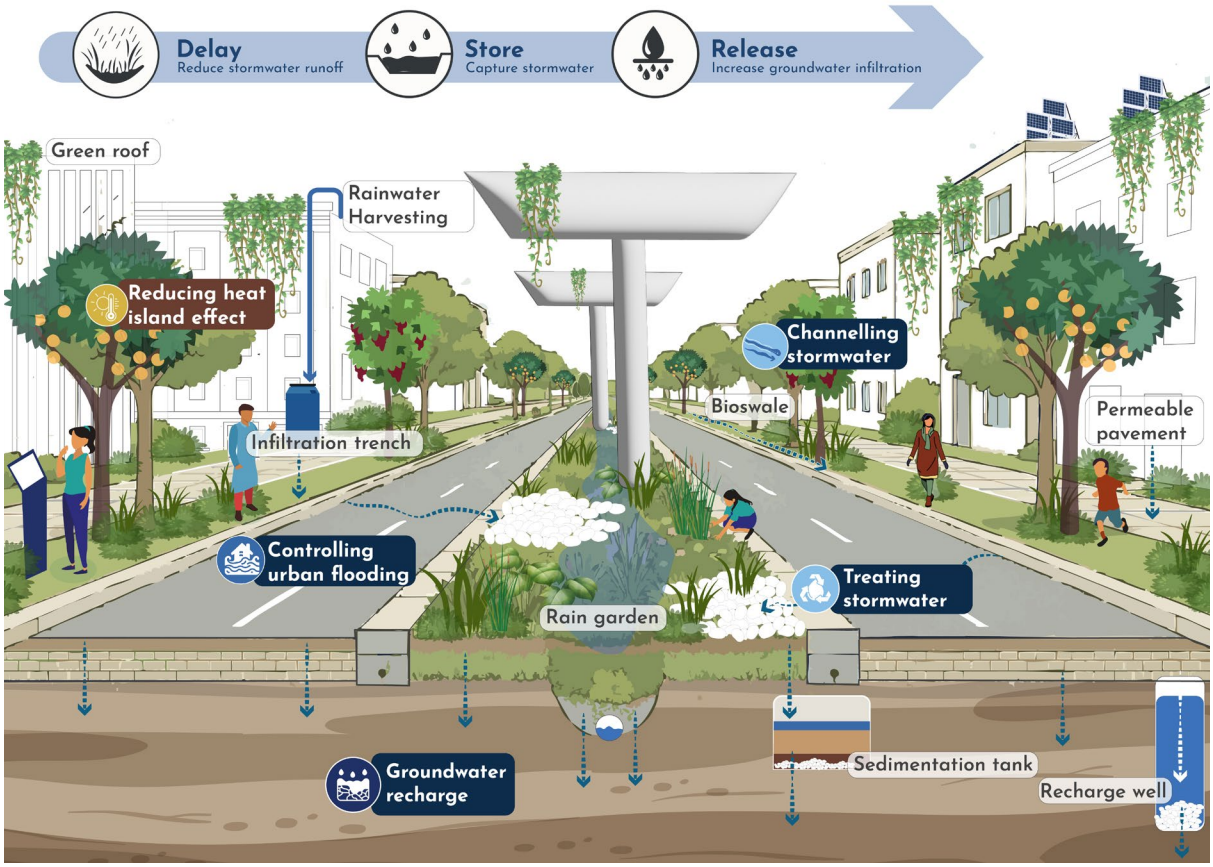


*Figure 1: NbS can be integrated into built-up spaces in urban areas to address environmental and other challenges*

Urban NbS include parks, ponds, green buildings, and green stormwater infrastructure, to name a few. These interventions provide benefits such as temperature regulation, carbon sequestration, recreation spaces, groundwater recharge, reduced energy costs, improved air and soil quality, habitat protection, improved public health, reduced exposure to natural hazards, and socio-cultural

services (Jones et al., 2022; Pandey & Ghosh, 2023). Estimates suggest that NbS can provide 37% of the climate change mitigation needed by 2030 to meet Paris Agreement targets (World Bank Group, 2022).

For these reasons, many cities and government agencies are incorporating NbS into water management and disaster risk reduction programmes, among others. They are seen as a cost-effective way to address multiple development challenges simultaneously.

NbS can be collective (aggregated) or individual (disaggregated). The former require more land area and are characterised by large-scale, centralised interventions. These could be large wetlands or urban parks that deliver significant, albeit localised benefits, such as flood peak attenuation, groundwater recharge, carbon sequestration, and habitat provision. They are most appropriate at the neighbourhood, catchment, and city scales, where large parcels of land are available. Thus, creating or restoring such interventions requires substantial land allocation and upfront investments.

In contrast, disaggregated NbS involve networks of smaller interventions distributed across urban landscapes. These include rain gardens, bioswales, green roofs, and pocket wetlands. These distributed systems excel in space-constrained environments, offering incremental, lower-cost installations that align with available budgets and foster community participation. Their modular nature supports high scalability and adaptability to evolving climate conditions and urban needs, making them particularly suitable for buildings and neighbourhood-level implementation.


*Figure 2: NbS projects can be implemented at various levels in cities*

While individual projects have a modest impact, they collectively provide broad runoff management, city-wide cooling effects, and enhanced habitat diversity. Benefits such as flood peak reduction, increased infiltration, temperature moderation, and groundwater recharge can vary significantly by location, depending on factors like land use and aquifer characteristics.

Rather than viewing these scales as mutually exclusive, the most effective urban resilience strategies typically blend consolidated projects with distributed micro-interventions, creating complementary systems that maximise environmental, economic, and social benefits across multiple scales.

There are multiple NbS projects in India, such as the Sponge Cities Initiative in Chennai, which aims to manage urban flooding by increasing permeable surfaces, recharging groundwater, and storing rainwater; biodiversity parks in Delhi; and Miyawaki forests in cities like Mumbai, Bangalore, and Chennai (ICF, 2025).

While these NbS have significant potential to address environmental challenges in urban India, barriers across financial, technical, institutional, and social dimensions hinder their large-scale adoption. This report delves into these barriers, synthesises insights from other geographies, and explores solutions to overcome these challenges.


Chapter Two

# Methodology

*Photo by Ritik Pathak*

This study combines insights from a literature review, policy analysis, multi-stakeholder workshop, and key informant interviews.

The literature review scanned Scopus and Google Scholar databases to identify peer-reviewed articles and grey literature on the barriers to NbS adoption across the globe. It used thematic analyses to categorise barriers across financial, technical, institutional, and social dimensions.

The policy analysis examined 23 national laws, 11 state policies, and eight city regulations using content analysis to assess NbS integration mechanisms, implementation guidelines, and financial provisions.

The key informant interviews were with 30 stakeholders working in different domains, such as real estate, academia, implementation, and policy. The semi-structured interviews comprised questions around their work on NbS, the challenges they face, the state of the science, gaps in the evidence, and strategies to increase the uptake of NbS in urban India, among other topics.

To explore solutions, WELL Labs co-organised a multi-stakeholder workshop with the Rocky Mountain Institute and Oak Foundation on 28 May 2025 in Bengaluru. It brought together 45 participants, including government officials, researchers, civil society representatives, and practitioners. The workshop employed elements from the World Café Method[2] and systems mapping exercises to validate the preliminary findings and chart a roadmap to promote the adoption of NbS at the building, neighbourhood, and city levels. The focus was on integrating NbS into urban development, climate action, and heat action plans.

*Figure 3: Multi-stakeholder workshop on mainstreaming urban NbS, Bengaluru, 28 May 2025. Photo by Ritik Pathak*

[2] The World Café methodology *is a "simple, effective, and flexible format for hosting large group dialogue".*

Chapter Three

# Barriers to Mainstreaming NbS in Indian Cities

*Photo by WELL Labs*

The literature review, policy analysis, key informant interviews, and multi-stakeholder workshop highlighted four key barriers to mainstreaming NbS in urban India.

**1. Lack of Scientific Evidence**

It is difficult to select appropriate NbS due to gaps in local scientific data and a lack of evidence from the Indian context. These knowledge gaps make it difficult to determine returns from NbS projects, which deters the private sector and philanthropic organisations from investing in them.

**2. Lack of Design Standards, Tendering Protocols, and Technical Capacity**

Ad hoc implementation, with no design or tendering guidelines, has hindered NbS scalability and impact. There is also a shortage of skilled professionals and low awareness among stakeholders, such as site engineers, about NbS design, implementation, and monitoring.

**3. Inadequate Funding and Financial Incentives**

The absence of clear revenue generation models, inadequate funding, and limited opportunities for green investments deter widespread adoption (Anjanappa, 2024). Public finance for NbS remains untapped due to a lack of awareness and the absence of effective mechanisms to leverage government schemes.

**4. Administrative and Institutional Barriers**

Policy and governance gaps, complex approval processes, weak enforcement mechanisms, and limited stakeholder coordination hamper NbS projects (see Table 1 for an overview of national policies that could potentially support NbS adoption).

These challenges and possible solutions to overcome them are discussed in detail in subsequent chapters.

*Table 1: NbS and National Policies*

*While the policy analysis covered 23 national programmes, this table focuses on the most relevant ones for mainstreaming urban NbS*

| Policy | Description | Relevant NbS | Features |
|---|---|---|---|
| Green India Mission (also known as National Mission for a Green India) 2014–2030 | Launched under the National Action Plan on Climate Change, it promotes climate adaptation and mitigation by enhancing forest/tree cover, improving ecosystem services, and supporting forest-dependent communities. | - Forests<br>- Wetlands*<br>- Mangroves |  |
| Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0 2021–2026 | A programme to make cities water secure through circularity principles, rejuvenation of waterbodies and wells, rainwater harvesting, sewage/septage management, and development of green spaces. It also seeks to provide functional tap water connections to all households. | - Rejuvenation of waterbodies<br>- Green Spaces |  |
| Nagar Van Yojana 2020–2025 | A scheme to develop 400 urban forests and 200 parks across India to enhance urban biodiversity, mitigate environmental challenges like pollution, improve residents' health, and build climate resilience. | - Forests<br>- Parks |  |
| Mangrove Initiative for Shoreline Habitats and Tangible Incomes 2023–2028 | The initiative aims to restore 540 sq. km of mangrove forests to enhance shoreline resilience against climate change and boost livelihoods and nature tourism. | Mangroves |  |

## Legend

**Community Engagement:** The policy has a provision for community engagement and participation

**Secured Funding:** The policy has adequate long-term budgetary allocations and funds, including for operations and maintenance

**Guidelines:** The policy provides design and/or implementation guidelines

**Scientific Rigour:** The policy is evidence-based, scientifically rigorous, or developed in consultation with academic instiutions

**Impact Assessment:** The policy has a monitoring framework

**Co-benefits:** The policy focuses on outcomes beyond environmental benefits, such as job creation and ecotourism

* The policies use wetlands interchangeably with lakes and waterbodies. The latter also include rivers.

| Policy | Description | Relevant NbS | Features |
|---|---|---|---|
| Green Credit Programme<br>2023 | A market-based mechanism incentivising voluntary environmental actions (afforestation, water conservation, etc.) through tradable credits. | - Green spaces<br>- Mangroves<br>- Others** |  |
| Jal Shakti Abhiyan<br>2019 | A campaign to promote water conservation through rainwater harvesting, treated wastewater reuse, rejuvenation of waterbodies, watershed development, and afforestation in water-stressed cities. | - Rejuvenation of waterbodies<br>- Green spaces |  |
| National Green Highways Mission<br>2015 | It aims to plant trees and shrubs along national highways to boost carbon sequestration, biodiversity, and employment. | - Green spaces |  |
| Namami Gange Programme [1][2]<br>2014–2026 | A river revitalisation prgramme focusing on pollution abatement, ecosystem restoration, and sustainable development along the Ganga river and its tributaries. | - Rejuvenation of waterbodies<br>- Green spaces |  |
| National Plan for Conservation of Aquatic Ecosystems<br>2019 | A scheme for the conservation and integrated management of wetlands to ensure that they contribute to human wellbeing through their diverse ecosystem services as well as sustain biodiversity. | - Wetlands |  |
| Smart Cities Mission<br>2015–2025 | A programme to upgrade urban infrastructure, public services, and the natural environment in 100 cities across India using ‘smart’ (tech-enabled) solutions. | - Green spaces<br>- Rejuvenation of waterbodies |  |
| National Environment Policy<br>2006 | India’s overarching environmental policy framework promotes conservation, the sustainable use of resources, equity, integration of environmental considerations into development projects, and environmental governance with focus on the sustainable management of ecosystems. | Encompasses a range of NbS |  |

** The Green Credit Programme includes tree plantation, water management, sustainable agriculture, waste management, air pollution reduction, mangrove conservation and restoration, ecomark label development, and sustainable building and infrastructure. It does not explicitly specify that these interventions must include NbS.


Chapter Four

# Lack of Scientific Evidence

*Photo by WELL Labs*

**Urban planners, policymakers, and implementing agencies face significant challenges in selecting appropriate NbS due to gaps in local scientific data.**

There is a lack of scientific evidence regarding the potential and limitations of NbS in tackling flooding, water scarcity, and heat stress, and providing socioeconomic and cultural benefits in the Indian context (Wadhawan, 2023; Anjanappa, 2024; Sharma Rana & Singh, 2024). Without robust evidence demonstrating the effectiveness, scalability, and context-specific suitability of different solutions, decision-makers struggle to identify which ones are apt for a given area.

**There is a lack of awareness regarding the extent to which NbS can effectively address a particular threat and provide benefits.**

NbS provide multiple benefits, but they have largely not been quantified and documented in the Indian context (Iora Ecological & Vertiver, 2022). For example, China's sponge city system, which is designed to manage urban water resources, is not equipped to handle rainfall events exceeding 200 mm per hour per day (Stanway, 2023). Similarly, we need to know the potential and limitations of NbS in the Indian context. The lack of scientific evidence primarily stems from insufficient empirical research on NbS outcomes, particularly regarding hydrological benefits, socioeconomic benefits, and context-specific effectiveness.

## Case Study 1: NbS Data Gaps

There are many solutions, such as floating wetlands, constructed wetlands, etc., to remove phosphorus, nitrogen, and other pollutants from lakes. While there is evidence regarding the broad mechanisms of how they work, we need more data on, say, how much phosphorus a *Canna indica* can remove versus another plant in a constructed wetland or lake.

In China, a comprehensive review of constructed wetlands with a median size of 754 hectares reported an average annual phosphorus load reduction of 0.77 g per sq. m per year (Yang et al., 2024; Rezania et al., 2021). These utilised a combination of emergent and free-floating plant species for nutrient removal. However, certain questions remain unanswered. For example, what is the ideal size of a lake or how many constructed wetlands are required for a given pollution load?

Similarly, in the case of bioswales, what would be the maximum amount of infiltration and flood peak reduction that a bioswale can provide for a given storm intensity and duration? Determining standards for the length, breadth, and width of a bioswale along the side of a stormwater drain can help determine its performance under different storm conditions.

In the case of buildings with retention tanks at the base and green roofs on top, what is the cumulative effect of both interventions on infiltration and temperature regulation? This kind of granular data is required to effectively plan NbS interventions.

NbS benefits, when quantified, span a large range (see Table 2 below) due to the following reasons:

1. **Variability in Ecosystem and Environmental Conditions**
   The effectiveness of NbS depends on local ecological characteristics, such as species composition, ecosystem resilience, and environmental stressors. Documenting the same benefits across multiple studies leads to a large range of values owing to different site characteristics (Seddon et al., 2020).

2. **Variations in Scale and Stakeholder Involvement**
   The scale of NbS projects and the degree of stakeholder participation can differ widely. Urban NbS may prioritise different outcomes (urban cooling, recreation, etc.) compared to rural or coastal NbS (flood risk reduction, biodiversity, etc.), leading to diverse impact profiles and values (Kauark-Fontes et al., 2023).

3. **Temporal Dynamics and Uncertainty**
   NbS impacts may accrue over different timescales and can be influenced by future climate change and other stressors. This temporal variability and uncertainty in ecosystem responses make it challenging to predict and value impact uniformly (Seddon et al., 2020).

*Table 2: Different studies show different quanta of NbS benefits as projects are extremely localised and vary based on hydrogeology, humidity, etc. Sources:* Alihan et al., 2017; Cai et al., 2024; Chen et al., 2022; Jia et al., 2021; Kasprzyk et al., 2022; Probst et al., 2022, Zhang et al., 2020; Kumar et al., 2024

| Intervention | Reduction in Runoff (Range of) | Groundwater Recharge (Range of) | Reduction in Temperature |
|---|---|---|---|
|  Permeable pavements/ parking lots | **5–30.8%** | **5–23.1%** annual rainfall infiltration | range of **3–5°C** reduction in air temperature |
|  Rain garden | **23–30.97% per sq. m** | **0.42–0.70 mm/day** infiltration rate | range of **3–5°C** cooling impact |
|  Wetlands | **31–41%** | **21–250 mm/yr** groundwater recharge | up to **11.1°C** reduction in surface temperature |

Thus, urban planners, architects, builders, or municipalities find it difficult to quantify the benefit provided by an NbS intervention and the point at which it will saturate and not provide the same benefits as it did when it was initiated.

**Most stakeholders lack clarity on how to effectively integrate NbS with existing grey infrastructure to fully realise their combined benefits.**

NbS interventions need not be standalone "either/or" interventions limited to the use of natural resources. In urban contexts, when integrated with existing grey infrastructure, they provide multiple benefits. For example, permeable pavements or bioswales alongside stormwater drains can provide additional infiltration and flood peak reduction (Sehrawat & Shekhar, 2025). This has been observed in case studies such as the redevelopment of the Ring Road in New Delhi and the Race Course Road in Coimbatore (Chadha, n.d.).

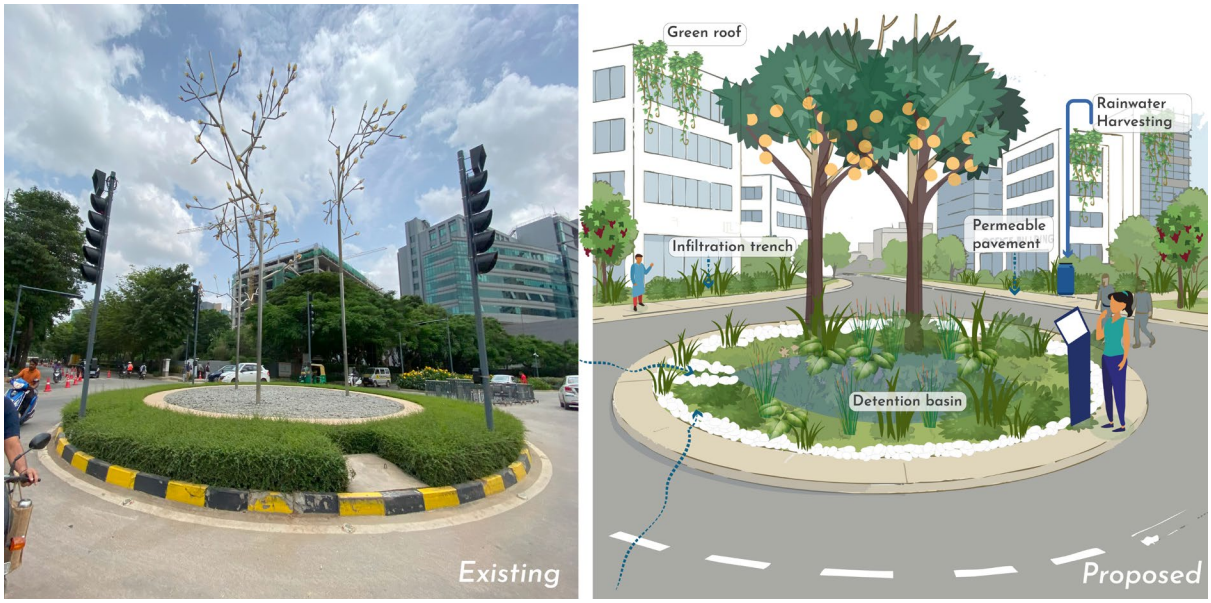


*Figure 4: NbS can be integrated with existing grey infrastructure, but many stakeholders are unsure of how to go about it.*

**There is not enough information about the benefits of individual or small-scale NbS interventions vis-a-vis collective or large-scale ones for Indian cities.**

Data points for traditional, large-scale NbS such as forests, wetlands, and mangroves are more easily available, as there are global databases that track deforestation, wetland loss, and mangrove cover, such as Global Forest Watch and Global Peatlands Assessment. The ecological benefits of traditional NbS (carbon sequestration, biodiversity, etc.) are well-documented (Key et al., 2022) due to the establishment of global monitoring systems that use NASA and European Space Agency data (World Bank, 2024).

Urban NbS, on the other hand, are often small-scale, decentralised, and vary by city, making standardised data collection challenging. Many urban interventions are relatively new. For example, the use of green roofs surged in the 2000s, so data on its long-term efficacy are scarce. Besides, urban environments are complex, with variables such as pollution, infrastructure, and concretised land areas making it difficult to isolate NbS impacts. Moreover, unlike global forest datasets, urban NbS data is often siloed in proprietary studies of pilot projects.

There are some exceptions to this dearth of data—cities such as Singapore, Copenhagen, and Portland have robust urban NbS monitoring programmes. Initiatives like the Urban Nature Atlas and the European Union's NATURVATION are improving urban NbS data accessibility. Globally, there is scientific evidence from the Sponge City Programme in China, projects in Europe, and the ABC Waters Project in Singapore.

Many studies have relied on modelling to estimate the potential benefits of NbS, such as flood risk reduction, carbon storage, or water quality improvements. These models help project outcomes under different scenarios (varying storm durations, storm intensities, climate types, etc.) and are especially useful where direct measurement is difficult or long-term impacts are still being assessed (Seddon et al., 2020; World Bank Group, 2023). There is also a substantial body of research that quantifies NbS benefits through empirical studies and case analyses (Jang et al., 2023).

## Case Study 2: Benefits of Individual Versus Collective NbS

**A study by Bah et al. (2023) in Conakry, Guinea has shown that individual low impact development interventions (LID)[3], such as rain gardens, bio-retention, infiltration trenches, permeable pavements, and rain barrels, provide less flood volume reduction and runoff reduction in comparison to a combination of these interventions.**

It covered a project area of 26.66 sq. km, with four main types of land use: 71% urban, 17% forest, 8% water bodies, and 3% agricultural land. The project area is representative of many urban areas in India in terms of land use.

The study demonstrates through modelling how different forms of low impact development interventions (individual and collective) can reduce flood peaks and runoff over different return periods. A return period (or recurrence interval) is the average time interval, typically expressed in years, between occurrences of a storm event of a given intensity. It is a statistical estimate of how often a storm of a particular size is expected to be equalled or exceeded. Thus, a 100-year return period means that a storm of that intensity is likely to occur once every 100 years.

[3] *Low Impact Development (LID) is a "comprehensive site design strategy that uses natural and engineered infiltration and storage techniques to control storm water where it is generated".*

*Table 3: Effect of low impact development interventions in terms of percentage flood peak reduction over different return periods, Conakry, Guinea*

| LID type | Percentage flood peak reduction over the following return periods | | | | |
|---|---|---|---|---|---|
| | 1 year | 5 years | 20 years | 50 years | 100 years |
| Infiltration trench | 58.5% | 30.7% | 24.1% | 20.7% | 16.9% |
| Bio-retention | 63.5% | 32.1% | 10.7% | 7.9% | 6.9% |
| Rain Barrel | 28.6% | 70.8% | 14.7% | 6.6% | 3.7% |
| Rain garden | 48.9% | 30% | 21.9% | 16.1% | 13.5% |
| Permeable pavment | 37% | 26.% | 17.8% | 12.2% | 10.9% |
| LID combination | **85.3%** | **72.7%** | **54.1%** | **46.2%** | **42.8%** |

*Table 4: Effect of low impact development interventions in terms of percentage runoff reduction over different return periods, Conakry, Guinea*

| LID type | Percentage flood peak reduction over the following return periods | | | | |
|---|---|---|---|---|---|
| | 1 year | 5 years | 20 years | 50 years | 100 years |
| Infiltration trench | 37.5% | 26.7% | 20.9% | 16.8% | 13.3% |
| Bio-retention | 54.8% | 27.3% | 8.8% | 7.2% | 6.5% |
| Rain Barrel | 16.6% | 44.3% | 11.3% | 4.7% | 3.5% |
| Rain garden | 36.1% | 24.9% | 16.2% | 13.4% | 12.6% |
| Permeable pavment | 33.1% | 20.9% | 12.7% | 11.1% | 9.7% |
| LID combination | **67.8%** | **65%** | **50.4%** | **40.2%** | **35.8%** |

Chapter Five

# Lack of Tendering Protocols, Design Standards, and Technical Capacity

*Photo by WELL Labs*

**Ad hoc implementation, with no design or tendering guidelines, has hindered NbS scalability and impact.**

In India, NbS have been introduced as pilot interventions in an ad hoc manner—they have not been integrated into standardised urban planning practices (ICF, 2025). To unlock their full potential and ensure their effectiveness and scalability, developing robust design standards and a city-wide integrated approach are essential.

The effectiveness of NbS in tackling a particular issue can differ from one location to another, depending on the local context and how a project is implemented. To maximise success, it is crucial to factor in the intervention's goals, the site's unique characteristics, and stakeholders' needs and inputs (Seddon et al., 2020).

Grey infrastructure benefits from mature procurement frameworks and design guidelines, unlike fragmented NbS processes. For example, the Ministry of Housing and Urban Affairs has detailed guidelines for grey stormwater drains (Ministry of Housing and Urban Affairs, 2019), which ensure that proper design and funding mechanisms can be established. However, there are no similar guidelines for NbS. Take the case of green spaces, an NbS category that governments prioritise. While there are guidelines for the percentage of green spaces [4] in urban areas, there are no set standards to develop and maintain them.

Besides, policymakers and practitioners often lack the technical knowhow to integrate NbS with traditional infrastructure, leading to a reliance on outdated grey infrastructure (Sharma Rana & Singh, 2024; Mitra & Mukhopadhyay, 2024).

Documenting grey infrastructure standards (for example, ISO 9001/14001) and determining analogous NbS standards could ensure that projects meet sustainability benchmarks and provide the intended benefits. ISO standards can also provide a foundation for policies, enabling the integration of NbS into infrastructure projects.

[4] *The Urban and Regional Development Plan Formulation and Implementation (URDPFI) Guidelines of 2014 suggest that 25–35% of a city's total area should be designated as recreational and open spaces, in addition to environmentally sensitive areas. The Atal Mission for Rejuvenation and Urban Transformation and* service-level benchmarks *of 2014 align with the URDPFI guidelines, specifying that urban local bodies should ensure the availability of 10-12 sq. m per capita green area.*

**For the consistent implementation of NbS across different forms of land use, aquifers, climate conditions, and other parameters, India needs detailed tendering guidelines, standardised expression of interest [5] and request for proposal[6] documents, and a robust tendering process specific to NbS.**

Without these, municipalities struggle to integrate NbS into infrastructure projects and default to grey infrastructure solutions. Take the case of stormwater management, where India has traditionally relied on grey infrastructure, such as concrete drains, pipes, and culverts. Their construction and maintenance rely on well-established tendering processes. Municipal corporations and water boards typically begin with feasibility studies and Detailed Project Reports before floating tenders on government portals like the Central Public Works Department or state Public Works Department websites. Contractors submit bids based on standardised designs, with awards often granted to the lowest bidder or through 'quality-cum-cost' selection.

*Figure 5: Green stormwater infrastructure in Hinsdale, Illinois. Photo Source:* Stormwater Management in Hinsdale, IL *by* Center for Neighborhood Technology, CC BY-SA 2.0

[5] *An expression of interest is a document to gauge if vendors would be interested in designing or executing a project. It is a preliminary step before moving to requests for proposals.*

[6] *A request for proposal is a document inviting financial bids and technical details from vendors to design or implement a project.*

In contrast, green stormwater infrastructure, such as bioswales, rain gardens, and permeable pavements, face significant challenges in India's tendering framework. Unlike grey infrastructure, green stormwater infrastructure lacks standardised guidelines, leading to ambiguous or no tender specifications and limited contractor expertise. Municipalities often perceive green stormwater infrastructure as costly and complex, resulting in their exclusion from large-scale projects or their relegation to pilot programmes under Smart City Missions.[7] The absence of performance-based contracts and long-term maintenance requirements further discourages their adoption. This results in an institutional bias towards conventional solutions, as engineers and contractors are more familiar with grey infrastructure, leaving green stormwater infrastructure projects underfunded and poorly executed.

The table below highlights the gaps in tendering processes for green stormwater infrastructure, an NbS analogue to stormwater drains.

*Table 5: Comparison of grey and green stormwater infrastructure*

| Aspect | Grey Stormwater Infrastructure | Green Stormwater Infrastructure |
|---|---|---|
| **Technical specifications** | • Detailed engineering standards for concrete drains/pipes (for example, Central Public Works Department manuals)<br>• Interception and diversion for flood prevention and water treatment within the catchment is available (Central Pollution Control Board, 2019) | • No standardised design criteria for bioswales, rain gardens, or permeable surfaces<br>• No mandatory environmental product declarations for sustainable materials<br>• Limited integration of circular economy principles in technical bids<br>• Intercepted and diverted water can be sent to NbS treatment systems to tackle surplus flows. These systems require technical specifications |
| **Eligibility criteria** | Requires previous construction experience | Rarely specifies ecological expertise or green technology experience for both designers and contractors |
| **Cost estimation** | Detailed budgets are available for materials and labour | Limited life cycle cost analysis leads to long-term maintenance savings being overlooked |

[7] Smart Cities Mission *is the Government of India's programme to upgrade urban infrastructure and services to provide a clean and sustainable environment, and a decent quality of life to citizens.*

| Aspect | Grey Stormwater Infrastructure | Green Stormwater Infrastructure |
|---|---|---|
| **Environmental compliance** | Focuses on runoff disposal without water quality mandates | Standards, guidelines, or pollution reduction metrics are absent |
| **Documentation** | Standardised tender formats and procurement channels, such as the Government e-Marketplace | No dedicated green procurement details are mentioned in bid documents |
| **Institutional capacity** | Procurement standards are set, making it easy for officials to navigate the procurement process | Officials lack training on green infrastructure performance indicators. Besides, there is no inter-ministerial group overseeing the implementation of Green Public Procurement[8] |
| **Market readiness** | Contractors are aware of what is expected of them | There are no registered or trained contractors with expertise in NbS |

**To bridge the gaps listed above, India must develop NbS-specific tendering guidelines, integrate hybrid grey-green solutions, and introduce performance-linked contracts that reward sustainable outcomes.**

NbS such as bioswales, retention ponds, and rain gardens lack standardised designs, requiring consultants to recreate them in Detailed Project Reports for each project. Standardising these designs could ensure that workers across the board are aware of the recommended specifications and streamline implementation.

Another challenge is the lack of standardised materials and designs in the Schedule of Rates (SOR).[9] For instance, plants used for phytoremediation and erosion prevention are typically not listed in most SORs, making them subject to vendors' discretion. In tree planting, SORs are not available for native species. Similarly, in retention systems, Reinforced Cement Concrete chambers are commonly included in SORs due to the availability of materials and labour, whereas sustainable materials are not.

Thus, the NbS planning rubric must take into account design criteria, performance parameters, context-specific considerations, and project implementation limitations.

[8] *The Energy and Resources Institute (TERI) defines Green Public Procurement as a process that allows the deliberate and systematic integration of environmental goals in the procurement process of goods, services, and works by public agencies.*
[9] *A Schedule of Rates (SOR) lists standardised rates for the materials and labour used in construction projects.*

**In India, there is also a shortage of skilled professionals and low awareness among stakeholders, such as site engineers, about NbS design, implementation, and monitoring.**

According to Ms Debashree Mukherjee, Joint Secretary, Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, there are few trained site engineers who understand the components that go into NbS design (Kumar, Suresh, Mall, & Maliwar, 2024).

Capacity-building to mainstream NbS is challenging due to knowledge gaps, institutional fragmentation, and inadequate training frameworks. Academic institutions lack dedicated NbS curricula and vocational training programmes rarely include ecological restoration or climate-resilient design. There is no training curriculum available on these topics for civil engineers, environmental engineers, and architects.

There is also a need to train contractors and government engineers working in Project Management Units (a body that implements government schemes), as local governments and communities are often ill-equipped to implement NbS.

Another fundamental barrier is institutional weakness—there is insufficient capacity within institutions to make informed decisions, particularly with respect to the use of scientific evidence for planning. Financial capabilities are also lacking, making it difficult for institutions to appraise project proposals.

# Lakes Framework

**Providing Technical Inputs for Lake Rejuvenation Projects**

Lakes can help regulate floods, recharge groundwater, support diverse ecosystems, and provide recreational spaces. While these advantages have made the rejuvenation of polluted and encroached lakes a popular NbS initiative in urban regions, many such projects are sub-optimal or follow a cosmetic approach rather than tapping into the full gamut of benefits lakes can provide.

As is the case with other NbS, the lack of technical capacity and design standards makes lake rejuvenation challenging. To address this gap, WELL Labs built the Lakes Framework in collaboration with Friends of Lakes and DCB Bank. It provides broad guidelines regarding problem diagnosis, visioning, community engagement, building consensus on the goals of the rejuvenation process, project design, implementation, operations, maintenance, monitoring, and evaluation.

Thus, the framework not only bridges technical gaps but also streamlines the lake-rejuvenation process, promotes inclusivity, and mitigates potential risks.

**Read More |** Framework for Lake Rejuvenation

*Figure 6: Lakes can help regulate floods, recharge groundwater, support diverse ecosystems, and provide recreational spaces*

Chapter Six

# Inadequate Funding and Financial Incentives

*Photo by WELL Labs*

**There is a lack of dedicated budgets and financing mechanisms for NbS, leading to piecemeal funding.**

Our policy analysis revealed that there is funding available for NbS projects such as tree planting and lake rejuvenation, but not for interventions such as green roofs, bioswales, etc. Since the latter can potentially provide a greater return on investment, there is a need for budget lines[10] for them.

Major public NbS projects operate on a cost-sharing basis between the national and state governments.[11] In this fragmented funding model, core activities receive direct funding, while ancillary activities need to secure funds from other government schemes. This forces project implementers to navigate multiple funding streams, coordinate across various agencies, and create complex convergence[12] strategies, often delaying project timelines and increasing the administrative burden.

The Mangrove Initiative for Shoreline Habitats & Tangible Incomes exemplifies this challenge. While the state Compensatory Afforestation Fund Management and Planning Authority (CAMPA) funds cover mangrove restoration activities, support activities[13] must be sourced from national CAMPA funds, the Mahatma Gandhi National Rural Employment Guarantee Act, etc. National CAMPA addresses financing gaps only after the state CAMPA allocation.

The National Plan for Conservation of Aquatic Ecosystems (NCPA) is a key initiative for the conservation and management of wetlands, including lakes, across the country. Currently, it primarily serves as a planning document that outlines broad conservation goals and lacks detailed guidelines on incorporating NbS in lake buffer zones.

NCPA provides core funding, covering at least 75% of the budget, for wetland management activities. However, comprehensive restoration efforts depend heavily on additional support from development sector programmes, both public and private. In the absence of a dedicated framework to allocate funds beyond lakefront development, lake restoration and other critical activities remain underfunded.

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*[10] A budget line refers to a specific amount of money allocated for a particular purpose or item within the government's overall budget.*

*[11] This is not just the case for NbS projects; it is a common feature across government programmes.*

*[12] Convergence refers to building synergy between various government schemes by coordinating efforts across different departments and administrative levels. It seeks to leverage pre-existing initiatives for new goals and optimise resource allocation.*

*[13] These include livelihood diversification, capacity-building, research and development, publicity, media and outreach, monitoring and evaluation, and ecotourism.*

Similarly, state governments have launched major initiatives, like the Urban Green Belt project in Haryana and Haritha Haram in Telangana. However, they also lack long-term, sustainable financing models and depend on repeated budgetary allocations to sustain operations.

**Even where public finance is available for NbS, it can remain untapped.**

India's 15th Finance Commission, constituted in November 2017, recommended the creation of targeted climate funds, such as the National Disaster Response Fund and Nationally Determined Contribution Goal 5 Grant. Participants in the multi-stakeholder workshop highlighted that these could be used for NbS related to air quality, forest cover, floods, etc., but they remain underutilised.

The 15th Finance Commission also seeks to incentivise forest conservation by assigning greater tax devolution weightage to states with a higher forest cover. This provides an opportunity for governments to finance NbS such as urban forests (Indian Institute of Forest Management, n.d.; World Resources Institute, 2021). However, their potential remains largely untapped.

*Figure 7: The 15th Finance Commission incentivises forest conservation, which could help fund urban forests. Photo Source: "Mumbai" by Climate Group, CC BY-NC-SA 2.0*

There is a provision to allocate up to 5% of the budget under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) for the development of green spaces and lake rejuvenation (Government of India, 2021). For more effective outcomes, this budgetary allocation should be used to fund a variety of NbS rather than just parks and lakes. Kochi is a pioneer in this regard—Oasis Designs, an urban design consultancy firm, incorporated bioswales in public spaces in the city using AMRUT funds.

**Despite the gaps, most of the financing for NbS in India comes from the government, with the private sector contributing only 17% of the total funding** (United Nations Environment Programme, 2023).

An analysis of 87 case studies in 2022 revealed that grants constitute the predominant source of funding, followed by loans and green bonds (Iora Ecological & Vertiver, 2022). The majority of NbS projects rely on public funding, particularly grants from national and state governments, and public sector institutions, such as the National Bank for Agriculture and Rural Development (NABARD) and Indian Renewable Energy Development Agency Limited. Additionally, international development finance institutions, such as the United States Agency for International Development, World Bank, KfW Development Bank, Japan International Cooperation Agency, and Global Environment Facility, play a significant role by providing grants and low-cost loans.

In contrast, private sector involvement in NbS financing is largely channelled through Corporate Social Responsibility grants, primarily for forestry and water-related projects. Private financing outside of Corporate Social Responsibility frameworks has primarily supported energy security initiatives (including renewable power generation), water harvesting, reservoir restoration, and sustainable habitat development. Weak public-private partnership frameworks also limit private sector participation.

**Without policy measures such as green bonds or incentives like tax breaks or offset trading, private sector participation will remain limited.**

While carbon credits are well-established in the NbS space, they apply only to certain types of projects. For example, carbon credits for forest conservation are widely established due to their direct carbon sequestration potential, established methodologies, and scalability. However, the localised effects and multifarious benefits of urban NbS, such as flood mitigation and increased infiltration, do not easily convert into tradeable carbon units. They also lack standardised methodologies for credit issuance. Besides, jurisdictional-scale approaches, which work for forests, are less feasible in fragmented urban landscapes (World Resources Institute, 2022).

**A framework similar to the carbon credit system could be developed for NbS, incorporating predefined metrics that capture the non-carbon ecosystem services these solutions offer.**

If strong markets are established for these services, many non-monetised benefits of NbS can be valued through mechanisms like credit systems. This, in turn, can boost private sector interest and investment in NbS.

The Government of India has launched market-based mechanisms to incentivise environmental initiatives, such as the Green Credit Programme (Ministry of Environment, Forest and Climate Change, 2023). However, the programme is limited to large blue-green infrastructure projects for afforestation and water conservation. We need to expand this list to include other blue-green infrastructure projects like rain gardens, bioswales, retention ponds, and green roofs. These provide

similar benefits on a smaller scale and are easier to implement in areas with space constraints. Recognising them under the Green Credit Programme, among other government schemes, would encourage the wider adoption of NbS.

**While environmental credit systems can promote NbS, their effectiveness depends not only on the presence of a strong market and returns, but also on how implementation challenges are managed.**

For example, projects often require large tracts of land. Land acquisition, especially of public or common land, has led to conflicts over ownership, access, and benefit-sharing. Without addressing these concerns, credit systems risk entrenching inequities rather than delivering long-term ecological and social benefits.

## Case Study 3: Incentivising NbS through Water Credits

**A credit system that goes beyond carbon sequestration to quantify other benefits of NbS interventions, such as water conservation, could help direct additional funding towards them.**

Water credits represent a specific amount of water that has been either conserved or produced. These credits can be traded between entities experiencing water shortages and those with a surplus. While the idea of water credits is comparable to that of carbon credits, a key difference is that, due to the localised nature of water resources, transactions must be confined to the same hydrological unit, such as a river basin or watershed (The Hindu BusinessLine, 2023).

Different types of NbS provide water savings through increased infiltration and groundwater recharge, while also contributing to flood peak reduction. Its implementation would require systemic intervention to include regulatory players, local water governance institutions, sustainability advocacy groups, and industry leaders.

**The stormwater retention credits (SRC) system, implemented in Washington, DC, is a form of water credits.**

It demonstrates how innovative financing mechanisms can aid in mainstreaming NbS. In 2013, DC's Department of Energy and Environment enacted regulations requiring most new developments and major renovations to manage a set amount of stormwater on-site using green infrastructure (rain gardens, green roofs, etc.). If developers cannot meet these requirements on their property, they have two options:

1. **Purchase Stormwater Retention Credits**
   Developers can buy credits from property owners who have voluntarily installed green infrastructure that exceeds their own requirements. One stormwater retention credit is equivalent to one gallon of stormwater retained for one year. Developers can meet up

to 50% of their stormwater retention obligations offsite, providing flexibility and reduced costs.

2. **Pay an in-lieu fee**
   As an alternative, developers can pay a fee to the city, but the credit trading market is usually more cost-effective (Metropolitan Planning Council, 2019).

Property owners who install green infrastructure beyond what is required benefit by generating and selling credits. The Department of Energy and Environment certifies and tracks these credits, ensuring both regulatory compliance and tangible environmental benefits.

The experience of Shaed Elementary School in Washington, DC, demonstrates how the system benefits all parties. Unable to meet stormwater requirements on-site due to space and cost constraints, the school bought stormwater retention credits from an apartment complex, The Westchester, which had installed rain gardens and generated surplus credits. This transaction allowed the school to comply with regulations affordably, while The Westchester received money to maintain and expand its green infrastructure (Urban Land Institute, 2021).

**Since its inception in 2013 to 2024, the programme has facilitated the sale of credits worth $1.7 million** (Green Finance Institute, n.d.).

Beyond its environmental impact, the initiative has contributed to the creation of new green spaces, improved water quality, and green jobs. To further encourage the voluntary adoption of green infrastructure, the SRC Price Lock Program guarantees a purchase price for credits, thereby reducing investment risk. Due to its success, the initiative has become a model for other U.S. cities, including Grand Rapids, Michigan, and Cook County, Illinois, which have adapted the framework to suit their own needs (The Nature Conservancy, 2024).

**The lack of data regarding the social, environmental, and economic impacts of NbS also presents a barrier to investments by private and philanthropic funders.**

Philanthropic funders often seek evidence of impact to justify their investments. The absence of reliable data on the benefits of NbS projects makes it difficult for them to assess the effectiveness and scalability of their contributions (Hudson et al., 2023). Without transparent benchmarks or standardised impact measurement, philanthropic organisations face high transaction costs and uncertainty, limiting their willingness to commit significant or long-term funding.

Commercial investors require clear, quantifiable data on financial returns and risk profiles. The lack of data on the financial performance and market rates of NbS projects means these investments are perceived as high-risk and low-return compared to conventional alternatives. The inability to monetise or reliably quantify the full suite of NbS benefits (ecosystem services, carbon sequestration, biodiversity gains, etc.) further discourages private sector investment. This is

compounded by the novelty of NbS as an asset class and the absence of established benchmarks or track records. Commercial capital is also deterred by the small scale and complexity of most NbS projects, which make it difficult to achieve the scale and efficiency required for profitable investments.

Blended finance is a tool that strategically uses public, philanthropic, and concessional capital[14] to de-risk and attract private investments. It can be used to scale NbS in India when there is a pipeline of bankable projects. However, without data to benchmark performance and outcomes, it is difficult to identify, replicate, and scale successful NbS models. This limits the pipeline of projects that can attract blended finance, as investors cannot easily compare or validate project viability (Climate Policy Initiative, 2024).

Effective blended finance depends on accurately identifying risk, return, and impact profiles. Data gaps make it difficult to design appropriate de-risking instruments, guarantees, or incentives that match the unique characteristics of NbS projects in India (Green Finance Platform, 2024).

**The long-term sustainability of NbS is threatened by inadequate funding for operations and maintenance.**

While some NbS projects initially elicit enthusiasm and funding, critical questions about long-term ownership, management, and financing are frequently left unresolved. This gap results in a lack of sustained commitment and insufficient resources for their operations and maintenance.

This has been the case for the Nagar Van Yojana, the federal government's urban greening programme. While it relies heavily on federal grants, these typically cover only initial establishment costs, leaving implementing agencies without secure revenue streams for long-term maintenance.

Public funding for NbS is typically directed towards capital-intensive, short-term projects rather than the recurring expenses necessary for maintenance. Urban planning processes often overlook the need for dedicated budget allocations for operations and maintenance throughout a project's lifecycle, leaving state and local government bodies to bear these costs, often without adequate revenue streams. Poor recovery of service charges, especially for urban lakes, exacerbates this challenge.

The absence of planning for long-term operations and maintenance, including the failure to account for material and labour costs, has led to the premature failure of several pilot projects. To address this issue, requiring builders and contractors to provide operations and maintenance for NbS should be considered an essential component of sustainable urban development.

[14] *Concessional capital refers to loans provided on more favourable rates or conditions as compared to the market standard.*


Chapter Seven

# Administrative and Institutional Barriers

*Photo by WELL Labs*

**Siloed governance has been a persistent challenge in the Indian bureaucracy.**

The lack of coordination between various government departments and agencies hampers the effective implementation of NbS as well. For example, managing urban flooding requires the seamless collaboration of departments responsible for wetlands, lakes, stormwater drains, and sewage systems. Even when deploying traditional grey infrastructure, these entities often operate independently, resulting in inefficiencies and gaps.

The introduction of integrated approaches, such as blue-green-grey infrastructure, which combines natural and engineered solutions, makes interdepartmental coordination even more critical. Without it, innovative interventions like green stormwater infrastructure struggle to move beyond the planning stage.

**Key ministries often hold overlapping responsibilities, but do not coordinate with each other effectively.**

At the national level, the Ministry of Environment, Forest and Climate Change oversees environmental protection and biodiversity; the Ministry of Housing and Urban Affairs is responsible for urban planning and infrastructure; and the Ministry of Jal Shakti manages water resources. Although these ministries have mandates that intersect, especially regarding urban water management and ecological restoration, there is little institutionalised mechanism for collaboration. This fragmentation often results in delayed approvals, contradictory policy directives, and inefficient resource allocation.

The multiple national programmes to address urban sustainability, infrastructure, and liveability also frequently operate in silos, with limited integration of NbS principles into their frameworks. For example, while the Atal Mission for Rejuvenation and Urban Transformation 2.0 focuses on urban water supply and green spaces, it rarely aligns its objectives with those of the National Mission for Sustainable Habitat, which deals with sustainable urbanisation, or the Smart Cities Mission, which prioritises technological solutions. There are exceptions, though: Srinagar, Chennai, and Coimbatore tap into the Smart Cities Mission to implement lake rejuvenation projects.

**State governments frequently prioritise conventional infrastructure development over ecological objectives, leading to NbS being sidelined.**

A case in point is Rajasthan's Mukhyamantri Jal Swavlamban Yojana. While it has been successful in mobilising resources for water conservation, it primarily focuses on constructing water harvesting structures rather than integrating holistic, nature-based approaches, such as watershed restoration or ecosystem-based adaptation (Everard et al., 2017).

*Figure 8: Cities such as Srinagar tapped into Smart Cities Mission funds for lake rejuvenation projects. Photo Source:* Wikimedia

**At the state level, bureaucratic bottlenecks and ambiguity regarding who can authorise clearance processes are also common.**

For example, it is unclear whether the forest department or urban local bodies legally govern 'tree parks' set up under the state of Karnataka's Tree Park Scheme. These parks do not fit under the Karnataka Parks Act, nor the Forest Conservation Act. Besides, urban forestry is constitutionally a municipal function.

There is no statutory clarity on roles or management and committees formed for their maintenance lack defined responsibilities, leading to inconsistent oversight. This jurisdictional overlap, along with the absence of a specific legislative mandate, results in delayed decision-making, lack of accountability, and persistent confusion about who is ultimately responsible for planning and maintaining these urban green spaces (Yanappa, 2023).

**The situation is further complicated by legal and regulatory overlaps, particularly between national and state laws.**

The Biological Diversity Act, 2002, administered by the Ministry of Environment, Forest and Climate Change, sets out a framework for the conservation and sustainable use of biological resources (The Biological Diversity Act, 2002). The National Green Tribunal and Central Pollution Control Board place limits on the development of grey infrastructure in buffer zones around water bodies (Central Pollution Control Board, 2019; National Green Tribunal, 2021). These rules can be leveraged in favour

of NbS, but they often clash with state-level regulations and local development priorities, hindering the mainstreaming of NbS into urban planning (PTI, 2019).

Sometimes, the overlaps can be between different departments in the state government. In Haryana's Van Mitra scheme, non-forest lands such as panchayat land, institutional land (government schools, offices), cremation grounds, and non-notified parcels of land can be diverted towards plantations (Government of Haryana, n.d.). These land parcels usually belong to the Revenue Department and urban local bodies. It is the Forest Department's responsibility to identify land, supply saplings, and provide technical guidance. This leads to dual control over the same land assets. In such cases of institutional overlaps, it is difficult to implement NbS projects without extensive cross-sectoral collaboration.

Multi-stakeholder governance has also been a challenge. The Namami Gange Programme has faced hurdles in harmonising efforts across various government agencies, nonprofits, and communities.

**Beyond institutional and policy fragmentation, regulatory and legal barriers impede the mainstreaming of NbS in India.**

The approval processes for projects involving land use change or ecological restoration remain complex and time-consuming, often requiring clearances from multiple agencies. Recent amendments to critical legislation, such as the Forest Conservation Act, have diluted certain environmental protections, making it easier for developmental projects to bypass safeguards that previously protected forests and other ecologically sensitive areas. This regulatory easing, while intended to streamline development, often comes at the expense of long-term ecological resilience.

**Enforcement of environmental regulations is another significant challenge.**

For example, the Jal Shakti Abhiyan, which aims to promote water conservation and management, lacks stringent penalties or accountability mechanisms for non-compliance. This weak enforcement undermines the credibility and effectiveness of such initiatives, allowing violations to go unchecked and reducing incentives for stakeholders to adopt sustainable practices (Bora, 2019; Singh & Goyal, 2025).

**Moreover, community involvement in NbS planning and implementation remains insufficient.**

Although frameworks like the Biological Diversity Act, 2002 recognise the importance of involving communities in biodiversity management, in practice, their participation is often minimal. Decision-making processes tend to be top-down, with limited opportunities for meaningful inputs from affected communities. This pattern is evident in large-scale urban initiatives, such as the Smart Cities Mission, where planning is typically led by technocrats and consultants, with little room for grassroots voices. Most heat action plans do not include local residents (Centre for Policy Research, 2023). This limits the social acceptance and long-term sustainability of NbS projects.

**Urban local bodies lack the technical expertise to design, implement, and monitor NbS initiatives.**

This gap is evident in most Heat Action Plans, where the limited technical knowhow of urban local bodies restricts the scope and effectiveness of interventions to mitigate heat (Parchure et al., 2022).

The lack of capacity at the city level also hinders the implementation of national programmes. This is evident in the slow uptake of NbS in projects under the Atal Mission for Rejuvenation and Urban Transformation 2.0.

Staff shortages compound the problem. For example, the Bengaluru Climate Action Plan has struggled to enforce its climate-resilience measures due to inadequate staffing for monitoring and compliance.

**Data deficits hamper governments' decision-making capabilities.**

The absence of localised ecological and climate data, such as heat maps or biodiversity inventories, hampers informed decision-making. The Kochi City Lab initiative highlighted how the lack of granular data can impede the planning and scaling of NbS interventions (Mok et al., 2021).

**Short-term political interests frequently drive the selection of projects that promise quick, visible results.**

The result is the sidelining of long-term, transformative NbS solutions. This tendency has been evident in the Smart Cities Mission, where high-visibility infrastructure often takes precedence over ecological restoration or green infrastructure (Mundoli et al., 2017).

**Another challenge is that governments, researchers, and practitioners do not work closely together.**

Research institutions such as the Indian Institute of Technology, Indian Institute of Science, and Council of Scientific and Industrial Research (CSIR)-National Environment Engineering Research Institute (NEERI) have researched and validated NbS benefits. The latter has developed phytorids[15] and inline treatment methods[16] for both water and wastewater in lakes and stormwater drain channels (NEERI, 2020). However, institutional collaboration between researchers and practitioners is largely missing. Overcoming this gap can help generate evidence, which can spur investors to fund NbS projects.

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[15] *A system of wastewater treatment using constructed wetlands.*

[16] *Inline treatment methods treat water within a pipe or channel, without diverting it to a separate treatment unit.*

Addressing these multi-level, cross-cutting barriers requires comprehensive capacity-building, interdepartmental coordination, streamlined approval processes, robust data systems, inclusive planning, and enhanced enforcement. These systemic reforms are key to embedding NbS in India's complex governance landscape and ensuring the successful implementation of projects.

Chapter Eight

# Mainstreaming NbS: The Way Forward

*Photo by Nabina Chakraborty*

**To accelerate the adoption of NbS in India, a strong bottom-up approach is essential, beginning with comprehensive data collection and evidence building.**

Establishing robust protocols for localised data collection and monitoring across India's diverse hydrogeological landscapes is essential to capture the ecological, social, and economic benefits of NbS.

Developing standardised metrics and methodologies for measuring outcomes such as carbon sequestration, flood mitigation, biodiversity enhancement, and community wellbeing is key to ensuring data consistency and comparability.

Open and accessible data platforms, such as the Environmental Information, Awareness, Capacity Building, and Livelihood Programme (EIACP), can help practitioners, policymakers, and researchers share case studies, datasets, and best practices. Such platforms are crucial to facilitate knowledge exchange and informed decision-making.

**Integrating NbS into curricula can help bridge knowledge gaps.**

Curriculum reforms should embed NbS concepts into undergraduate and postgraduate programmes in architecture, civil engineering, environmental science, and urban planning. Encouraging interdisciplinary learning that combines ecology, engineering, social sciences, and economics is critical to foster a holistic understanding of NbS.

**Capacity-building and technical guidance are critical for translating knowledge into action.**

Formulating clear, context-specific technical design guidelines tailored to India's varied climates and ecosystems can support the effective planning and implementation of NbS projects.

Updating procurement and tendering frameworks to include NbS criteria is key to embedding them in public-sector projects.

Furthermore, regular training programmes and certification courses for government officials, engineers, architects, and communities help build the practical expertise needed to design, execute, and maintain NbS.

**On the investment front, developing tools and frameworks to assess the risks of and returns on NbS investments (including benefits such as resilience, health, and improved urban spaces) can attract funding.**

Pilot projects supported by rigorous monitoring and evaluation can generate credible evidence to de-risk larger investments. Additionally, fostering blended finance models that bring together the government, private sector, philanthropies, and multilateral institutions can create innovative funding mechanisms to scale NbS implementation.

Financial incentives like grants, concessional finance, tax breaks, or performance-based payments can motivate private entities to take up NbS projects.

**From a top-down perspective, policy and institutional reforms are necessary to create an enabling environment for NbS.**

Mandating cross-departmental collaboration through 'joint task forces' or working groups involving environment, urban development, water resources, and agriculture departments can help overcome siloed approaches.

Updating infrastructure policies to integrate NbS with grey infrastructure, such as combining wetlands with stormwater systems, can promote hybrid solutions.

**Regulatory and planning frameworks must embed NbS into master plans, zoning regulations, and environmental impact assessments.**

Policies should also mandate long-term maintenance and stewardship of NbS, with clear funding and accountability mechanisms to ensure sustainability. Institutionalising participatory planning processes will allow local communities to contribute their knowledge and address their needs, enhancing the relevance and acceptance of NbS interventions.

**Finally, public awareness and engagement play a vital role in driving NbS adoption.**

Nationwide awareness campaigns can educate stakeholders and the general public about the benefits of NbS. Showcasing successful projects through the media, conferences, and awards can inspire replication and scaling. Involving citizens in monitoring and maintaining NbS through citizen-science initiatives can foster a sense of ownership and stewardship, ensuring better operations and maintenance.

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Thus, a comprehensive approach that addresses both bottom-up and top-down barriers through robust evidence, capacity-building, policy reforms, and public engagement can unlock the potential of NbS in India. This integrated strategy is key to enhancing climate resilience, promoting sustainable development, and supporting inclusive growth.

**To learn more about addressing knowledge, design, governance, and finance barriers to mainstream NbS in India, read our report Unlocking Nature-Based Solutions, produced in collaboration with the Rocky Mountain Institute and Oak Foundation.**

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## Acknowledgements

We are grateful to Oak Foundation for their support in making this work possible.

### Published
October 2025

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### Cover Page Design
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**Suggested Citation** Sundaresan, R., & Nayak, N. (2025). Barriers to Mainstreaming Nature-Based Solutions in Urban India. WELL Labs, Institute for Financial Management and Research (IFMR) Society.

## About WELL Labs

WELL Labs is transforming water systems at scale across India through research, partnerships, and collective action. We take on audacious challenges, tackling complex problems by designing comprehensive solutions that provide large social returns. Our work is science-led and community-focused. We address the interconnections between water, environment, land, and livelihoods. To create impact at scale, we embed solutions within governments, work with the private sector, and collaborate with civil society and active citizens. Based in Bengaluru, WELL Labs is part of the Institute for Financial Management and Research (IFMR) Society.

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