WHITE PAPER

Making an Economic Case for Nature-Based Solutions in Anekal, Karnataka

July 2024 | Radhika Sundaresan

TABLE OF CONTENTS

Executive Summary

India's urbanisation narrative is entering a new phase, one in which the significance of small and medium towns is on the rise. Cities are sprawling outward, with continuously expanding urban boundaries. This over-spill of population and increasing demand for resources such as water and agricultural produce is accommodated within and by the peri-urban regions of cities. Small- and medium-sized towns also play a vital role in the process of peri urbanisation in India, but are not taken into account in the literature (Shaw & Das, 2018).

Anekal taluk[1] is one such town that lies in the southern part of the Bengaluru Urban district, known for the Bannerghatta wildlife sanctuary, Jigani industrial estate, silk industry, and Electronic City. The Chandapura-Anekal stretch is an emerging residential hub. Anekal is located approximately 36 km from Bengaluru and around 15 km from Hosur and Electronic City. As a fast-growing suburban area, Anekal faces high water scarcity, groundwater depletion, and reduced water quality based on the analysis done by WELL Labs using DHI tools.

Traditional "grey" infrastructure solutions to these issues are often costly and unsustainable. The need for clean water in the taluk's pharmaceutical industries has resulted in the Bengaluru Water Supply and Sewerage Board (BWSSB) supplying Cauvery water to them. However, ordinary citizens still depend on depleting and unsafe groundwater for drinking. So, there is an urgent need to address quality, quantity, and equity concerns in the heavily water-stressed region of Anekal.

Nature-based solutions (NbS) offer a cost-effective and environmentally friendly alternative. This white paper makes an economic case for investing in NbS in the Indian context. It outlines the opportunities for bio-physical benefits, income generation, and economic resilience, and provides a sample cost-benefit analysis to illustrate the returns from NbS initiatives.

[1] A taluk or taluka is an administrative unit in India comprising several villages. A district is composed of many taluks.

Introduction

Anekal taluk, located in the Bengaluru-Chennai industrial corridor, has emerged as Bengaluru's industrial hub, with many highly polluting chemical and pharmaceutical factories. While this industrial development has provided an economic boost to the region, it has also resulted in extraordinary negative externalities in the form of pollution of rivers, lakes and underground aquifers. (Gowda et al., 2010)

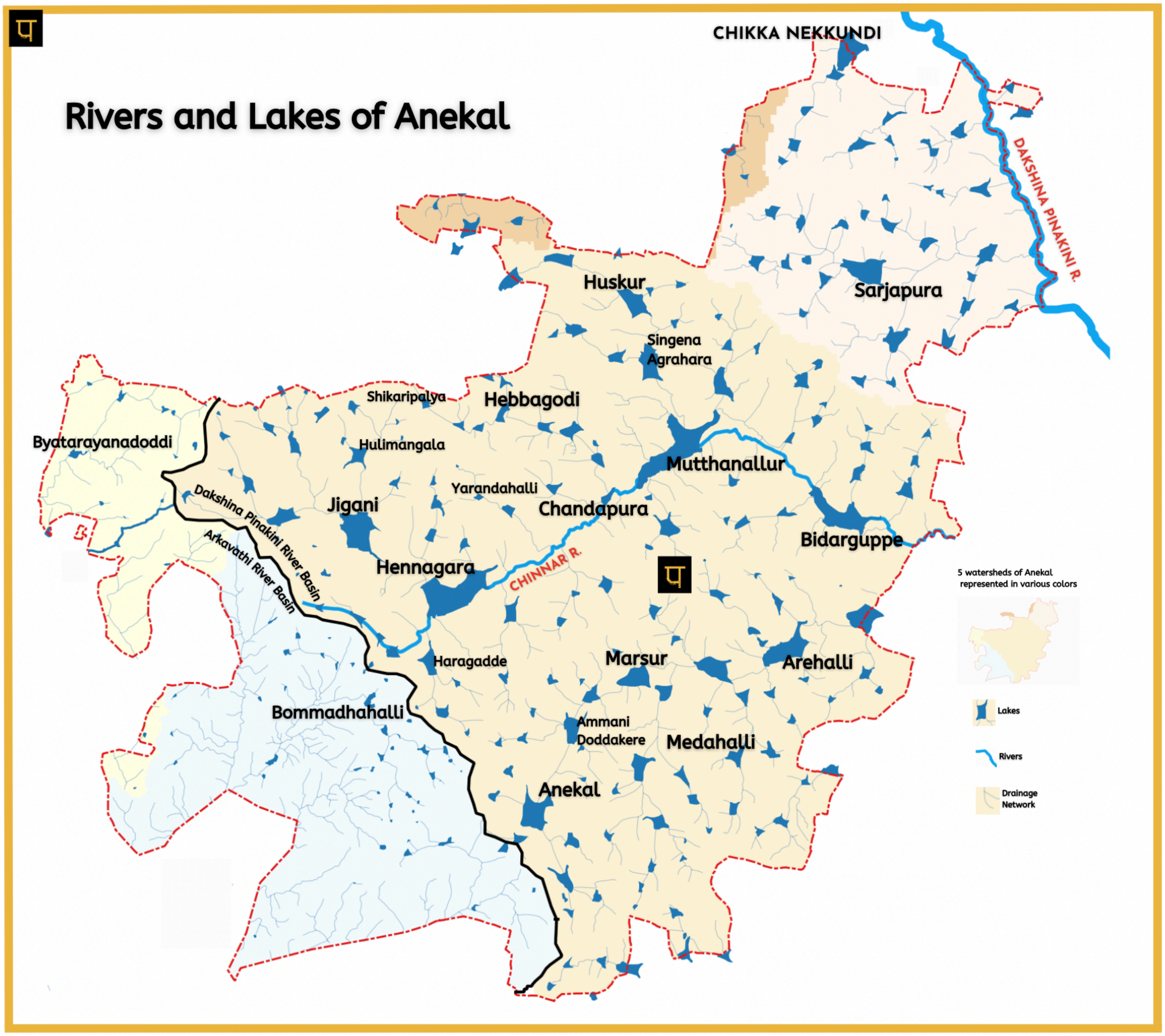


Figure 1: Map of Rivers, Lakes and Watersheds of Anekal. Source: [Paani.Earth]

The interactive map of Anekal taluk by Paani Earth visualises key water resources and environmental stressors in the region. It shows the three major rivers — Chinnar, Suvarnamukhi, and Dakshina Pinakini — as well as 285 lakes and their interconnected drainage network, spanning 533 square kilometres.

Overview of key water challenges in Anekal and the need for nature-based solutions

Anekal's urban area is expected to grow from 16% to 52% in the next decade based on the analysis done by WELL Labs using DHI water tools. This will result in an increase in impervious surface, making Anekal more prone to flooding. Encroachments on drainage channels have exacerbated the problem. A detailed map of Land use Land Change (LULC) gives a good understanding of how Anekal will expand in the near future.

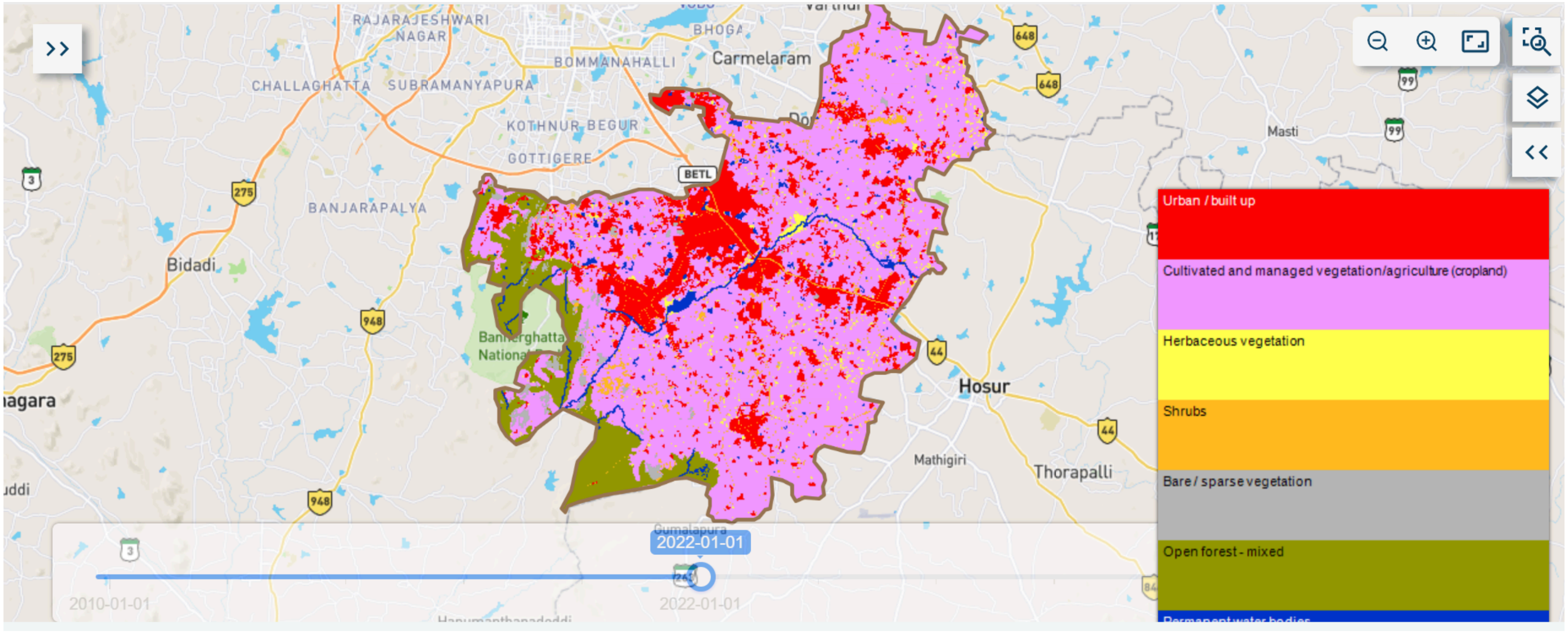


Figure 2: Land use in Anekal, 2022. Source: DHI water tools

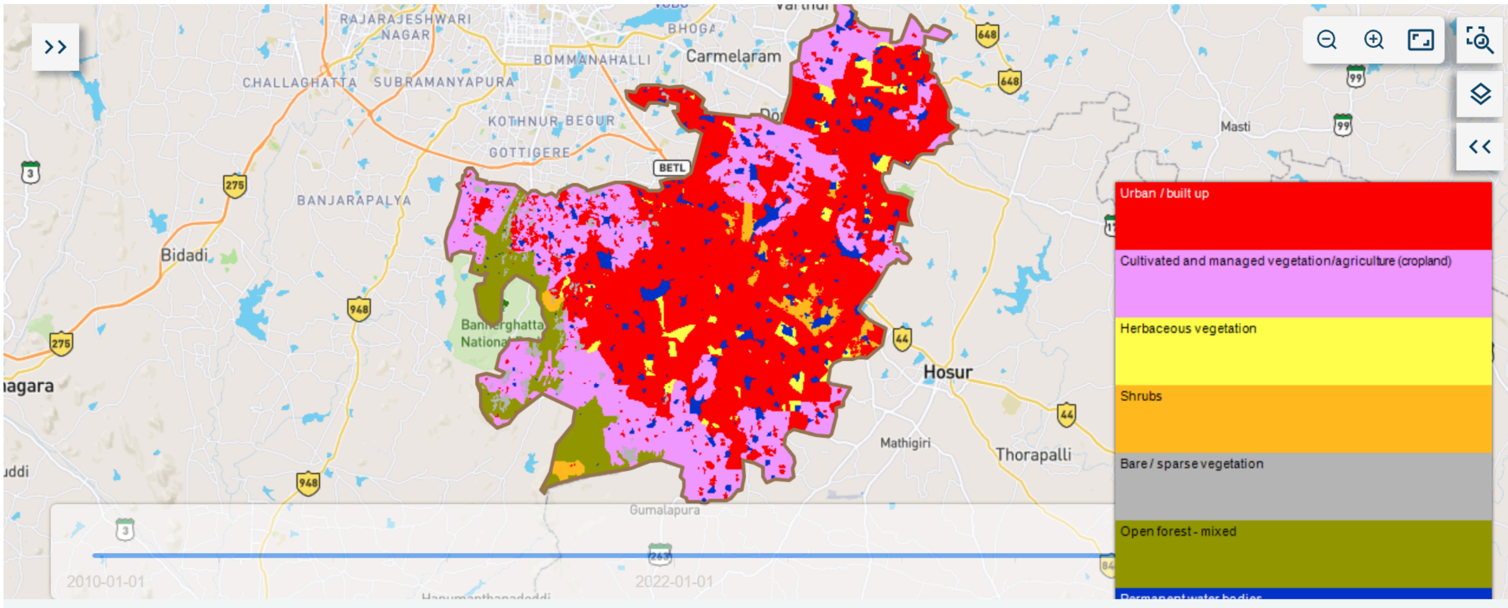


Figure 3: Land use in Anekal, 2031. Source: DHI water tools

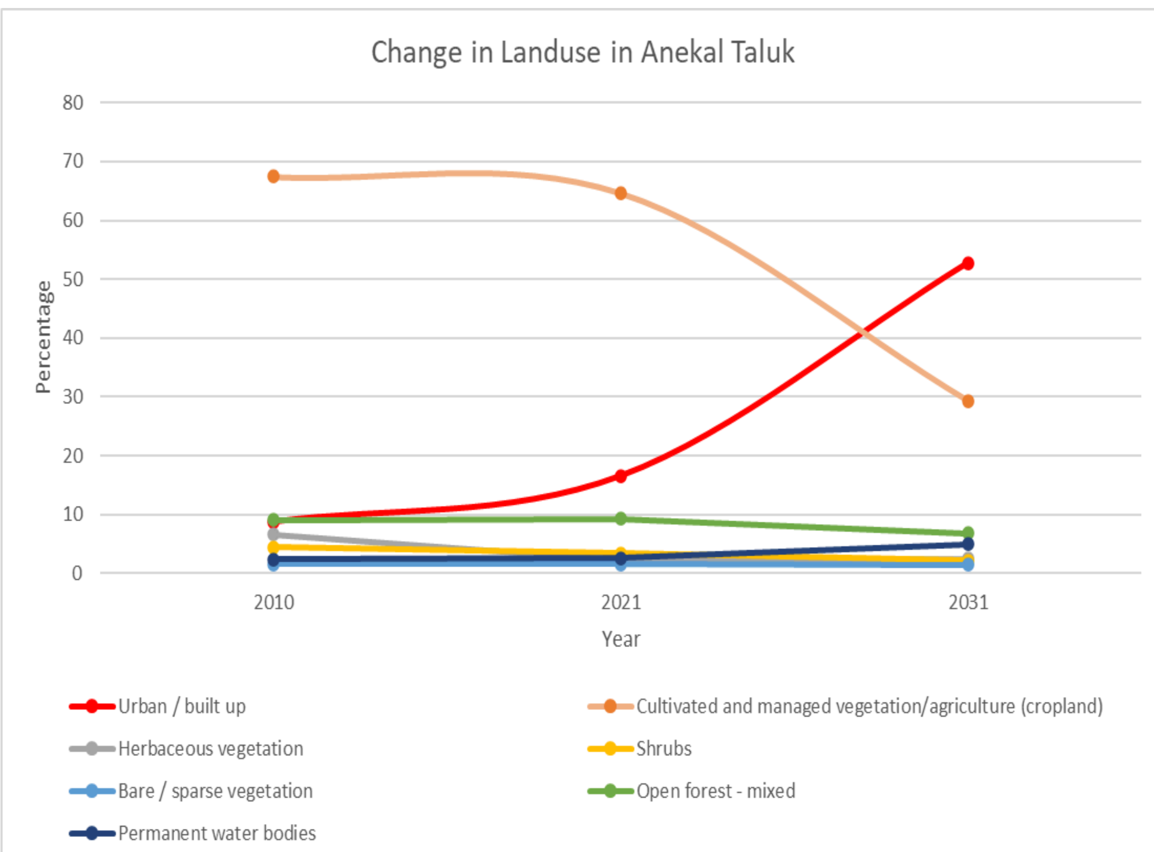


Figure 4: Change in landuse in Anekal taluk over the years from 2010-2031. Source: DHI water tools

Based on Water Resilience Coalition's Watershed Diagnostic Template (Microsoft, 2023), the main water challenges in Anekal are:

Water Quality

Many groundwater assessment units are contaminated with nitrate and/or salinity from geogenic and anthropogenic causes. Untreated effluents from industries and households are the major reason for low water quality in rivers and lakes. Only 9% of domestic and industrial wastewater is safely treated.[2]

Studies have also found issues with the physicochemical and biological quality of groundwater in Anekal, with high levels of contaminants like fluoride, nitrates, and E.coli. This poses health risks for residents relying on this water source.

Water Quantity

All assessment units in urban Bengaluru, including Anekal, are classified as overexploited in terms of groundwater usage. The groundwater recharge rate is very low compared to extraction, causing depletion of this resource. Surface water stress level is 11.4% and groundwater stress level is very high at 167%.[3] Over-extraction of groundwater is common as most areas depend on it due to temporal and spatial variability of surface water. Lack of regulation on groundwater extraction and wastewater recycling aggravates the problem further.

Access to Water and Sanitation

Anekal has the lowest density of piped water connections per household compared to other sub-districts in Bengaluru East. This leads to heavy reliance on groundwater and water tankers, which is unsustainable. Access to safely managed drinking water services is low in rural areas (27.01%) compared to urban areas (100%).[4] Many rural households access water from sources like tanks, rivers, lakes or from sources not within their premises. Water sources also go dry during some seasons.

100% toilet coverage was achieved by building community and public toilets, but many are not functional or used due to lack of water supply, awareness, space, and affordability. Access to functional toilets with water supply is lacking for all households. The map below shows the distribution of access to water and sanitation.

[2] DHI Water Tools
[3] DHI Water tools
[4] DHI Water tools

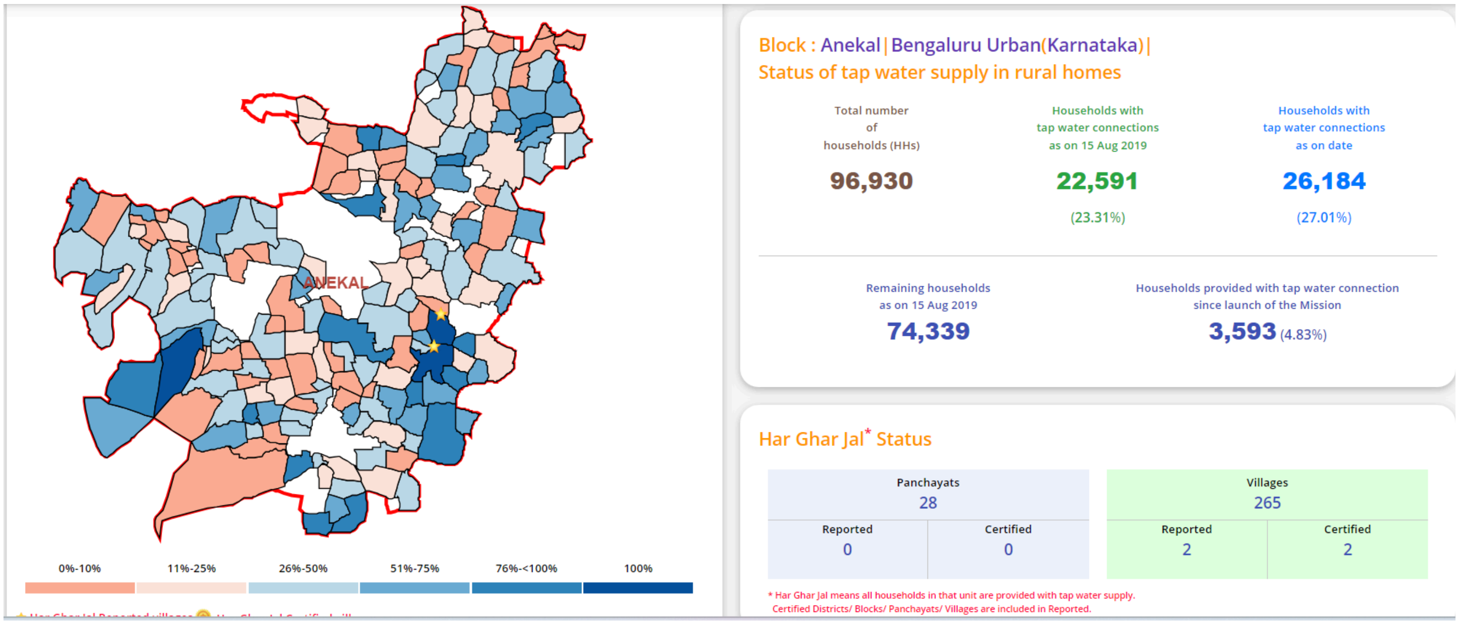


Figure 5: Access to drinking water in rural areas. Source: JJM Dashboard

Coordination and Infrastructure

Addressing the challenges of inequitable access to piped water, overexploitation of groundwater, neglected water infrastructure like lakes and drainage, and poor groundwater quality requires coordinated efforts by various government agencies and community stakeholders. Coordination is currently lacking because different departments related to the water sector work in silos. Inadequate infrastructure for water supply, wastewater treatment, and source sustainability measures and lack of funds for maintenance and upgradation of distribution systems aggravates the problem further.

The need for Nature-based solutions

NbS can address water supply through managing precipitation and humidity, and water storage, infiltration and transmission, thereby, improving the location, timing and quantity of water available for human needs. This is especially important as traditional options like building more reservoirs become increasingly limited. NbS like natural wetlands, improved soil moisture, and groundwater recharge can be more sustainable and cost-effective than traditional grey infrastructure. (GFDRR, World Bank).

Defining Nature-based Solutions

IUCN defines Nature-based Solutions 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. The aim of nature-based solutions is to build resilient ecosystems, whether natural, managed, or newly created, that can provide solutions for the benefit of both societies and biodiversity.

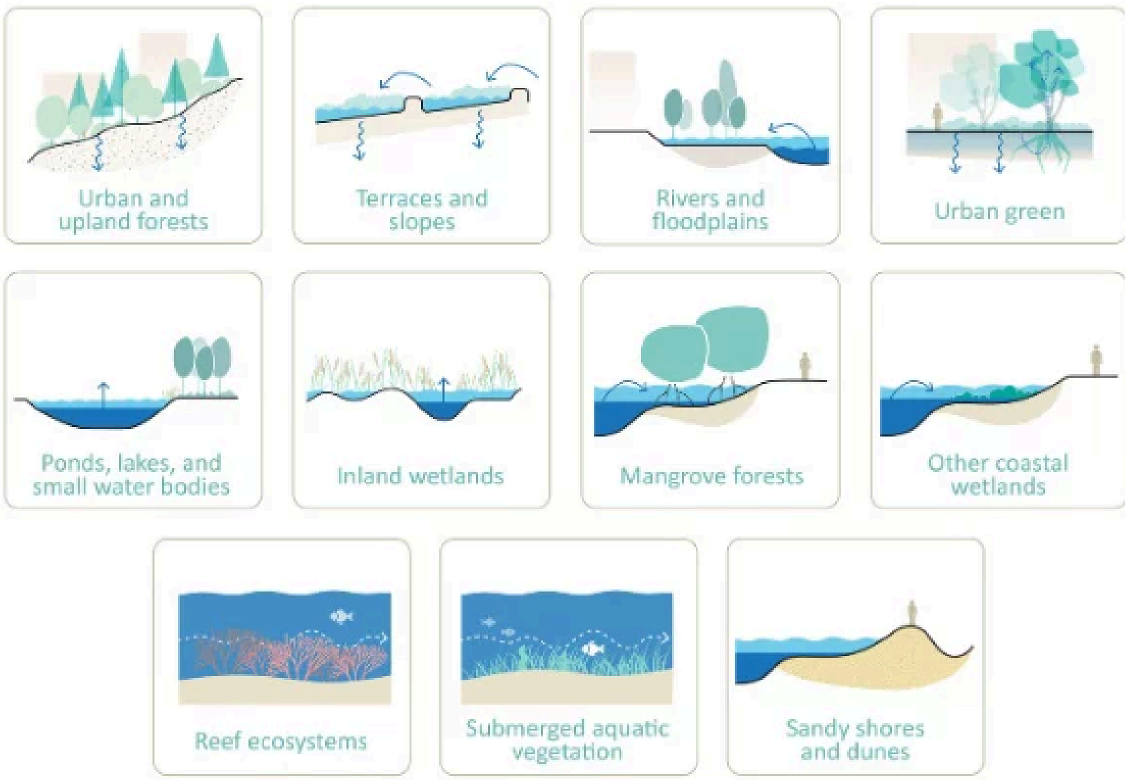


Figure 6: NBS for climate resilience families
Source: Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers, World Bank

NbS provides multi-functional benefits such as climate regulation, water purification,disaster risk reduction and biodiversity enhancement. These solutions are sustainable, resilient, and implemented using the involvement of the community. NBS can be applied in urban and rural settings, adapting to specific contexts and needs.

Estimates suggest nature-based solutions can provide 37% of the climate change mitigation needed by 2030 to meet Paris Agreement targets.Many cities and agencies are incorporating NbS into projects for water management, disaster risk reduction, and other areas. NbS are seen as a cost-effective way to address multiple development challenges simultaneously.

Ecosystem Services

Nature-based solutions (NbS) can be considered as a form of ecosystem services, as they leverage the natural functions of ecosystems to address various societal challenges while simultaneously providing benefits to both people and biodiversity.

Ecosystem services in India encompass a wide range of benefits derived from natural ecosystems, which are crucial for human well-being and economic development. These services can be categorised into **provisioning, regulating, cultural, and supporting services.**

Key Ecosystem Services:

Provisioning Services: These include the supply of food, fresh water, timber, and other raw materials. India's forests and agricultural systems are vital for providing these resources, which are essential for the livelihoods of millions.

Regulating Services: Ecosystems play a critical role in regulating climate, air quality, water flow, and soil fertility. For instance, forests in India significantly contribute to carbon retention, which is crucial for climate change mitigation. The economic value of carbon retention alone surpasses the gross value added of the forestry sector.

Cultural Services: Natural landscapes in India support recreational activities and cultural practices, contributing to tourism. The economic value of ecosystem services related to nature-based tourism has seen a substantial increase, highlighting the importance of preserving these natural areas for both ecological and economic reasons.

Supporting Services: These include nutrient cycling and soil formation, which are fundamental for the production of other ecosystem services. Healthy ecosystems support biodiversity, which in turn enhances the resilience of these systems against environmental changes. (Government of India, 2020)

Classifying the services is crucial to ensure all aspects of benefits provided by an ecosystem can be captured to eventually conduct an economic valuation of services provided. Despite the recognition of ecosystem services' importance, several challenges persist, especially in the Indian context. There are significant gaps in spatially explicit data on various ecosystem services. There are significant gaps in literature too to quantify the ecosystem services, this will be dealt with in the upcoming sections.

Selecting appropriate NbS for Anekal

The project required suggesting specific NbS interventions that can be implemented in Anekal's landscape based on the information we have on other NbS projects that have been implemented in the area. Unfortunately, there are no NbS projects in Anekal that have been implemented and can be used as an example. As a solution to this, this working white paper documents projects that have been implemented in other areas of India. The compendium of case studies documented can be used as a starting point to design and implement similar projects in other parts of the country making specific adjustments to suit the local hydrogeological characteristics of the area where it can be adopted.

Compendium of case studies in the Indian context

Anekal is an evolving peri-urban area similar to Chintamani, (Ramamoorthy et al., 2024) another city in the outskirts of Bengaluru. A periurban interface is a socioeconomic-environmental interface where all three systems comprising agriculture, urban dimension, and natural resources constantly interact with one another (Allen, 2003; Narain & Nischal, 2007). The fact that what is peri urban today would be urban tomorrow makes it significant to plan for sustainable development of peri urban areas, specially through the lens of water security. Hence, we have chosen a mix of urban, peri-urban and rural NbS solutions that can be implemented in Anekal. The table below lists out appropriate NbS that can be implemented in different parts of Anekal based on the localised context of the location where the project is being chosen to be implemented.

Table 1: Compendium of case studies of NbS implemented in India

Type of NBS	Urban/Rural	Scale
Green Roofs, Prestige University, Indore	Peri-urban	Institutional
Rainwater harvesting, Tughlakabad Institutional Area, New Delhi	Urban	Institutional/Site

Lake restoration, Sembakkam Lake, TN	Peri-urban	Community level/ open space
Rain gardens, Begumpet, Hyderabad, TS	Urban	Community level/ open space
Bioswales , Sheshadri Marg, Kondapur well, TS	Urban	Community level/ open space
Wastewater pond technology with anaerobic, facultative, and maturation ponds in Trichy, India	Urban	City
Parks : Yamuna Biodiversity Park	Urban	City
Zero Tilling – Sugar Cane Field, Belgaum, Karnataka	Rural	Plot level
Mulching	Rural	Plot level
Zero based Natural Farming (ZBNF) Prakasam District, Andhra Pradesh	Rural	13 acres of farmland
Zero based Natural Farming (ZBNF) in Andhra Pradesh West Godavari, Prakasam, Vizianagaram, and Anantapuramu.	Rural	District Level

Green Roofs, Bioswales, Rain Gardens, Detention Ponds and Permeable Pavements are interventions that can be implemented in urban and peri-urban areas. Wastewater treatment using NbS can be a good method to reduce the level of polluted wastewater from industries that can be used for irrigation in locations such as Anekal. These interventions can be implemented in rural areas too with necessary modifications. Agroforestry, Zero-based Nature Farming, farms ponds, zero tilling and mulching are rural interventions that can be implemented in the climate-smart agriculture context.

Quantification of Water and Energy-based Indicators

For Beyond the Boundary 2, the indicators chosen follow the themes pooled from EU-NbS Practitioners Handbook, SEBI-BRSR for Sustainability disclosures), World Bank, S&P global, MSCI Climate Index.

The key water-based indicators used to measure the performance of NbS include:

Table 2: Water-based indicators to measure performance of NbS

Metric	Description
Infiltration rate	Measures the rate at which water enters and moves through the soil
Groundwater recharge	Measured by changes in groundwater levels and depth to groundwater
Runoff rate	Quantified as the percentage change in runoff rates
Water quality	Measured by changes in pollutant levels, faecal coliform content, and other water quality parameters

The energy-based indicators include:

Table 3: Energy and carbon based indicators to measure performance of NbS

Metric	Description
Carbon Management	Quantified as the change in carbon emissions due to NbS implementation
Energy Footprint	Measured as the change in energy use and savings due to NbS

As a next step, we map out the different indicators with the metrics to measure various variables that can measure the efficacy of NbS to tackle the challenges being addressed

Table 4: Map of indicators to different challenges that Anekal faces:

Theme	Challenge[5]	Variable	Data/metric to determine the indicator effectiveness	Unit
Environmental indicator	Climate resilience	Carbon storage/emissions / sequestration	Total carbon removed or stored in vegetation and soil per unit area per unit time	kg/hectare/year
			Avoided greenhouse gas emissions from reduced building energy consumption	tCo2 equivalent/year
			Carbon emissions due to treatment of runoff water (stormwater/sewage)	tCo2 equivalent/year
		Green-house gas (GHG) footprint	Total Scope 1 emissions (Break-up of the GHG into CO2, CH4, N2O, HFCs, PFCs, SF6, NF3, if available)	GHG (CO2e) Emission in Mn MT / KT / MT Direct emissions from organisation's owned- or controlled sources
			Total Scope 2 emissions (Break-up of the GHG (CO2e) into CO2, CH4, N2O, HFCs, PFCs, SF6, NF3, if available)	GHG (CO2e) Emission in Mn MT / KT / MT Indirect emissions from the generation of energy that is purchased from a utility provider
			GHG Emission Intensity (Scope 1 +2) - urban, rural water systems	Total Scope 1 and Scope 2 emissions (MT) / Total Revenue from Operations adjusted for PPP
				Total Scope 1 and Scope 2 emissions (MT) / Total Output of Product or Services

[5] indicators as listed on EU-NbS Practitioners Handbook, SEBI-BRSR for Sustainability disclosures), World Bank, S&P global, MSCI Climate Index

Environmental indicator	Water management	Water Quality	Water quality: general urban	various
			Water quality: total fecal coliform bacteria content of NBS effluents	%
			Nitrogen and phosphorus concentration or load	%
		Water consumption	Total water consumption	Mn Lt or KL
			Water consumption intensity	Mn Lt or KL / Water intensity per rupee of turnover
				Mn Lt or KL / Product or Service
			Water Discharge by destination and levels of Treatment (surface water, ground water, sea water, sent to third parties, others)	Mn Lt or KL
		Drought vulnerability	Depth to groundwater	metres
		Water stress	Levels of water stress	% change
Environmental indicator	Natural Capital Management	Biodiversity enhancement	Number of native species	% shift
Social indicator	Enhancing Employee Wellbeing and Safety	Wellbeing	Quality of life	Rating (on a scale of 5)
Social indicator	Food Security	Agriculture, forestry, fishing, value added	Produce or units produced per ha/acre of land used	% of GDP
Economic indicator	Enabling Inclusive Development	Sustainable job creation in smaller towns	Wages paid to persons employed in smaller towns (permanent or non- permanent /on contract) as % of total wage cost	In % terms – As % of total wage cost
Economic indicator		Economic opportunities	Economic value of urban nature	INR

Governance indicator	Policy and regulatory effectiveness	Access, usage, and quality of finance	Estimate	%
Governance indicator	Business and Economic Environment	Overall impact of business and economic health of the region	Estimate	%
Governance indicator	Innovation	Scope of innovation in the region	Estimate	Extent of how effective an NbS intervention is improving the extent of innovation
Governance indicator	SME financing	SMEs involved in NbS implementation and vice-versa benefitting through its implementation	Number	Number of SMEs impacted with the NbS interventions

Estimating the Economic Value of Ecosystem Services

The need for estimating the economic value of ecosystem services is as follows:

Economic valuation provides an objective way to compare the benefits derived from different ecosystem services, or the impacts of different policy decisions on ecosystem services. It allows for comparing the benefits of public investment in ecosystem services regulation or delivery with the benefits of other policy programs, such as in healthcare or defence. This helps inform policy decisions on resource allocation.

Working on economic valuation provides insights into how markets operate with respect to ecosystem services, many of which are not traded in traditional markets. This can help identify market failures and externalities that lead to suboptimal allocation of resources for ecosystem protection. Since many ecosystem services are not bought and sold in markets, their value is not captured. Economic valuation techniques can quantify the monetary value of these non-market benefits, allowing them to be considered in decision-making alongside more easily measured market values. By attaching economic values to ecosystem services, decision-makers can better prioritise and justify programs, policies, or actions that protect or restore ecosystems and the services they provide.

In summary, economic valuation of ecosystem services is crucial for making informed, evidence-based decisions about the use and management of natural resources, and ensuring their sustainable provision for the benefit of society.

List of ecosystem valuation methods that can be used for the compendium of case studies documented for this project:

Table 5: Revealed Preference Approaches

Valuation method	Description	Benefit
Travel cost	Costs incurred in the travelling required to consume or enjoy a benefit provided by green infrastructure	Recreational value
Hedonic pricing	Measured as the change in energy use and savings due to NbS	Property prices and Land productivity

Table 6: Direct Market Valuation

Valuation method	Description	Benefit
Market price	Valuations are directly obtained from the prices paid for the good or service in markets	Carbon Sequestration, Crop Yield

Replacement cost	Measured as the change in energy use and savings due to NbS	Water Quality, Groundwater Recharge
Avoided cost	Economic losses that would be incurred if a particular form of green infrastructure were removed or its function significantly impaired	Flood Damage, Air Pollution, Drought, Urban Heat

Table 7: Stated Preference Approaches

Valuation method	Description	Benefit
Travel cost	Costs incurred in the travelling required to consume or enjoy a benefit provided by green infrastructure	Recreational value
Hedonic pricing	Measured as the change in energy use and savings due to NbS	Property prices and Land productivity

Methodology for conducting cost-benefit analysis for nature-based solutions

The methodology for conducting a cost-benefit analysis (CBA) of NbS involves the following key steps:

1. **Identify and Characterise Ecosystem Services:** The first step is to identify the relevant ecosystem services provided by the NbS and characterise them as either qualitative or quantitative benefits.
2. **Cost Estimation:** The next step is to estimate the costs associated with implementing the NbS, including capital expenditures (CAPEX), operational expenditures (OPEX), and any transaction costs.
3. **Benefit Valuation of NbS Actions:** The quantitative benefits of the NbS are then quantified using appropriate indicators and metrics. These biophysical data are then translated into monetary values using various valuation methods.
4. **Economic Valuation of Goods and Services:** The economic value of the goods and services provided by the ecosystem services is determined using techniques such as market price, replacement cost, avoided cost, and contingent valuation.
5. **Conduct a Cost-Benefit Analysis**: Finally, a CBA is conducted to compare the costs and benefits of the NbS and determine its overall feasibility and viability

Framework for cost-benefit analysis of NbS:

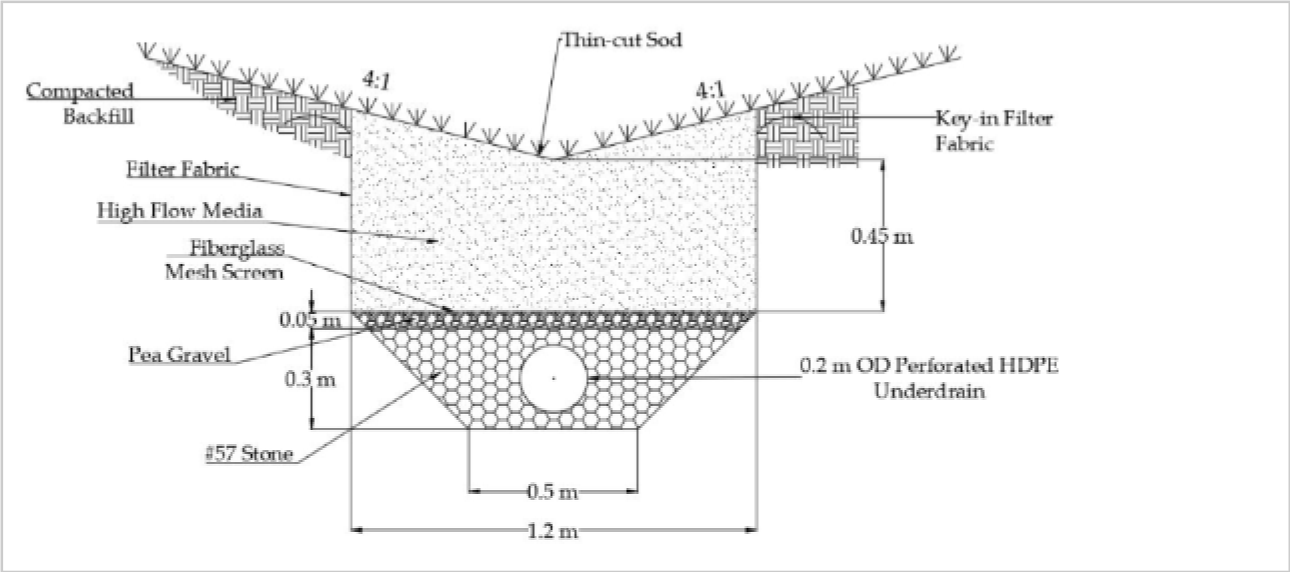
NbS Type	**Costs**			**Comparative grey infrastructure cost**	**Benefits**			
	CAPEX	**OPEX**	**Transaction Costs**		**Environmental**	**Economic**	**Social**	**Governance**
Intervention 1					Improve water quality by reducing pollutant levels			
Intervention 2					Reduction in flood risk and erosion			
Intervention 3					Groundwater recharge			
Intervention 4					Increased aquifer recharge			

Cost Benefit-Analysis for Bioswales in Kondapur, Hyderabad

Cost-benefit analysis (CBA) is essential for NBS because it helps the investor in making informed decisions to plan for implementation, and estimate various benefits by assigning a dollar valuation or INR valuation to the benefits accrued. CBA provides a framework for evaluating the economic viability of NBS, which is crucial for securing funding and justifying investments. Without CBA, NBS often struggles to compete with traditional engineering solutions, despite their potential to provide multiple ecosystem services such as flood management, clean water, and disaster risk reduction. For instance, the use of mangroves for coastal protection in Indonesia has been shown to be economically viable, but only through rigorous CBA (World Bank, 2022).Therefore, developing robust CBA methods for NBS is vital to ensure their effective integration into climate resilience strategies and to support sustainable development

The CBA was conducted for the case study of bioswales in Kondapur. The capex and opex of the case study was obtained from the rainwater project. The benefits were listed, quantified and an equivalent economic valuation of the benefits was obtained. The CBA curve below was arrived at using a CBA tool. Owing to limited data availability, only 4 out of 9 benefits have been quantified. This leads to the benefits being undervalued. To account for this reduction in valuation of benefits, costs have been reduced for this case study by making a few assumptions as listed below. This is to ensure that the investors get a better idea about the cumulative Net Present Value (NPV)

Cost split up of a bioswale patch in India can be found in this sheet.



Conducting a CBA, we get the following curve for cumulative NPV which is for representative purposes alone. The curve shows investors that NBS solutions such as bioswales begin to show profit for the investors after a few years of investing. In this case, it takes 18 years to break even. The count in the number of years for breakeven may happen earlier if all costs and benefits are accounted for.

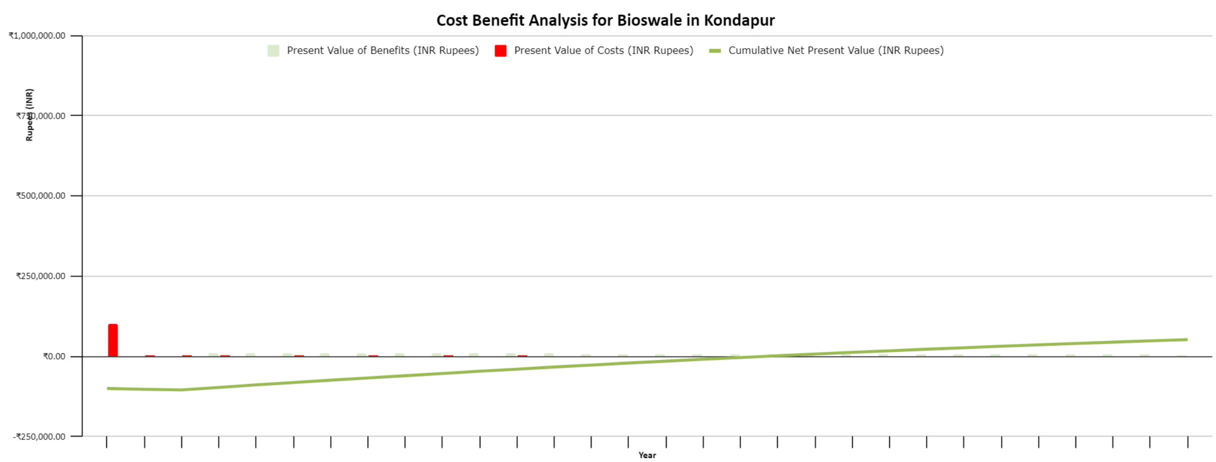


Figure 7: Cost-benefit analysis curve for the bioswales project implemented in Kondapur, Hyderabad, Telangana (assuming lesser costs accounting for 4/9 benefits quantified)
Source: WELL Labs

Similarly, other projects can be quantified and evaluated to arrive at a project-specific CBA. It is very important to account for design and costing differences that will come into place due to differences in local aquifer characteristics.

Conclusion

There are several gaps in the current understanding and implementation of NbS in India. Projects are usually implemented at very small scales and there is no documentation of costing details or the benefits that a project creates. A very important point to remember in NbS is that benefits take time to accrue. This makes it very important for organisations or civic bodies investing in NbS to factor in operations and management costs. Documentation of benefits accrued is another data point that is generally not available. If the benefits are documented properly mentioning details of the local aquifer and extent of urbanisation, economic valuation of benefits becomes more robust and easy to calculate. From an economic perspective, the lack of standardised unit cost per unit of NbS benefit poses a great challenge for investors. Not having unit cost per unit of benefit does not allow a planner to create a bespoke model from a purely costing perspective.

Technical design manuals explaining the steps to be followed during the gestation period of the project, and how the operations and maintenance have to be taken care of are crucial to ensure good standards of the project being implemented. Further, developing comprehensive monitoring and evaluation frameworks along with proper risk management frameworks will be important next steps.

To address these gaps, the report recommends the development of a unit cost per unit benefit for the Indian context, the creation of technical design manuals for each NbS intervention, the mapping of policy barriers, and the development of hydrological heuristics to aid in the quantification of benefits.

This will act as a basic reference to scale up the integration of nature-based solutions into already existing grey infrastructure thus improving resilience of cities and towns.

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