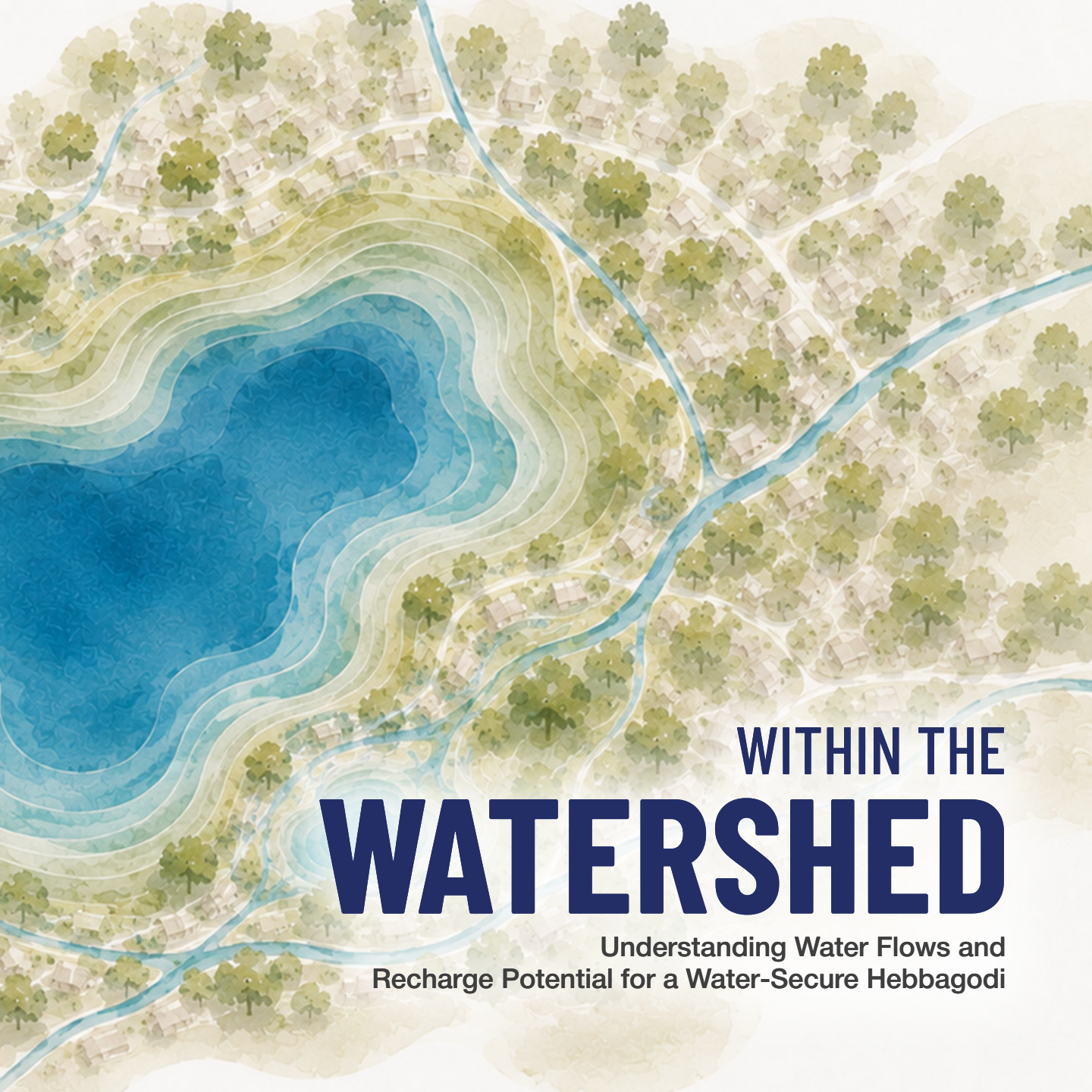




WITHIN THE **WATERSHED**

Understanding Water Flows and
Recharge Potential for a Water-Secure Hebbagodi



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All illustrations are created through AI based on the author's analysis and data from Innpack solutions and Elixirgeotech Consultancy Services. All photos by FISH-BORDA.



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WITHIN THE
WATERSHED

1 THE CHANGING WATER STORY OF INDIA'S SMALL TOWNS

Understanding how rapid urbanisation is reshaping water systems across India's emerging towns

India's urban transition is increasingly unfolding in small and medium towns. As these settlements expand through industrial growth, improved connectivity and outward development from larger cities, they are emerging as important centres of economic activity. (Economic Survey, 2025-26) Unlike metropolitan cities, however, many of these towns are urbanising without corresponding investments in infrastructure, institutional capacity or long-term spatial planning. As a result, natural systems that once regulated water are being transformed faster than they can be understood or managed. (World Bank, 2023)

The Water Challenge in Small Towns

1 Small towns are growing

3,984 → 5,704

Indian towns with fewer than 100,000 residents



+40% in one decade
2001–2011

Source: Census 2001–2011

2 Small towns rely heavily on groundwater

Up to 46%

of households in India's smallest town classes rely on wells, handpumps or tubewells for drinking water



Source: Census 2011; NIUA, Towns of India

3 Responsibilities are fragmented

Different agencies manage supply, drains, groundwater and lakes, while limited staff and data at ULB level constrain coordinated planning.



Four Shifts Putting Pressure on Water Systems



Limited Capacity

Rapid growth, limited technical capacity and fragmented responsibilities make long-term contextualised water planning difficult.

Source: *Following the Flows*, BORDA-FISH, 2025; *Economic Survey*, 2025-26



Changing Climate

Erratic rainfall, intense storms and longer dry periods are increasing pressure on already stressed water systems.

Source: *Chintamani CAP*, BORDA-FISH, 2025



Disrupted Water Flows

Urbanisation alters natural drainage, reduces infiltration and disconnects water from the landscape.

Source: *Following the Flows*, BORDA-FISH, 2025)



Inter-connected Water Challenges

Groundwater dependence, urban flooding, polluted surface water, groundwater and stormwater are interconnected, not separate problems.

Source: *Following the Flows*, BORDA-FISH, 2025; *Chintamani Climate Action Plan*, BORDA-FISH, 2025)

What happens when a rapidly growing town begins to outgrow its water system?

Hebbagodi
is one such story.

Source: Pexels, Roy A, 2025

2

HEBBAGODI: A SMALL TOWN IN TRANSITION

Located along Bengaluru's southern growth corridor, between Electronic City and the Hosur industrial region, Hebbagodi has experienced rapid urban expansion over the past decade. Its strategic location has attracted industries, technology parks, educational institutions and residential development, transforming the municipality into an important economic node within the Bengaluru Metropolitan Region. Reflecting this rapid growth, Hebbagodi was directly upgraded from a Gram Panchayat to a City Municipal Council in 2015, bypassing the Town Municipal Council stage. Today, the municipality supports a resident population of approximately 1.32 lakh, alongside a substantial floating population drawn by employment and industrial activity (Reuse for Resilience, BORDA-FISH, 2026).

Hebbagodi at a Glance



Population
~1.32 lakh



Floating population
~13,000



Average annual rainfall
~1,000 mm



Administrative status
City Municipal Council (2015)



Strategic location
Bengaluru-Hosur Growth Corridor

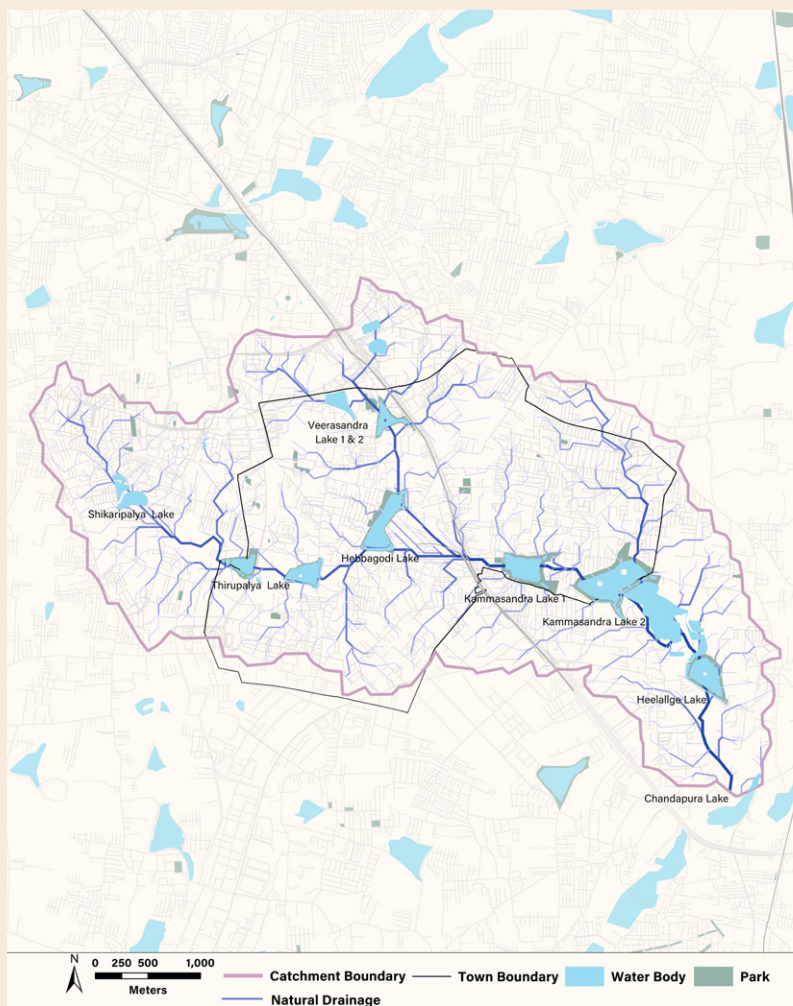


Major employment hubs
Infosys, Wipro, Titan, Biocon and surrounding industrial estates

Understanding how rapid urban growth is reshaping water in Hebbagodi

Hebbagodi forms part of the Bommasandra-Heelalige watershed, one of the four sub-catchments draining towards Chandapura Lake. Although municipal boundaries define governance, water follows watershed boundaries. Understanding these natural connections provides the foundation for interpreting how rainfall, lakes, groundwater and drainage interact across the town.

7 lakes in the Bommasandra Heelalige watershed falls within the Hebbagodi municipal boundary.

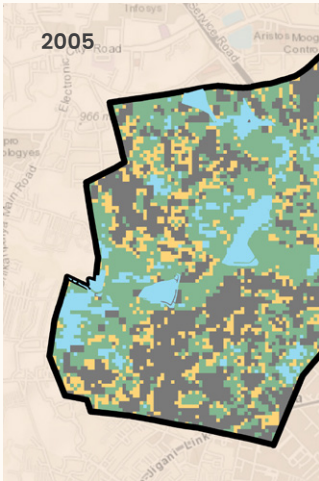
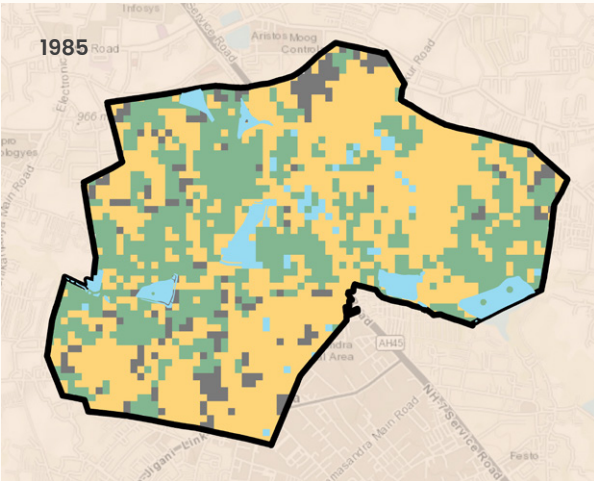


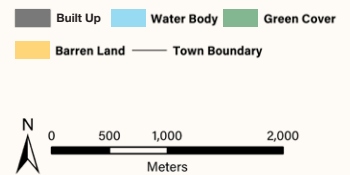
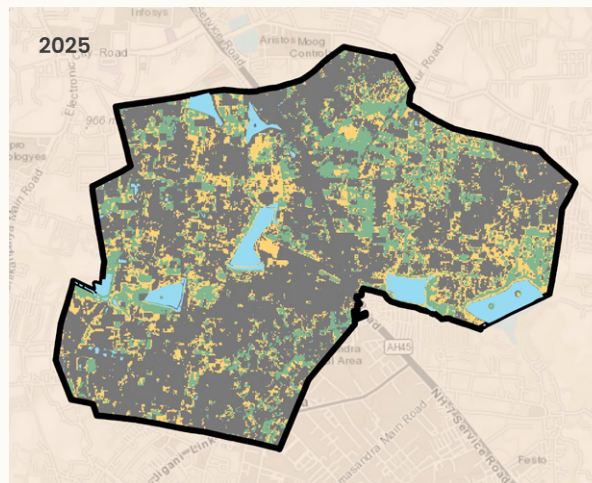
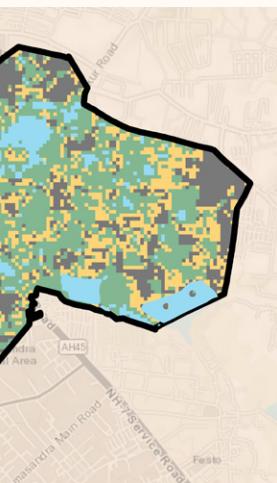
Source: Integrated Action Plan (CDD India- WIPRO)

Over the last two decades, Hebbagodi's landscape has changed significantly as open land and scattered settlements have gradually given way to industries, residential layouts, commercial developments and transport infrastructure. Satellite imagery shows that this transformation extends beyond the built environment and has also altered the way water moves through the town. Natural drainage corridors have been modified, impervious surfaces have increased, and lakes that once functioned as interconnected components of the landscape are now increasingly isolated from their catchment.



**Land Use
Transformation
(1985 - 2025)**





Source: Sentinel 2 and Authors Analysis

3 BUILDING THE EVIDENCE

Bringing together multiple perspectives to understand Hebbagodi's water system

Understanding Hebbagodi's water system required combining existing knowledge of the wider watershed and municipal water system with detailed assessments of the landscape and subsurface conditions. Existing studies provided the broader context, while additional spatial and hydrogeological assessments, supported by field investigations and stakeholder consultations, helped identify where and how water security could be strengthened.



Integrated Action Plan

CDD India | WIPRO

Provided the broader watershed context, including the nine-lake system, drainage connectivity, land-use change and used-water flows.

Parameters

- Watershed and lake network
- Drainage connectivity
- Land use
- Water flows



Reuse for Resilience – A Reuse Readiness Assessment for Chintamani & Hebbagodi-Bommasandra

BORDA-FISH

Provided the municipal-level understanding of water demand, wastewater generation, treatment infrastructure and treated used water reuse opportunities.

Parameters

- Water demand and supply
- Wastewater generation
- Sewerage and treatment
- Reuse demand
- Institutional readiness

What was already done

Within the Watershed

Layer 1. Geospatial Assessment

BORDA-FISH | 2026

A 485-ha hydrologically connected watershed was selected to examine how urbanisation has altered runoff and infiltration, and to identify where Nature-based Solutions could improve watershed performance. The assessment used GIS-based spatial analysis and EPA-SWMM modelling.



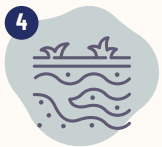
Parameters

- Land use and land cover
- Drainage and flow accumulation
- Rainfall
- Impervious surfaces
- Building, road and park characteristics

Layer 2. Hydrogeological Assessment

BORDA-FISH | 2026

The hydrogeological assessment identified where recharge could be considered; **hydrogeological investigations examined the subsurface conditions needed to determine whether and how recharge could occur** at specific locations. Investigations were undertaken around Hebbagodi, Veerasandra and Tirupalya Lakes.



Parameters

- Subsurface geology
- Weathered and fractured zones
- Recharge potential
- Land availability

CROSS-CUTTING | Field & Stakeholder Evidence



Field
observations



Site
investigations



Municipal
datasets



Stakeholder
consultations

Used to validate technical findings and understand **ground realities, data gaps and implementation constraints.**

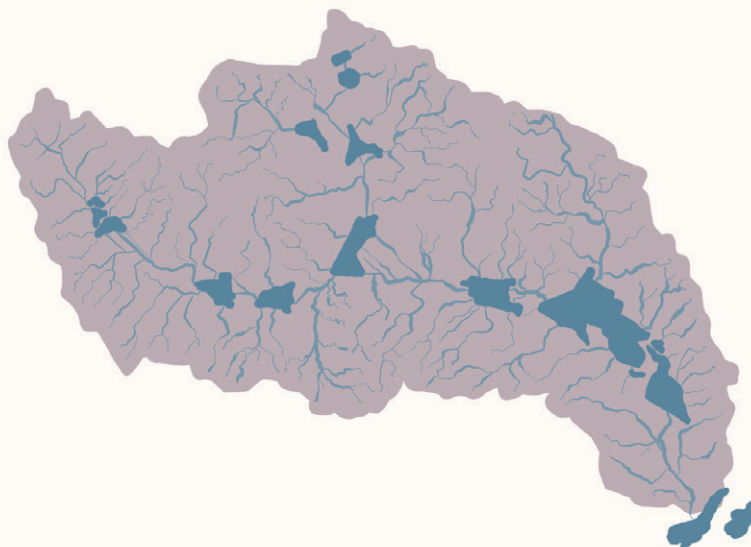
Where We Looked, and Why

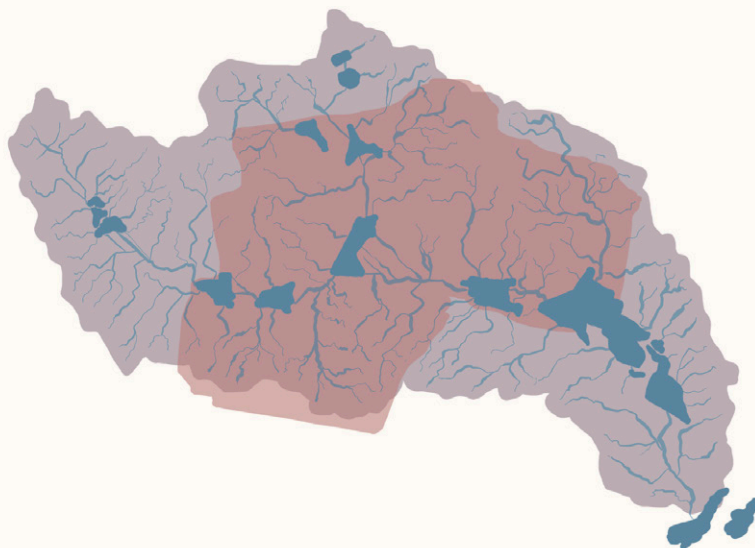
Understanding the different scales of the study

01 | The Bommasandra-Heelalige Watershed

To understand the wider catchment context and the interlinkages between lakes, drainage networks, land use and water flows.

Integrated Action Plan
CDD India | WIPRO

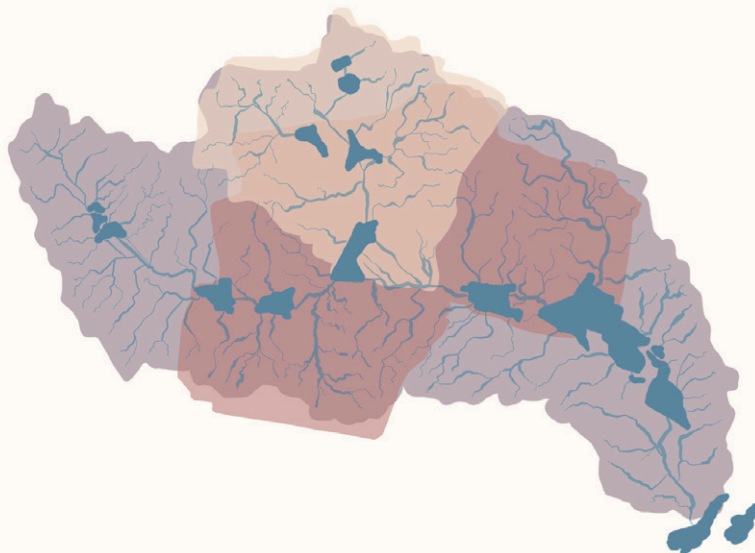




02 | Hebbagodi Municipal Boundary

To understand Hebbagodi's water system at the town scale, including its water demand, wastewater, reuse potential and on-ground conditions.

Reuse for Resilience BORDA-FISH
Field Investigation & Stakeholder
Consultations BORDA-FISH



03 | 485-ha Micro-Watershed

To understand how water moves and can be retained within a micro watershed, and where groundwater recharge interventions are technically feasible.

Within the Watershed –
Geospatial and Hydrogeological
Studies BORDA-FISH

4 KEY INSIGHTS

How Hebbagodi's water system works and where it is under pressure

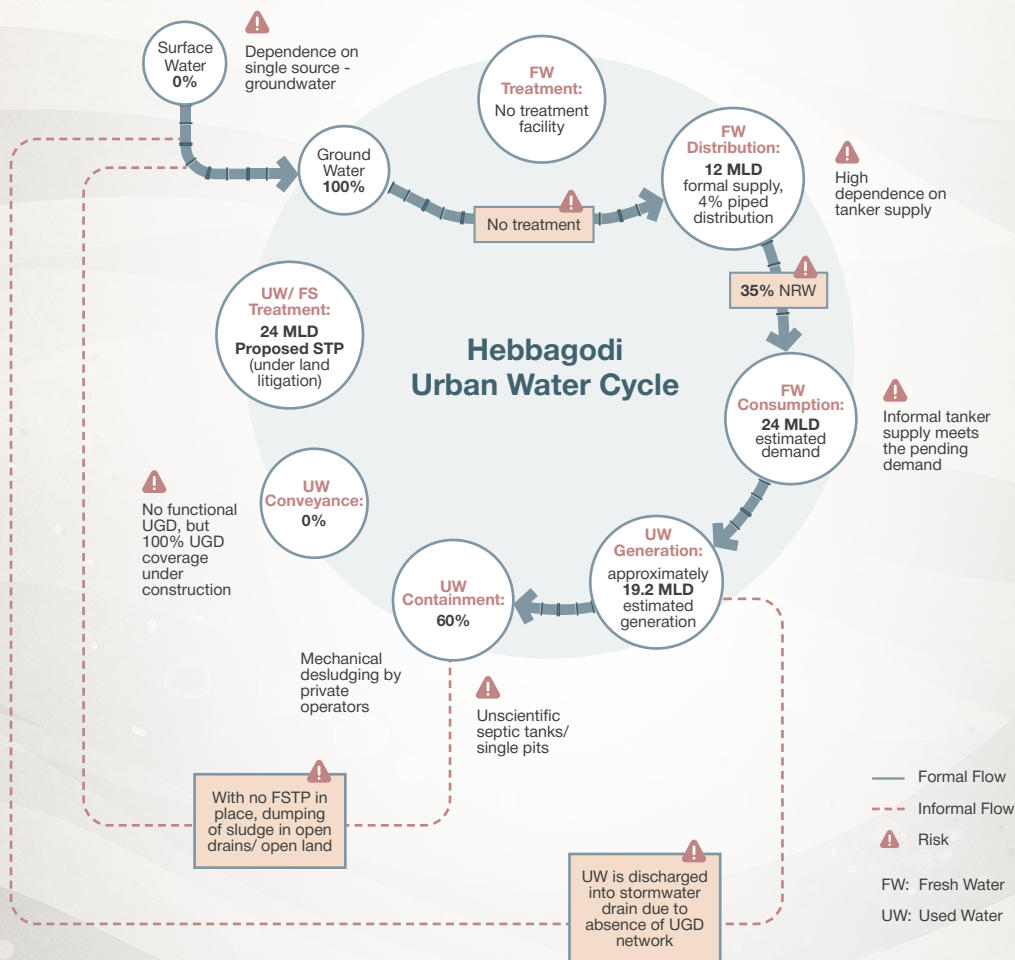


The assessments bring together evidence from the larger catchment, the town, micro-watersheds within the town. Together, they reveal a water system shaped by rapid urbanisation, high dependence on groundwater, limited wastewater-treatment infrastructure, and disrupted natural water pathways - all of which affect Hebbagodi's water security.

The first step is to trace the town's total urban water flow - from source, supply and use to wastewater collection, treatment and reuse or discharge. Drawing on field and stakeholder evidence, this also brings out the everyday realities of how water flows, water and sanitation services, where critical gaps and connections lie, and how pressures in one part of the system affects the wider town and catchment.

Hebbagodi's Urban Water Flow

How water enters, moves through and leaves the system



Source: Field observations and Hebbagodi CMC consultations

Tracing Hebbagodi's urban water flow - where its water comes from, how it is supplied and used, how wastewater is collected and treated, its stormwater flows and whether they are discharged or reused. Following this journey from source to reuse helps reveal how the town's water and sanitation systems function and where critical gaps and connections lie.



1 Groundwater is the primary source

Hebbagodi remains highly dependent on groundwater for domestic and other urban uses, making its availability critical to long-term water security.



2 Water supply does not meet demand

Around 12 MLD of formal supply is available, with the remaining demand met through private sources such as tankers, reflecting a significant supply gap.



3 Wastewater flows are largely unmanaged

Most sewage is contained through on-site sanitation. Without underground drainage, the remaining sewage enters stormwater drains, flowing into rajakaluves and downstream lakes and contributing to water pollution.



4 Treated used water reuse can close part of the gap

The existing water flows present opportunities to capture, treat and reuse wastewater, reducing dependence on its overexploited freshwater sources and strengthening water security.

Potential Reuse Avenues



Private Institutional Use

0.08 MLD | Moderate | Scattered

Campuses and open spaces with irrigation needs



Municipal Non-potable Reuse

2.4 MLD | Sustained | Across town

High Interest demand



Construction Sector

1.6-2.7 MLD | Seasonal | Corridor-based

short-term, flexible demand



Industrial Demand

7.1-10 MLD | Sustained | ~3-8 km

Stable, high-volume anchor



Fire Department Demand

0.005 MLD | Erratic | Near STPs

Low but essential demand for storage and drills



Release to Surface Body

~18-20 MLD | Seasonal | Lake & recharge zones

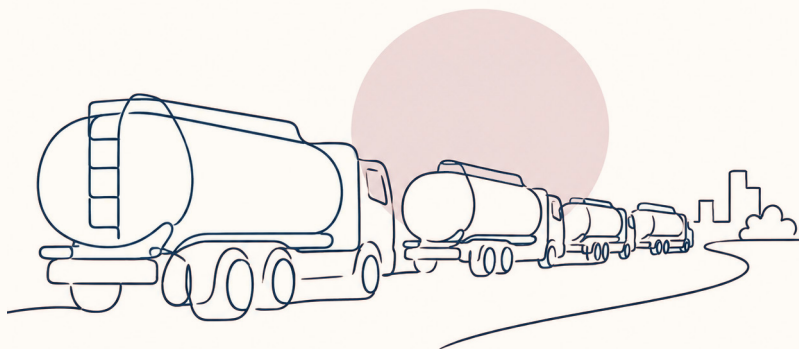
High quantity demand

Source: Reuse for Resilience - BORDA-FISH

What We Saw on the Ground

Field observations revealing how Hebbagodi's water system works in practice

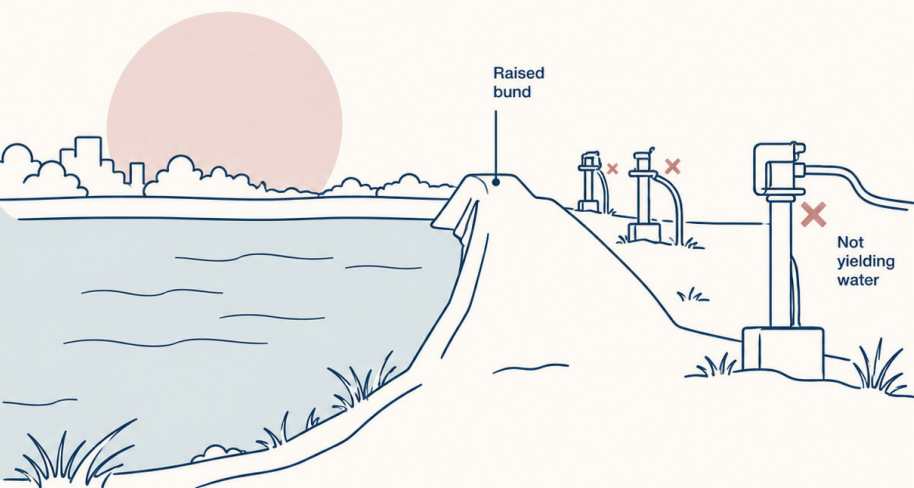
Field visits across Hebbagodi helped ground the assessments in everyday water realities. These observations capture how residents, infrastructure and natural drainage systems interact with a rapidly changing urban water system.



As kids, we used to count passing vehicles for fun. In Hebbagodi, we found ourselves doing it again!

The steady stream of yellow tankers caught our attention, with nearly 20 passing in just 15 minutes, a striking indication of the town's dependence on tanker water.



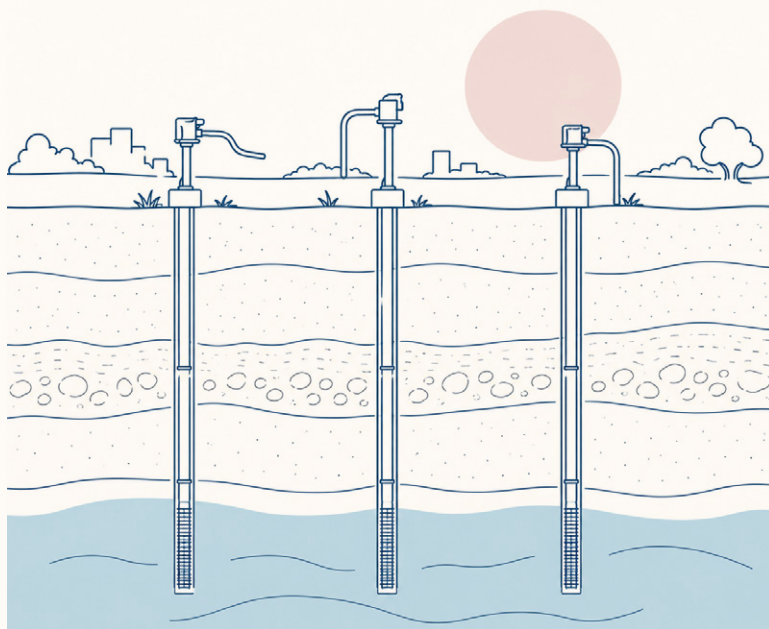


The lake has not only changed on the surface; its consequence runs deeper. Around 20 municipal borewells once yielded water around Hebbagodi Lake.

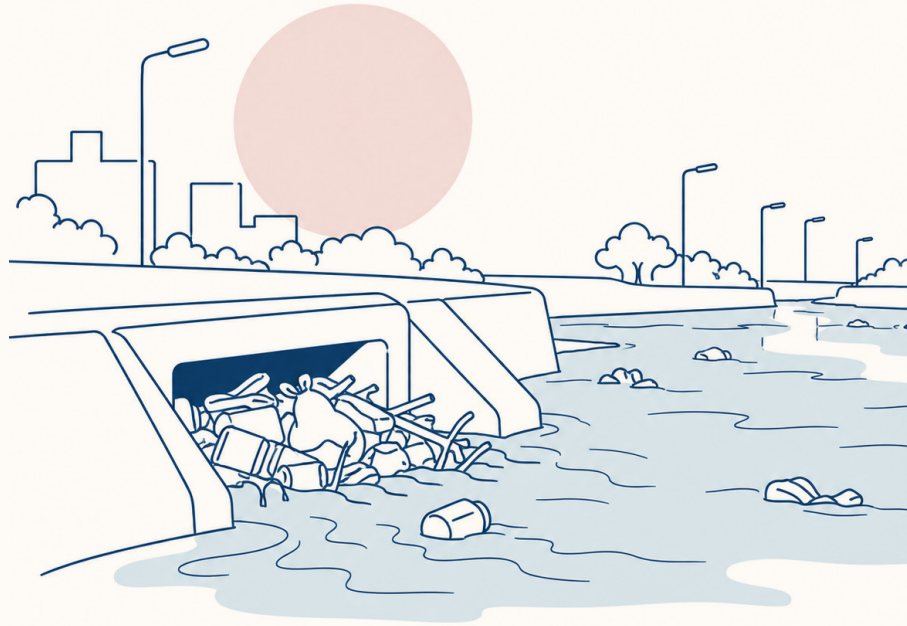
Today, only 4-5 remain productive, following changes to the lake's bunds and inlets.

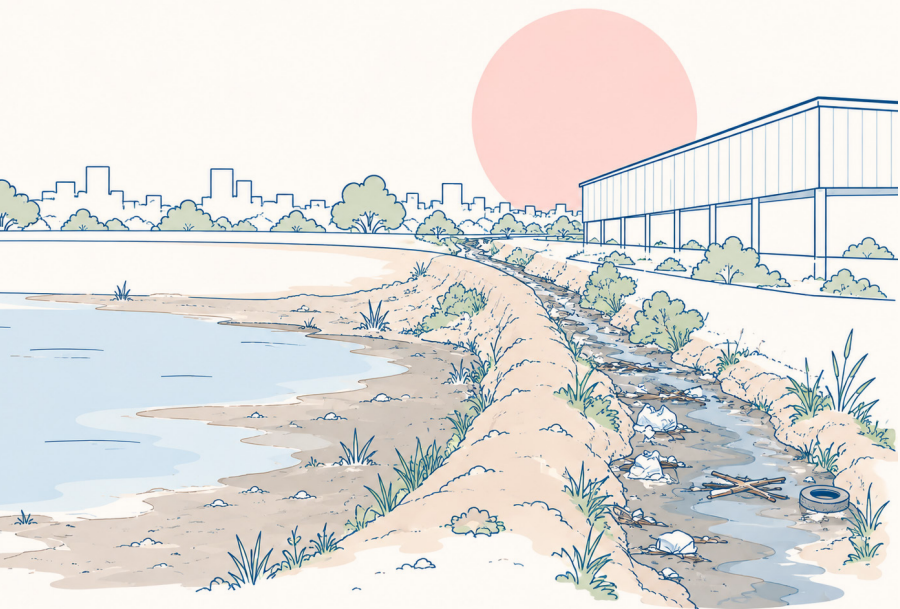


Hebbagodi's groundwater levels tell a story in depth. Several borewells reach 1,400-1,500 feet, a striking indication of the over-exploitation of this vital resource.



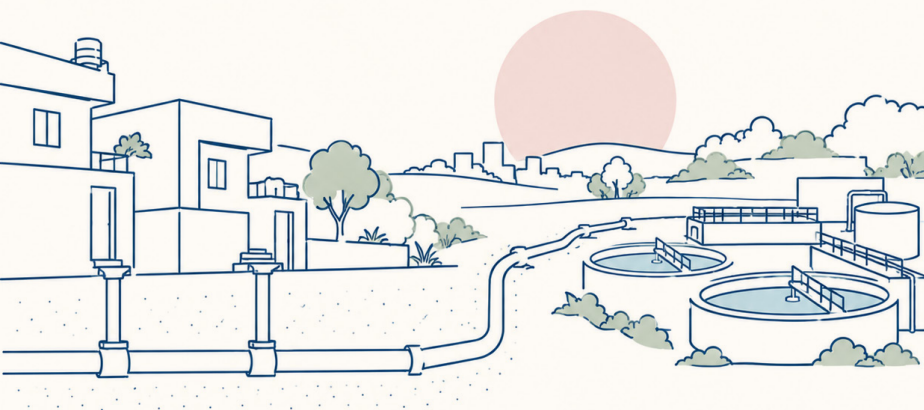
The infrastructure itself was not necessarily missing, the challenge was also what happened around it. Even where proper stormwater drains exist, solid waste enters uncovered sections, affecting the flow and contributing to localised flooding. It showed that infrastructure works only when waste management, maintenance and everyday use work alongside it.





The water seems to have lost its way to the lake. Natural stormwater drains, once meant to flow to the lake, now run alongside the lake (next to the bunds) carrying mixed wastewater. The metro yard further interrupts the flow, leaving a narrow outlet, a stagnant stretch and a recurring monsoon bottleneck.





Hebbagodi's sanitation story is beginning to turn a corner!

From having no operational UGD or STP, the town is now seeing UGD connections take shape, with a 24 MLD STP planned at Ramasagara village.

4.1

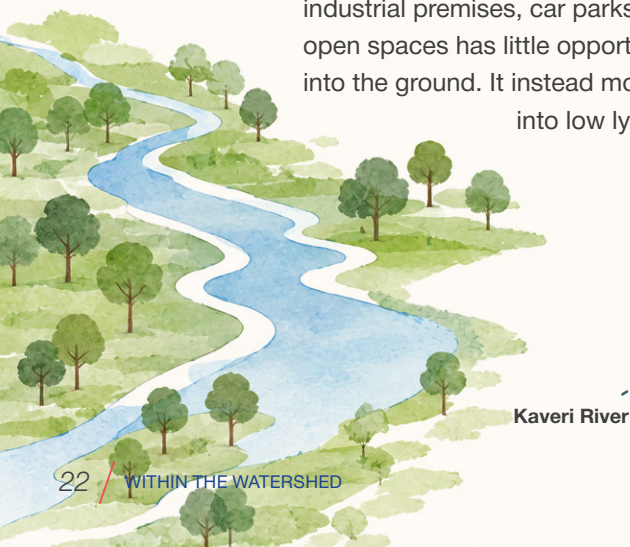
Rapid urban growth has created a dual challenge: increasing flood risk and declining groundwater

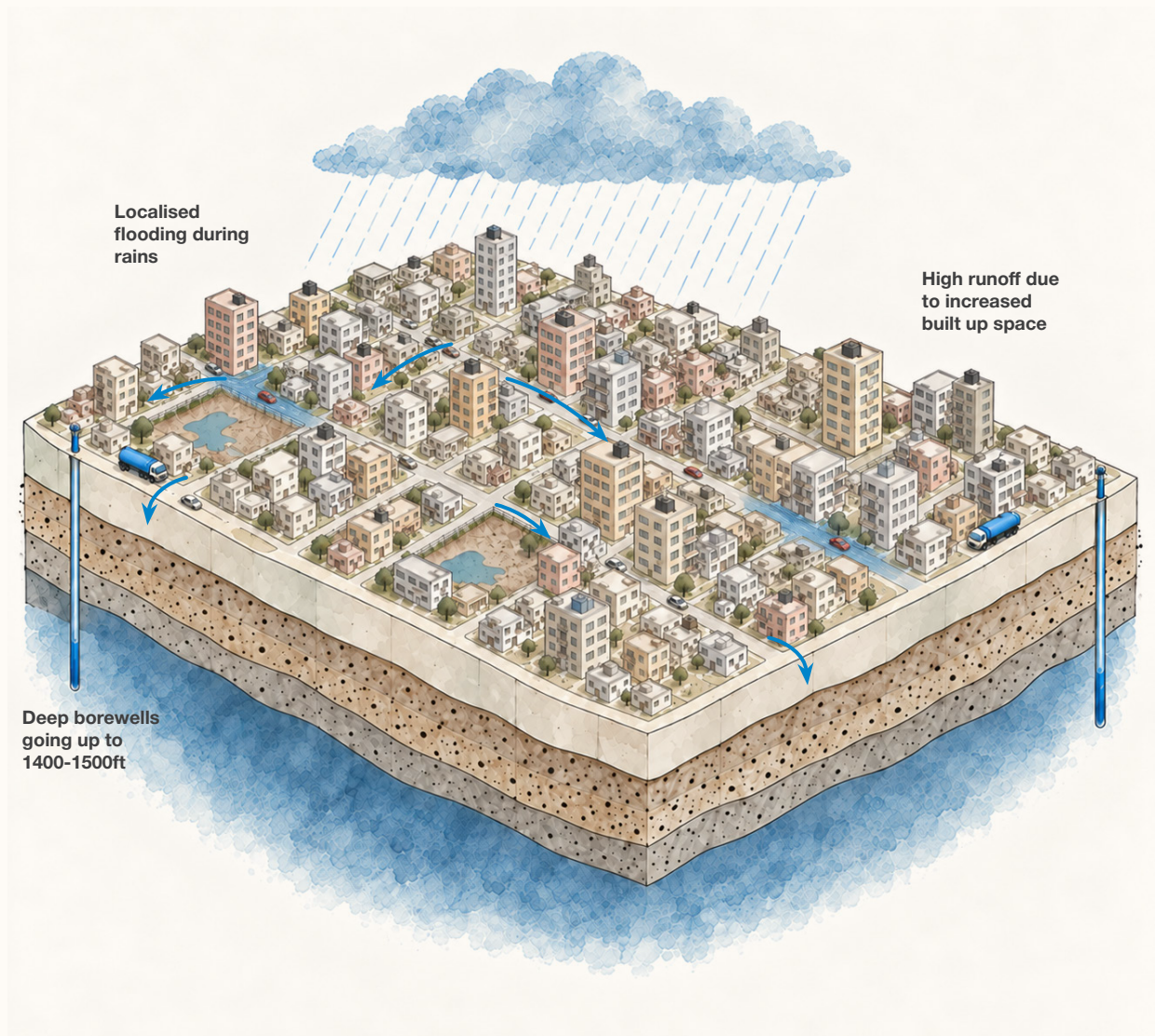
Hebbagodi and Electronic City are among Karnataka's fastest-growing urban areas. The arrival of major employers has transformed an area that was largely rural as recently as the 1990s. Population growth, industries and new development have sharply increased water demand, while the area continues to depend substantially on groundwater.

Urbanisation has also changed how the land responds to rainfall. Approximately 76% of the assessed micro-watershed is built up. Rainfall falling on roofs, roads, industrial premises, car parks and paved open spaces has little opportunity to soak into the ground. It instead moves rapidly into low lying areas

and drainage channels already burdened by wastewater inflows and solid-waste accumulation, contributing to localised flooding while reducing groundwater replenishment.

The effects are visible at both ends of the water system. Borewells reach approximately 1,400–1,500 feet, reflecting more than a decade of groundwater overexploitation, while Cauvery water is proposed to be conveyed from nearly 100 km away to meet future demand. Flooding and groundwater depletion are therefore not separate problems; both arise from too much impervious surface and too little infiltration. Future water decisions must combine external supply with measures that retain rainfall and replenish local shallow and deeper groundwater systems.





4.2 Watershed-scale opportunities must be filtered through ownership and on-ground feasibility

The study asked whether nature-based solutions such as green roofs, stormwater-harvesting systems, bioswales (planted drainage channels), and integrating rainwater retention and infiltration features into park designs, could reduce flooding while also increasing groundwater recharge.

Hydrological modelling of the 485-hectare study watershed identified three interconnected drainage zones and traced how rainfall moves from buildings and private plots through streets, parks, drains and lakes before leaving the watershed. Five intervention packages were developed using actual GIS data and tested using the United States Environmental Protection Agency's Storm Water Management Model, an internationally recognised urban drainage and flood-modelling tool.

The modelling identified many potential locations for intercepting and retaining runoff. However, mapped potential does not

automatically translate into implementable projects. A large share of the opportunity lies within privately owned residential, commercial and industrial properties where the government cannot directly construct recharge measures. Public investment must therefore focus on government-owned roads, parks, lakes, institutional premises and other open spaces.

Even public land is not necessarily available or suitable. Several parks are extensively paved, while portions of lake boundaries have also been concretised. Site selection must therefore bring together five considerations:

- How water moves through the watershed
- Where runoff can be intercepted
- Who owns the land
- Whether sufficient physical space is available
- Whether the soil and subsurface geology can receive and store water

Potential interventions in the micro-watershed based on modelling led urban watershed assessments done by Innpact Solutions



Source: Proposed NbS interventions across the micro watershed

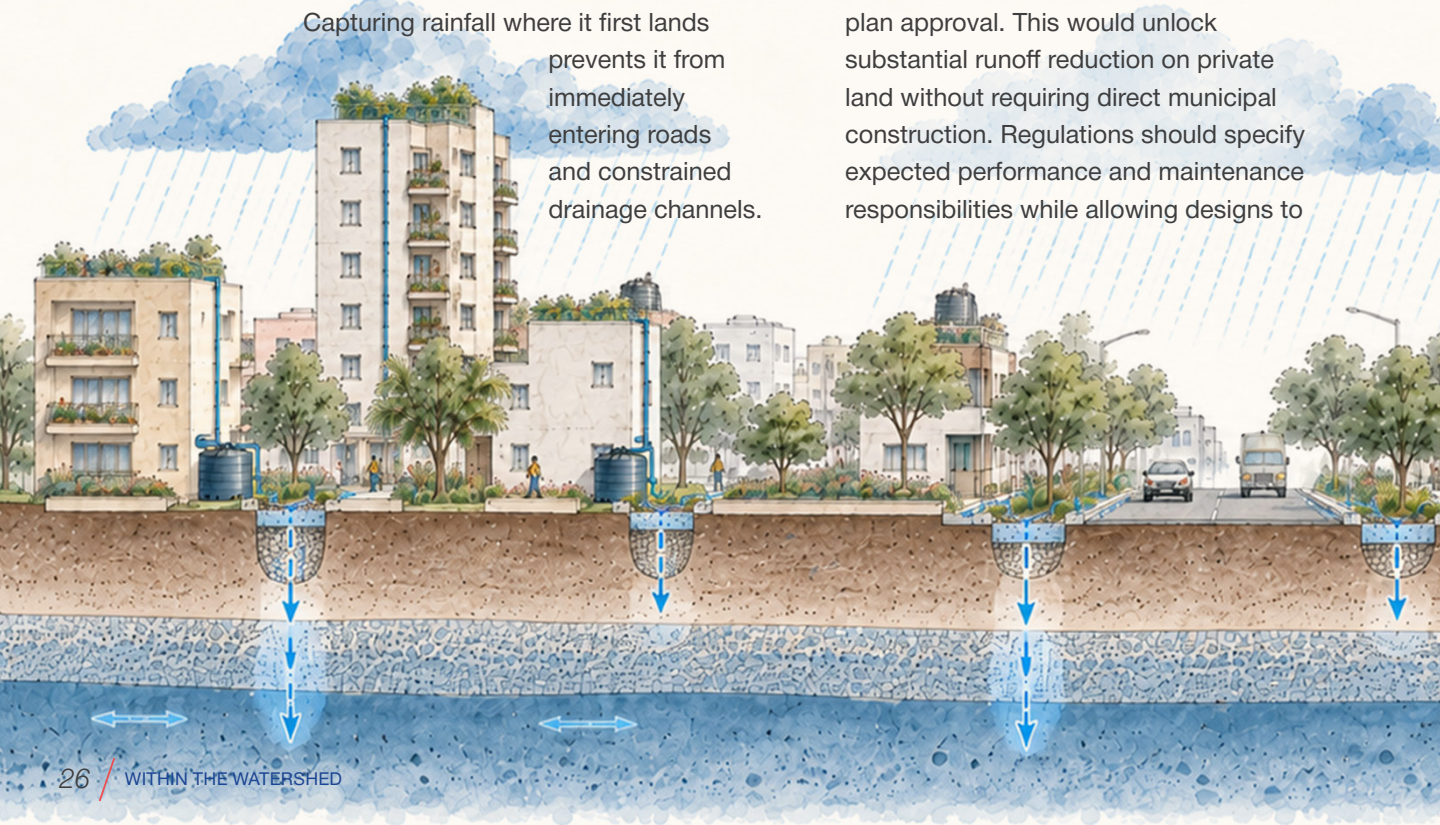
4.3

Buildings are the strongest starting point, while roads and public spaces complete the system

Within the micro-watershed, green roofs and recharge pits on 361 large buildings emerged as the most impactful standalone intervention. Building-level measures alone could reduce stormwater outfall volume by approximately 50%.

Capturing rainfall where it first lands prevents it from immediately entering roads and constrained drainage channels.

Buildings with roof areas of 500 m² or more therefore offer a clear regulatory starting point. Green roofs, rain barrels, stormwater-storage systems and appropriately designed recharge pits could be made a condition of building-plan approval. This would unlock substantial runoff reduction on private land without requiring direct municipal construction. Regulations should specify expected performance and maintenance responsibilities while allowing designs to



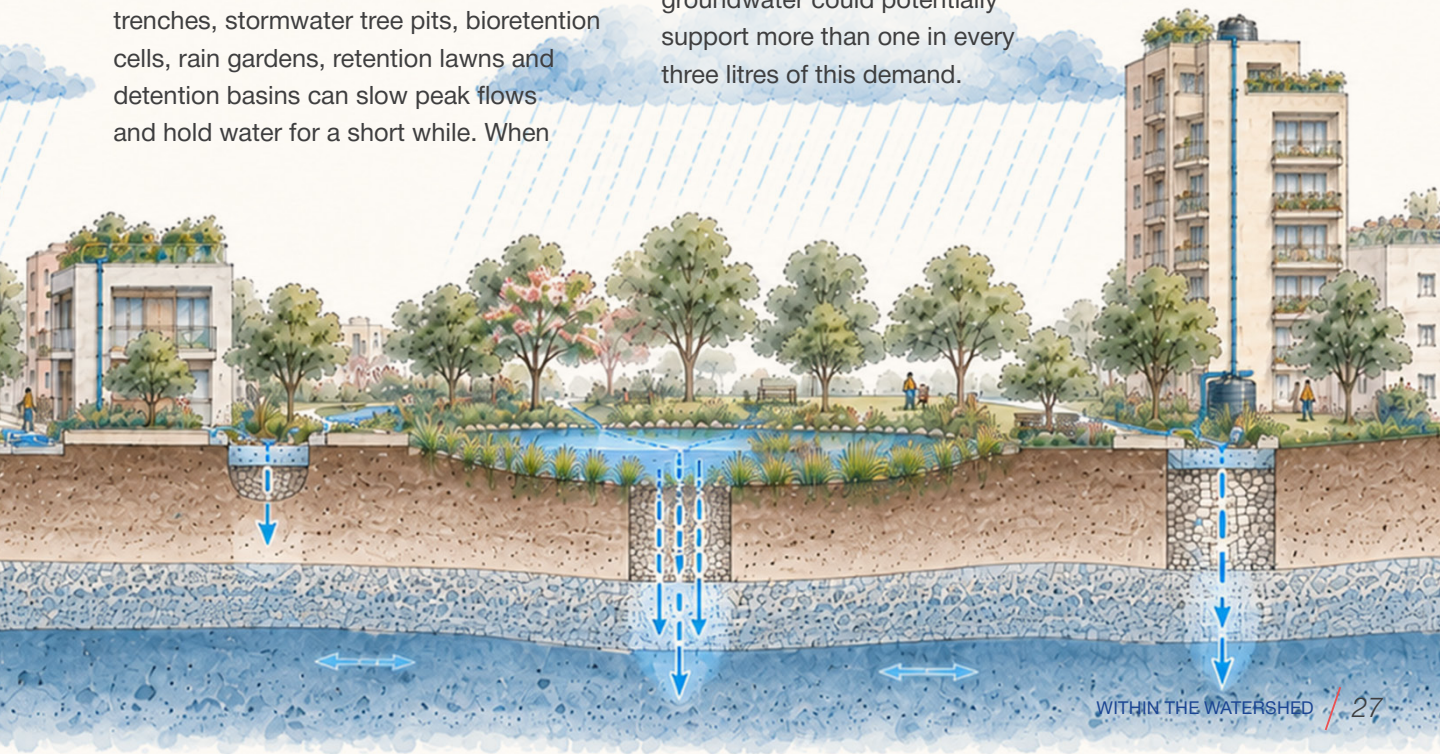
respond to plot size, soil conditions and local hydrogeology.

Roads and public spaces provide a supporting layer. Road-level nature-based measures increased infiltration to approximately 58.5%, although their standalone effect on total outfall volume was limited to around 1.6%. Their principal value lies in intercepting runoff along its pathway, reducing local accumulation and supporting distributed recharge.

Bioswales connected to infiltration trenches, stormwater tree pits, bioretention cells, rain gardens, retention lawns and detention basins can slow peak flows and hold water for a short while. When

measures across buildings, roads, parks and open spaces were combined, total outfall volume reduced by 62.3%, infiltration increased to 88.6% of rainfall, and peak flood flow fell by more than 35%.

Across the Hebbagodi CMC area, full implementation could potentially contribute approximately 1.27 million cubic metres of usable groundwater annually which is around 37% of the annual water demand of 70,000 residents. Based on these estimates, locally recharged groundwater could potentially support more than one in every three litres of this demand.



4.4

Recharge potential depends on what lies beneath the surface

As practical entry points for future interventions, the assessment focused on Hebbagodi, Veerasandra and Tirupalya lakes. These locations were prioritised because they are municipally owned and have some land available where recharge, retention or stormwater-management measures could potentially be implemented.

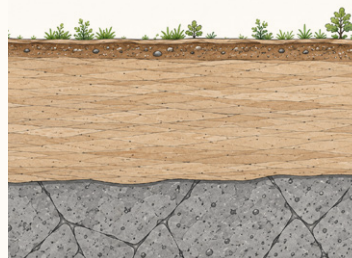
Double Ring Infiltration Tests and Vertical Electrical Sounding investigations were undertaken around these locations to understand what types of interventions the surface and subsurface conditions could support. The infiltration tests show how quickly water enters the near-surface soil, while the VES investigations reveal the underlying clay-rich layers, weathered formations, fractured rock and compact basement.

Initial infiltration was high at several locations but declined as the soil became saturated. Recharge structures must therefore be designed using stabilised rather than initial infiltration rates. Clay-

rich soil does not mean that infiltration is absent; it means that water moves more slowly. Where sufficiently thick weathered formations exist, the subsurface can provide valuable and accessible groundwater storage. The objective is not to send water as deep as possible, but to retain it within the most suitable part of the local aquifer system.

Tirupalya Lake: prioritise storage and flood moderation

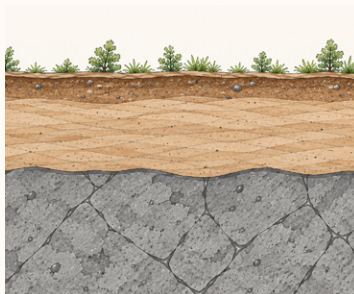
Tirupalya Lake has limited potential for deep groundwater recharge due to clay-rich layers and compact basement rock. Water can be retained temporarily within the lake and the upper soil layers, but the opportunity for substantial aquifer recharge is limited. Hence, it is better suited for temporary runoff storage and flood moderation, with gradual release of water after rainfall.



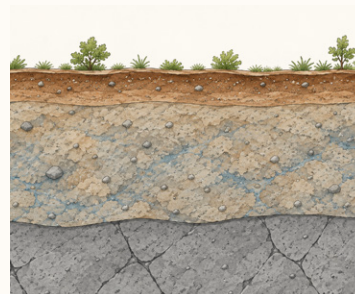
Saturated, weathered, clayey section capable of storage, but can't transmit water

Veerasandra Lake: locate recharge where favourable formations occur

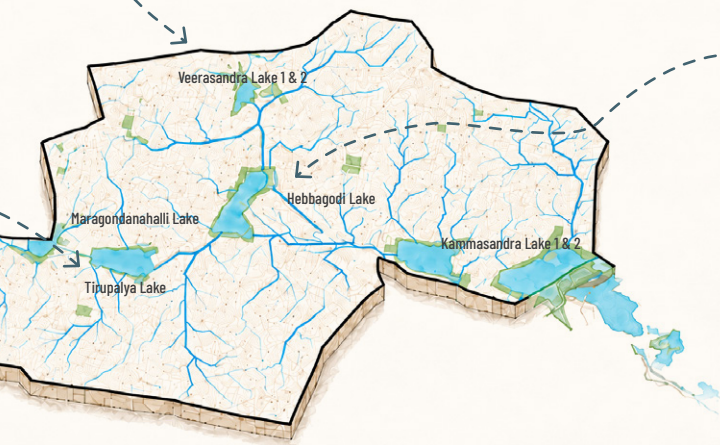
Veerasandra shows how recharge conditions can vary considerably within the same lake area. At favourable locations, relatively thick weathered formations can receive and store water. Elsewhere, clay-rich material followed by compact granite restricts vertical movement and reduces available storage. Recharge measures should therefore be concentrated in the favourable weathered zones. Less permeable areas can instead provide temporary detention and controlled release.



Site 1: Thin clay-rich, fine-grained sediments, capable of retaining moisture but restricting downward movement

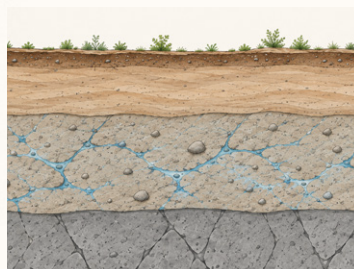


Site 2: Deep weathered mantle, below topsoil, capable of storing and transmitting groundwater



Hebbagodi Lake: bypass restrictive layers to reach favourable storage

Hebbagodi Lake offers strong potential for targeted groundwater recharge. While the upper clay-rich layers slow natural infiltration, the weathered and fractured formations below provide substantial storage potential. Selective desilting and filtered recharge wells or shafts can improve recharge into these zones.



Clayey layer below topsoil with low permeability, followed by deep weathered and moderately fractured granite with significant storage and transmitting capacity

Soil profiles generated through AI

-  **Topsoil:** Moist, weathered material
-  **Clayey layer:** fine grained, low permeability layer
-  **Fractured zone:** Weathered granite, storing and transmitting groundwater
-  **Basement rock:** Compact granite

Source: VES tests conducted by
Elixirgeotech Consultancy Services

Together, the three locations demonstrate why a uniform recharge design cannot be applied across the study area or even at every point around the same lake. The appropriate intervention must respond to how quickly the surface receives water, what lies beneath it, where water can be stored, and whether the site is better suited to recharge, retention or controlled release.

4.5

Lakes must be restored as parts of an interconnected hydrological system

The lakes within the Bommasandra–Heelalige watershed form a connected system that receives and retains runoff, moderates peak flood flows, supports groundwater recharge where geology permits, and conveys excess water downstream.

Field observations and stakeholder consultations indicate that this connectivity has been weakened. Altered bunds, modified inlets, disconnected drainage channels and surrounding development have changed how water enters and leaves the lakes. Around Hebbagodi Lake, development associated with the metro shed has altered the earlier marsh and drainage system. With natural flow pathways constrained, stormwater and wastewater are diverted around parts of the lake, creating stagnant and contaminated areas. In some locations, measures introduced to keep wastewater out have also unintentionally blocked cleaner rainfall runoff.

Lake rejuvenation must therefore extend beyond beautification, fencing or ecological improvement within individual lake boundaries. It should restore appropriate inlets, outlets and upstream–downstream connections while recognising the function that each lake can perform. Hebbagodi may support targeted recharge, suitable parts of Veerasandra may strengthen shallow aquifer storage, and Tirupalya may primarily retain and moderate floodwater. Their individual functions must work together as part of the wider watershed.





Veerasandra
Lake 1

Veerasandra
Lake 2

Hebbagodi Lake

Kammasandra
Lake 1

Kammasandra
Lake 2

Andapura Lake

Heelalige
Lake

Chandapura Lake

Construction over
natural water-flow
pathways

Metro shed
obstructing
outflow from
Hebbagodi Lake

4.6

Water quality protection must precede groundwater recharge

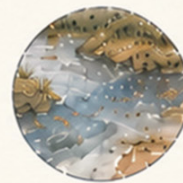
Rajakaluves around Hebbagodi receive untreated wastewater from households and commercial establishments. Solid waste further obstructs these channels, disrupting stormwater movement and creating polluted and stagnant flows. Water in a stormwater drain cannot

therefore automatically be considered suitable for recharge.

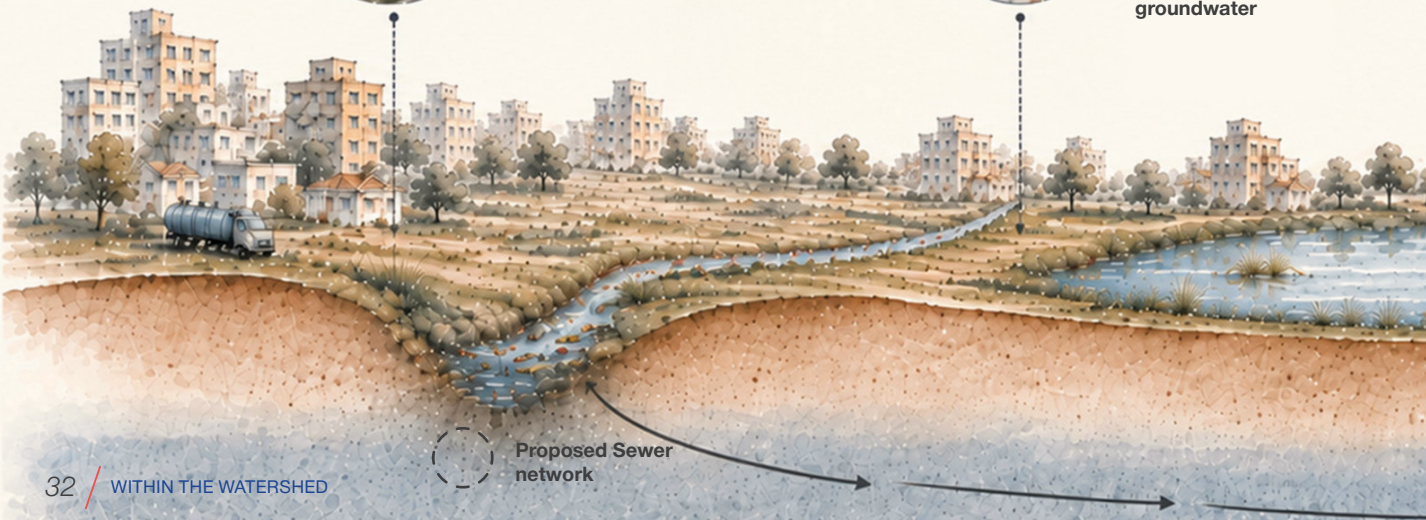
Directing mixed wastewater and stormwater underground could contaminate both shallow and deeper aquifers. Wastewater interception,



Solid waste is dumped into the open rajakaluves



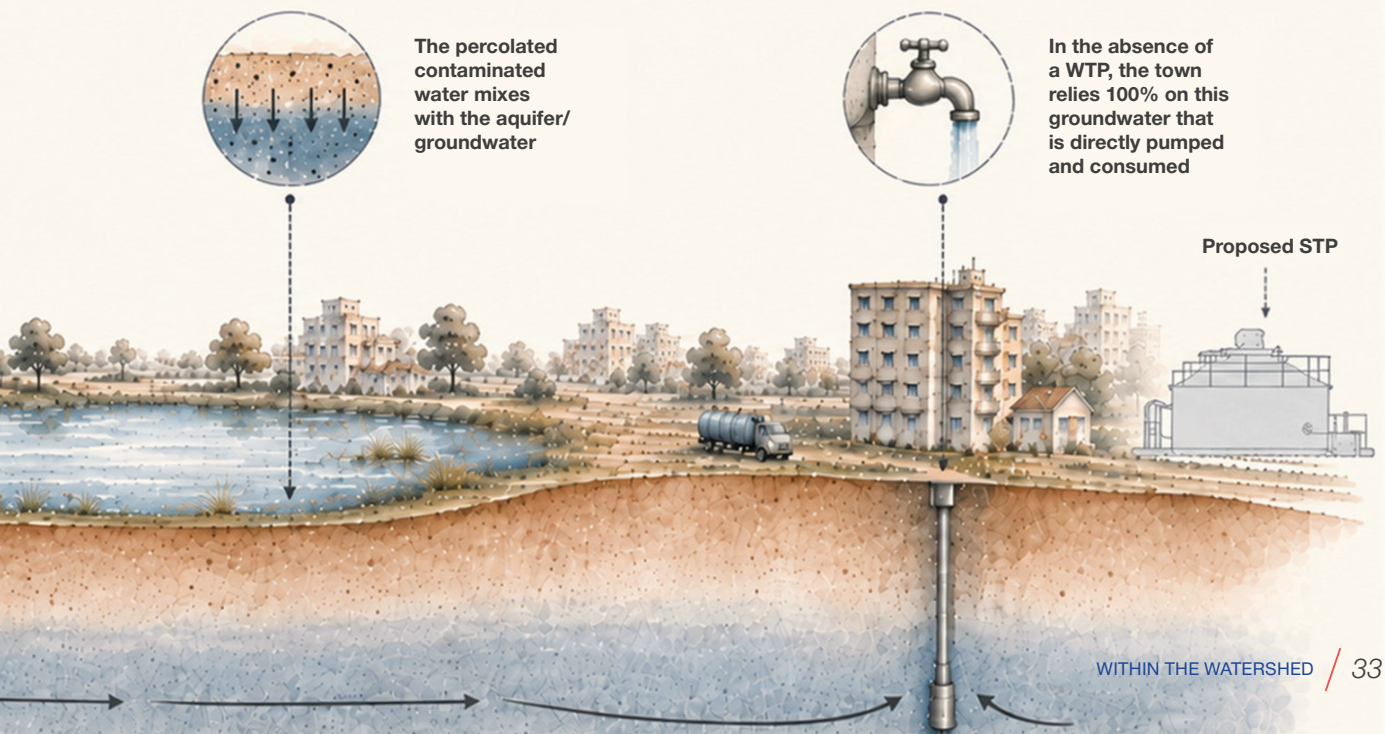
With 0% functional sewerage network, wastewater mixes with the rajakaluves and percolates to the groundwater



diversion and treatment must consequently form the foundational layer of recharge planning. The proposed sewer network and 24 MLD sewage treatment plant provide an opportunity to plan wastewater management, stormwater drainage and groundwater protection together.

Only clean stormwater or water treated to a standard appropriate for the selected

recharge method should be directed towards groundwater. The resulting system should work as one connected sequence: buildings capture rainfall; roads and public spaces slow and treat runoff; lakes store, recharge or convey water according to their hydrogeology; excess flows move safely downstream; and wastewater is intercepted before it enters the recharge network.



4.7

An interconnected water system requires coordinated institutional action

While water moves as one interconnected system, responsibility for managing it is distributed across multiple institutions. Water supply, wastewater, stormwater drains, groundwater, lakes, roads and public open spaces fall under different departments, levels of government and parastatal agencies. A decision concerning one asset can therefore alter water flows or create unintended consequences elsewhere in the watershed.

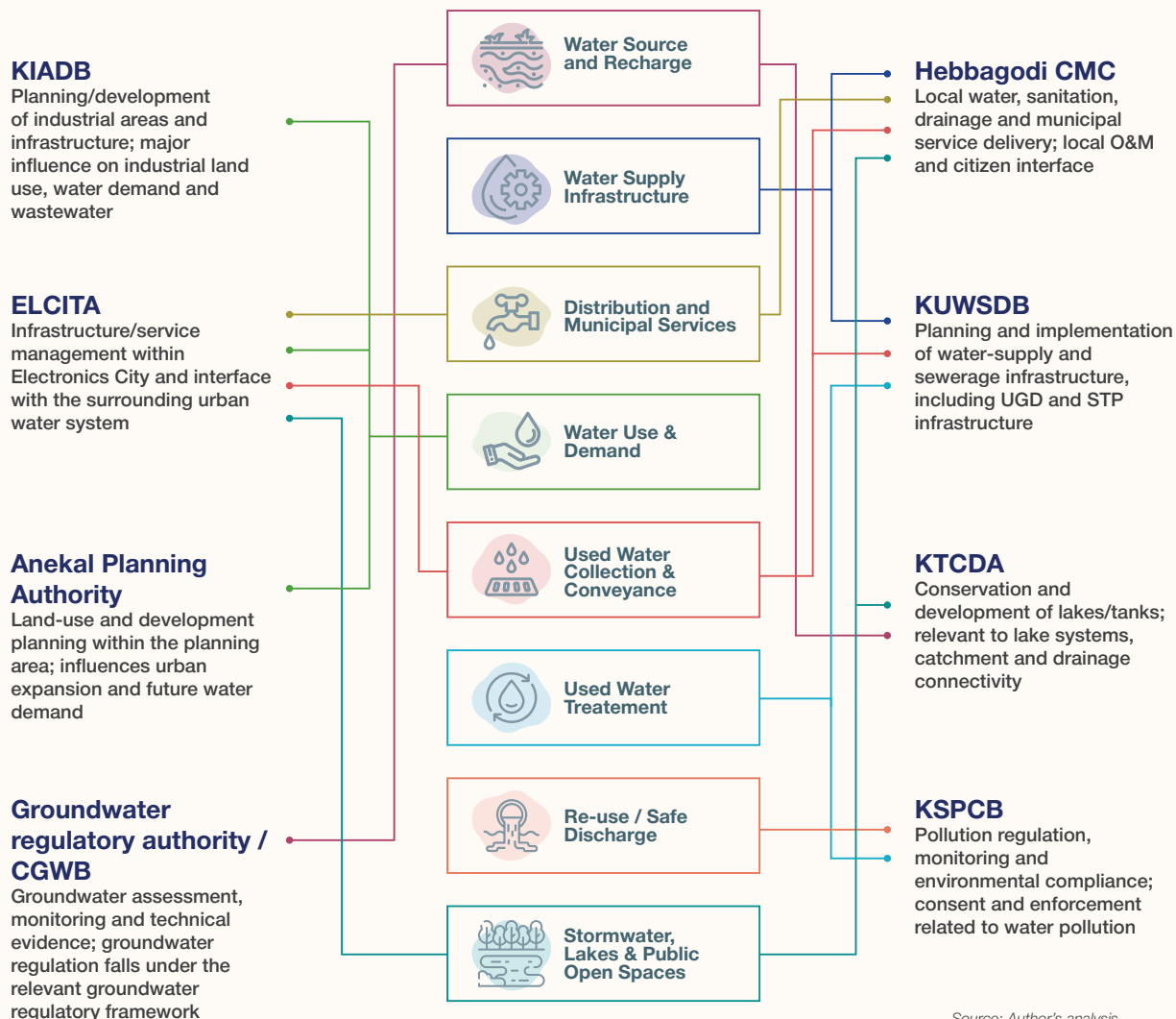
This challenge is particularly evident in Hebbagodi, which transitioned directly from a Gram Panchayat to a City Municipal Council. The rapid institutional transition has contributed to gaps in staffing, technical capacity, historical records and clarity over responsibilities. Several important infrastructure and investment decisions also remain with agencies beyond the municipal council, making coordination essential.

The consequences of fragmented decision-making are evident in the case

of Tirupalya Lake, where a bund built to prevent wastewater from entering the lake was later breached by an elected representative after wastewater began flowing around it and was affecting nearby residents. This reactive intervention, taken without adequate coordination, highlights how decisions addressing local concerns can have wider implications for water quality and watershed management.

A watershed-based planning framework can provide institutions with a shared spatial and evidence base to understand how water flows, infrastructure and proposed interventions are interconnected. By fostering a common understanding of water-security priorities, clarifying institutional roles and strengthening coordination, it can help authorities make informed, collective decisions that address the needs of the wider watershed.

Institutions Across the Watershed Water System



Source: Author's analysis

CONCLUSION

At the heart of Hebbagodi's water security is the need to reconnect the flows that urbanisation has fragmented.

By restoring watershed connectivity, capturing rainfall, protecting water quality, recharging groundwater where feasible, and treating and reusing wastewater, rapidly growing small towns can turn fragmented local flows into a more resilient water system.



Key Documents Referred

Reuse for Resilience: A Systems Readiness Assessment of Treated Used Water Reuse for Small & Medium Towns - Insights from Chintamani & Hebbagodi-Bommasandra

BORDA South Asia & FISH

Integrated Used Water Management Plan – For Pollution Mitigation in the Storm Water Channels within the Catchment of Bommasandra-Chandapura Nine Lake Series

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