Integrating Sacred Hydrology and Resilient Urban Strategies: A Blue-Green Framework for Flood Mitigation in Peri-Urban Bengaluru

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Abstract:

This research presents an integrated blue-green urban framework to address persistent water logging in the Manyata Tech Park region of Bengaluru. Drawing on the principles of sacred temple hydrology, Sir M. Visvesvaraya's engineered flood resilience strategies, and Patrick Geddes' Valley Section theory, the paper proposes a culturally rooted and ecologically sound solution. Using GIS-based mapping and ground analysis, the study assesses lake connectivity, volumetric deficiencies, and hydro-logical disconnections. The proposal emphasizes the cascading of neighborhood lakes, creation of sacred wetlands, implementation of natural percolators, and strategic placement of manmade recharge structures. This design reestablishes ecological flows, promotes aquifer recharge, and restores sacred spatial memory while engaging local communities. The result is a prototype for urban water resilience rooted in cultural wisdom and ecological science.

Keywords: Sacred hydrology, cascading lakes, Visvesvaraya, Valley Section, waterlogging, blue-green infrastructure.

1. Introduction

Peri-urban regions of Indian cities are facing increasing vulnerability to climate-induced stresses, particularly urban flooding. In Bengaluru, the Manyata Tech Park area exemplifies the effects of unplanned urban expansion, impermeable surface growth, and disconnected natural systems. With the traditional lake cascade system broken, and rainwater being forced into stormwater drains that quickly overflow, the area suffers from chronic inundation. This paper addresses the need for an integrated, culturally responsive urban design framework that not only mitigates flooding but also enhances groundwater recharge, urban biodiversity, and community stewardship.

These issues are exacerbated by the loss of natural buffers such as wetlands, grasslands, and vegetated canal edges that once allowed rainwater to percolate into the soil. Instead, concrete infrastructure dominates, accelerating runoff and disrupting natural drainage flows. The situation reflects a deeper disconnect between modern urban planning and the region's ecological memory. It is imperative to revisit traditional water wisdom—embedded in temple tanks, stepwells, and cascading lake systems—and reinterpret these systems through a contemporary, scientifically grounded lens. This research thus seeks to propose a spatial and hydrological design that is both resilient and reverent, rooted in place-based heritage and ecological intelligence.

2. Background of the Study

2.1 Overview of Bengaluru:

Bengaluru, today hailed as the administrative, cultural, industrial, and knowledge capital of Karnataka, has come a long way from its humble beginnings. Nestled on the Deccan Plateau at an altitude of 920 meters above sea level (12.95° N, 77.57° E), this city once known as a modest village in the 12th century has grown into one of India's most dynamic urban centers. From a population of just over 1.6 lakh in 1901, it surged to nearly 8.5 million by the 2011 Census (Census of India, 2011), marking its emergence as a fast-growing incipient megapolis.

This explosive growth has been fueled by economic opportunities, favorable weather, and ample space for expansion. The city's salubrious climate—cooler than many other Indian metros—earned it the nickname "Pensioner's Paradise" in the colonial era. Over time, it also evolved into the "Garden City" due to its lush green cover, public parks like Lalbagh and Cubbon Park, and tree-lined avenues that once defined its urban fabric. However, rapid migration and unchecked development have led to extensive urban sprawl and the fragmentation of the natural landscape in and around Bengaluru

The city's name itself carries the memory of its ecological and cultural roots. Popular folklore traces "Bengaluru" to *"benda kaalu ooru"*—the "town of boiled beans." The story goes that Hoysala King Vira Ballala, during a hunting trip in the 12th century, was offered a humble meal of boiled beans by an old woman living in this region. Touched by her hospitality, he named the place in her honor (Rice, 1897a). However, historical records show that the name "Bengaluru" appeared in inscriptions as early as the 9th century, making this tale more legend than fact

A more plausible origin story comes from the local ecology. Historian Kamath (1990) suggests that the name might have stemmed from *"benga,"* the Kannada word for the Indian Kino tree (*Pterocarpus marsupium*), once abundant in the area, and *"ooru"* meaning town. In this sense, Bengaluru was quite literally the "town of trees," rooted in its natural landscape. The region's dry deciduous forests and undulating terrain gave rise to a network of man-made lakes (tanks), constructed to harvest rainwater and sustain agriculture—a critical adaptation in a city without a major river.

The modern city's story began in 1537, when Kempe Gowda I, a local chieftain of the Yelahanka dynasty, laid its foundations. Visionary in his thinking, he marked the city's anticipated limits by erecting four towers in the cardinal directions from the central "Petta" area—an early attempt at urban planning. Kempe Gowda also emphasized environmental resilience, establishing tanks, markets, and gardens as essential components of urban life. Yet, Bengaluru quickly outgrew these boundaries. Since 1949 alone, its physical footprint has expanded more than tenfold, with the most dramatic changes occurring over the last five decades.
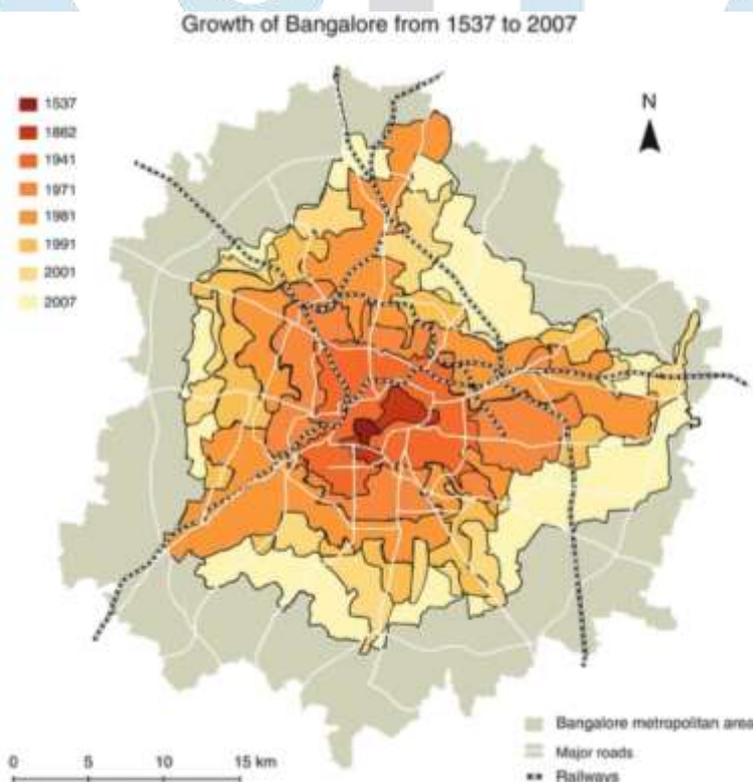

Figure 1. Spatial growth of Bangalore from 1537 (red) to 2007 (light yellow) (Source data from Census of India. Prepared by H.S. Sudhira and modified by Jerker Lokrantz/Azote. Published with kind permission of ©H.S. Sudhira 2013. All Rights Reserved)

2.2 Traditional Water Systems and Sacred Landscape

Historically, the Bengaluru landscape was shaped by an ingenious network of cascading lakes, designed to suit the natural slope of the Deccan Plateau's undulating terrain. Over 1,000 lakes were once part of this intricate system, many of them connected by stormwater channels (rajakaluves) that directed overflow from higher elevations to lower-lying basins. These lakes were more than utilitarian—they were embedded in the spiritual and ritualistic fabric of society.

Temple tanks (kalyanis), often placed in the northeast quadrant of temple complexes according to Vastu Shastra, functioned as sacred reservoirs for rituals and also supported groundwater recharge, temperature regulation, and flood buffering.
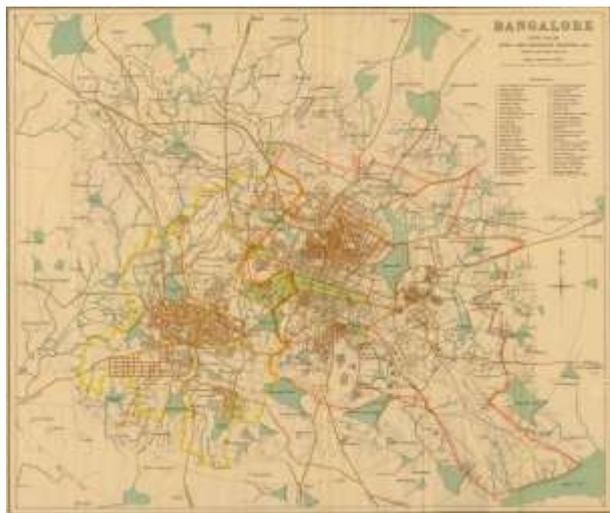

Figure 2- 1930s Map of Bangalore /geomapp.wordpress.com/the-missing-lakes-of-bangalore/
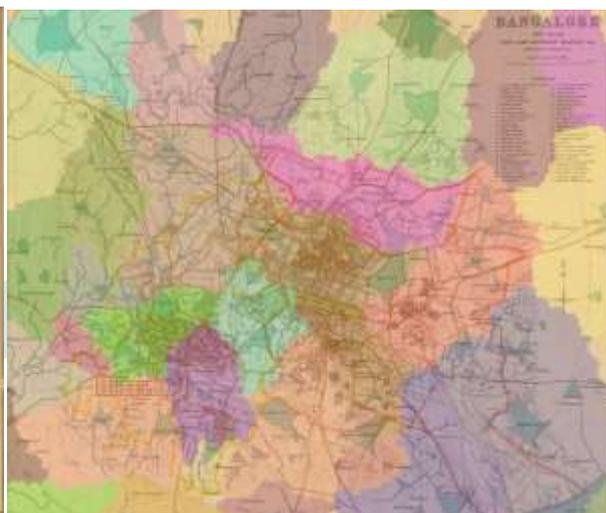
Figure 3- 3" SRTM Data Draped over Old Bangalore Map /geomapp.wordpress.com/the-missing-lakes-of-bangalore/

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2.3 Hydrological Structure of the City

As per studies by IISc and LDA, the number of functional lakes in Bengaluru has reduced from 379 in 1973 to fewer than 167 by 2023, with most remaining lakes being semi-functional or heavily polluted. Many lakes have been replaced by tech parks, roadways, or housing developments, severing the hydrological connectivity once maintained by valley lines. This study revisits that sacred logic—not as nostalgia, but as a resilient infrastructure model suitable for peri-urban contexts like Manyata Tech Park, where both flooding and water scarcity coexist paradoxically.
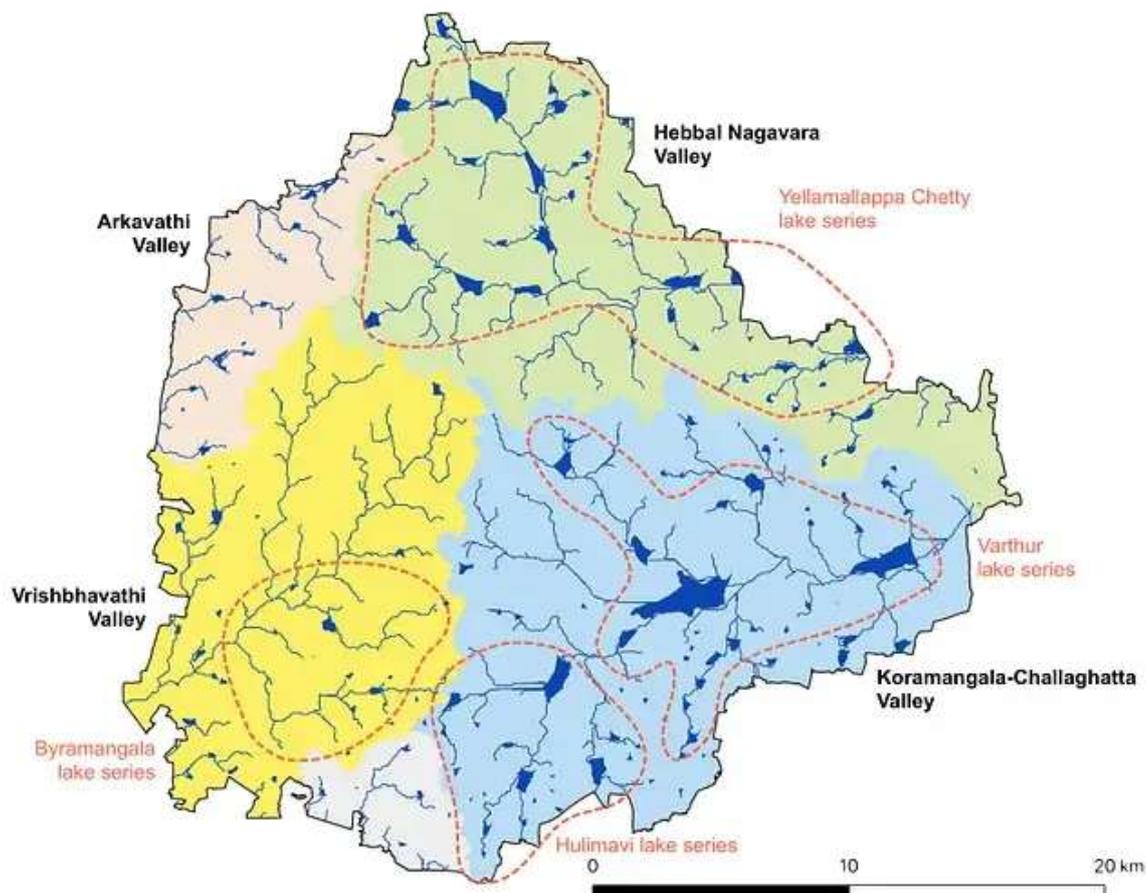

Figure 4. Some of the larger lake systems of Bengaluru. The networks have been fragmented due to encroachment into lakes and connecting canals/rajakaluves. Map by Shashank Palur.

Source - Well labs

The hydrological map of Bengaluru, highlighting the city's natural drainage valleys and interconnected lake systems. Bengaluru, though urbanized, is fundamentally shaped by three major natural valleys: Hebbal-Nagavara Valley (green), Vrishabhavathi Valley (yellow), and Koramangala-Challaghatta Valley (blue). These valleys act as primary drainage basins, guiding rainwater runoff across the undulating terrain of the Deccan Plateau.

Each valley contains its own lake series, traditionally designed in a cascading manner to harvest and manage monsoon rain. The Hebbal-Nagavara Valley connects to the Yellamallappa Chetty lake series, managing inflow in northern Bengaluru.The Varthur lake series falls under the eastern zone within the Koramangala-Challaghatta Valley, receiving overflow from upstream tanks like Bellandur and Varthur.The Hulimavu lake series and Byramangala lake series belong to the southern and southwestern extents of the city, draining into the Vrishabhavathi Valley.This hydrological structure, once sustained by stormwater channels and wetlands, helped Bengaluru manage its rain-dependent water supply and flood mitigation. However, with increasing urbanization, fragmentation of lake networks and encroachment on valleys have disrupted this system.

2.4 Rainfall and Flooding Profile of Bengaluru Urban District

Annual Rainfall Overview (2022) - In 2022, Bengaluru Urban district recorded significantly higher rainfall than average. The total actual annual rainfall was 1456 mm, while the normal average is 846 mm, showing a departure of +72% from the long-period average. This categorizes 2022 as a Large Excess rainfall year.

Parameter	Value
Normal Rainfall	846 mm
Actual Rainfall	1456 mm
% Departure	+72%
Rainfall Classification	Large Excess

Table 1: Annual Rainfall – District Level Summary (2022)

Bengaluru receives rainfall from three primary seasonal systems: the Pre-Monsoon (Jan–May), South-West Monsoon (Jun–Sep), and North-East Monsoon (Oct–Dec). In 2022, all three seasons recorded above-average rainfall.

Season	Normal (mm)	Actual (mm)	% Departure	Classification
Pre-Monsoon	156	326	+109%	Large Excess
South-West Monsoon	471	790	+68%	Large Excess
North-East Monsoon	219	340	+56%	Excess
Annual Total	846	1456	+72%	Large Excess

Table 2: Seasonal Rainfall Distribution – Bengaluru Urban (2022)

Several historical rainfall events have led to severe urban flooding in Bengaluru. These events highlight the vulnerability of areas built on or near former lakebeds and valley systems.

Year	Nature of Event	Impact Areas
2005	Monsoon floods and lake breaches	Koramangala, Domlur, Ejipura
2017	Overflowing storm drains, blocked channels	Whitefield, Bellandur, HSR Layout
2019	Intense pre-monsoon rain	Rajajinagar, Jayanagar, Indiranagar
2022	City-wide flooding due to extreme rainfall	Bellandur, ORR Tech Parks, Sarjapura Rd, Varthur

Table 3: Notable Flood Years in Bengaluru

In 2022, several areas in Bengaluru experienced severe urban flooding, primarily due to excessive rainfall combined with disrupted hydrological systems. Among the most affected were the Bellandur and Varthur lake catchments, where overflows and backflows led to major road inundation, disrupting traffic and damaging infrastructure. The Outer Ring Road corridor, particularly between Sarjapura Road and Ecospace, saw extensive waterlogging across tech parks and densely built residential enclaves, highlighting the vulnerability of newly developed zones built over former wetlands and drain paths. In Koramangala, especially the 4th and 6th Blocks, stormwater drains failed to cope with the volume of

runoff due to encroachments and silt accumulation. Similarly, Mahadevapura and KR Puram experienced repeated flooding incidents triggered by the breakdown of inter-lake connectivity and overloaded drainage systems. These flood-prone areas are all located within the natural valleys of Hebbal, Koramangala, and Vrishabhavathi, which were historically structured to channel excess rainfall through a cascading network of tanks and open water channels—systems that have now been severely fragmented by urban development.

3. Analysis

3.1 Integrative Framework and Rationale

This study adopts an integrative approach to understanding urban flooding, moving beyond conventional engineering-centric perspectives. It synthesizes sacred hydrology principles, the rational infrastructure planning ethos of Sir M. Visvesvaraya, and Patrick Geddes' ecological planning model—specifically the Valley Section—to develop a culturally rooted yet scientifically grounded understanding of hydrological dysfunction in peri-urban Bengaluru. The Manyata Tech Park area, characterized by rapid vertical development, shrinking open spaces, and remnants of a historically resilient lake network, serves as a critical lens through which this hybrid analysis is applied.
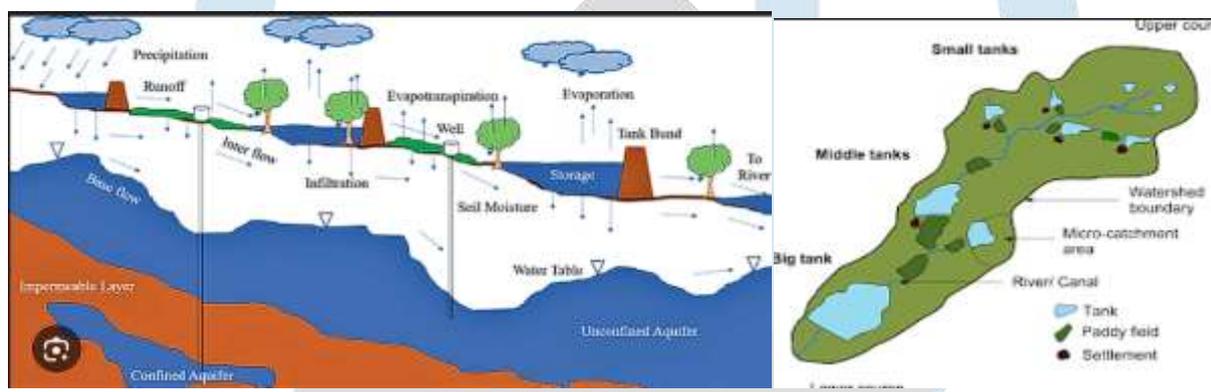

Figure 5. Explaining about the cascading techniques connecting lakes /Lake Systems on the Dynamics of Nutrient Circulation in Catchment Areas/by Angela Kuriata-Potasznik

3.2 Hydrological System Overview

The Manyata Tech Park region sits at the confluence of multiple natural drainage valleys that historically formed part of the Hebbal-Nagavara basin system. However, the current built environment has largely ignored the site's topographic logic. High-density development—comprising multi-story office parks, expansive impervious parking lots, and tightly packed residential colonies—has significantly altered surface runoff patterns. The limited presence of pervious ground, along with under-dimensioned and poorly maintained stormwater drains, results in accelerated runoff concentration during peak rainfall events.

3.3 Existing Lake System and GIS-Based Observations

GIS and remote sensing analysis reveal the presence of a once-robust lake network consisting of seven major lakes: Nagavara, Rachenahalli, Jakkur, Hebbal, Doddabommasandra, Allasandra, and Yelahanka. These water bodies were historically interconnected via a cascading system of rajakaluves (stormwater canals) that facilitated staged overflow from one tank to the next, simultaneously recharging groundwater and mitigating floods.

However, field verification and spatial analysis indicate that most of these lakes are now semi-functional, owing to silt accumulation, disrupted interconnectivity, urban encroachments, and catchment fragmentation.

(Figure 6 - Lakes near Manyatha tech park neighbourhood in OSM)   *(Figure 7 - Lakes near Manyatha tech park neighbourhood in Google earth pro)*

Lake Name	Location (Direction)	Functional Status	Connectivity Status	Density (per sq.km)	Catchment Condition	Major Issues
Nagavara Lake	South-East (SE)	Semi-functional	Broken	0.8	High mismatch due to built-up area	Illegal encroachment, siltation, poor recharge, canal break
Rachenahalli Lake	North-East (NE)	Semi-functional	Broken	0.8	Altered catchment, high runoff	Missing link to Jakkur, sedimentation, edge development
Jakkur Lake	North (N)	Semi-functional	Partially connected	0.8	Urban runoff inflow dominates	Lack of recharge zones, inlet clogging, upstream load from Rachenahalli
Yelahanka Lake	Furthest North	Semi-functional	Disconnected	0.8	Catchment partially urbanized	Encroachments, blocked canal from Allasandra, limited overflow
Hebbal Lake	West (W)	Semi-functional	Disconnected	0.8	Catchment heavily built-up	High silt load, construction near inflow, weak link to Nagavara
Doddabommasandra Lake	West-Northwest (W-NW)	Semi-functional	Broken	0.8	Fragmented runoff zones	Encroachments, missing feeder canals
Allasandra Lake	North-Northwest (N-NW)	Semi-functional	Broken	0.8	Mismatch due to road barriers	No defined outflow, cutoff from Yelahanka, no recharge trenches

Table 4: List of lakes in the Manyata neighbourhood

The lake system around Manyata Tech Park—including Nagavara, Rachenahalli, Jakkur, Yelahanka, Hebbal, Doddabommasandra, and Allasandra—is semi-functional and hydrologically fragmented. Although lake density is adequate (0.8 lakes/sq.km), urbanisation has disrupted natural catchments and broken the cascading interconnectivity between lakes. Common issues include siltation, encroachment, missing or blocked feeder canals, and high surface runoff from impervious areas. As a result, these lakes no longer function as a cohesive flood-buffering system, leading to increased waterlogging, reduced recharge, and ecological degradation in the region.

3.4 Causes of Waterlogging and Urban Flooding

The region suffers from a collapsed hydrological cascade, wherein natural overflows between lakes have been obstructed or erased due to urban development. This breakdown has been intensified by several interrelated factors. First, the disruption of natural drainage pathways—particularly through the encroachment of stormwater drains (rajakaluves) and lake buffers—has eliminated vital flow corridors that once formed the

backbone of Bengaluru's rainwater management system. These channels now often terminate abruptly into constructed plots, roads, or sealed drain chambers, preventing natural flow continuity. Secondly, the unchecked expansion of impervious surfaces such as parking lots, rooftops, and highways has significantly reduced infiltration zones, causing rapid and polluted surface runoff to overwhelm nearby lakes. In parallel, the absence of micro-infiltration systems—like bioswales, infiltration trenches, and recharge wells—has further compromised the urban hydrology, resulting in both surface flooding and declining groundwater levels, even during seasons of high rainfall. Additionally, construction around lake peripheries has led to the degeneration of lake edges and the loss of vegetative buffers. Without reed beds, wetlands, or earthen bunds, lakes no longer function as dynamic systems capable of absorbing and filtering excess water. Finally, the failure of decentralized infrastructure has resulted in excessive reliance on artificial pumping mechanisms to evacuate stormwater from low-lying basins. These systems are neither ecologically sustainable nor resilient, particularly during intense monsoon periods, as demonstrated by the 2022 flooding of tech parks and arterial roads. Collectively, these issues point to a fundamental misalignment between urban development and the natural hydrological logic of the landscape.

3.5 Estimated Extent of Waterlogging Near Manyata Tech Park (2020–2024)

Located in a low-lying zone within the Hebbal Valley system, Manyata Tech Park and its surrounding areas have witnessed recurring waterlogging over the past five years. The issue is driven by a combination of intense seasonal rainfall, inadequate stormwater infrastructure, and fragmented lake connectivity. While precise GIS-based measurements are unavailable, approximate estimates based on incident reports and hydrological assessments provide a clear picture of the growing extent of urban flooding in this region.

Year	Estimated Waterlogged Area (% of tech park & surroundings)	Remarks
2020	~5–8%	Localized flooding after heavy showers; storm drains partially clogged; low impact on interior areas.
2021	~12–15%	Nov 2021 rainfall (~150 mm in 3 hrs) caused basement flooding, lake overflow; major arterial roads affected.
2022	~18–20%	Severe flooding city-wide; Manyata's entry/exit roads and peripheral blocks were under 2–3 feet of water.
2023	~10–12%	Recurring waterlogging incidents; less rainfall than 2022, but drain capacity still inadequate.
2024	~15–18%	Retaining wall collapse, flash flooding at Hebbal junction; arterial access routes submerged.

Table 5: Estimated Waterlogged area

On average, 10–15% of the Manyata Tech Park zone experiences waterlogging annually during monsoon events, with peak years like 2022 reaching nearly one-fifth of the area affected. While these are consistent flood incident reports and satellite observation summaries from hydrological studies.

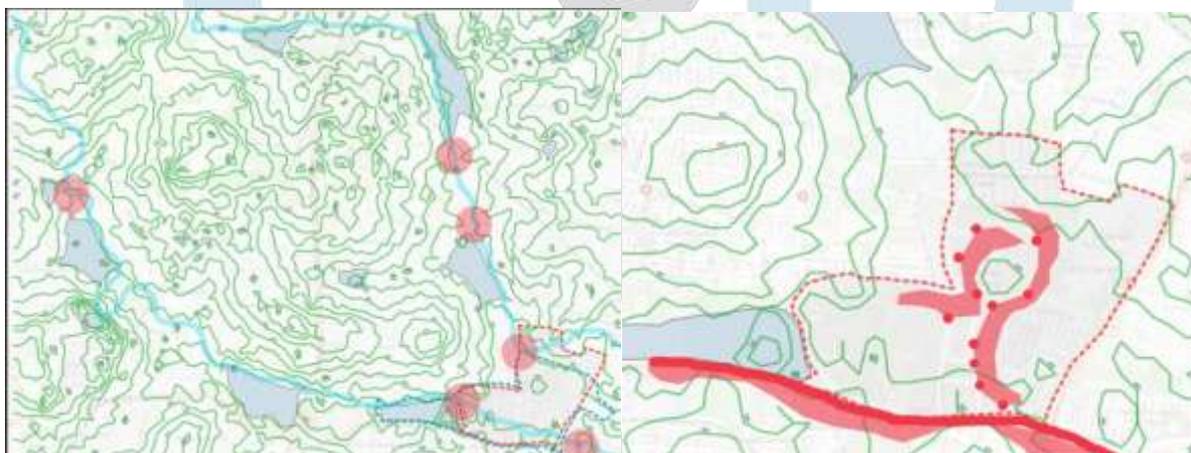*(Figure 8 - Manyatha tech park neighbourhood)*   *(Figure 9 - Manyatha tech park neighbourhood in QGIS)*

4. Ground Realities: Waterlogging Challenges Around Manyata Tech Park

Urban flooding around Manyata Tech Park is not just the result of intense rainfall but is deeply rooted in structural, administrative, and cultural challenges. One of the most critical issues is the irreversible loss of original valley lines, many of which have been built over by roads, high-rise developments, and boundary walls. This has disrupted the natural flow of water from higher to lower elevations, creating artificial water stagnation points with no defined outlet. Additionally, poor maintenance and lack of desilting in existing drains and lakebeds have further reduced the system's ability to absorb or redirect water during peak rains.

The absence of legally enforced buffer zones around lakes, rajakaluves (stormwater drains), and wetlands has enabled unchecked construction within sensitive hydrological corridors. Furthermore, the fragmentation of responsibilities among multiple civic agencies—such as BBMP, BWSSB, and BDA—creates coordination gaps, delaying preventive action and emergency response. Compounding these infrastructural and institutional issues is the lack of cultural association with water as a sacred resource, especially among corporate users and residents in the tech park area. Unlike older settlements that preserved kalyanis and temple tanks, the present urban fabric lacks awareness of the ecological or spiritual role of water systems.

(Figure 10 -Waterlogging mapping near Manyata tech park neighbourhood illustrated through red markers in QGIS)

(Figure 11 -Waterlogging mapping near Manyata tech park neighbourhoodillustrated through red markers in QGIS)

(Figure 12 -Waterlogging mapping near Manyata tech park neighbourhood)
Source: Google

(Figure 13 -Waterlogging mapping near manyatha tech park neighbourhood)
Source: Google

5. Strategic Interventions and Anticipated Benefits

To address the complex hydrological challenges in and around the Manyata Tech Park region, a set of integrated and context-sensitive strategies is proposed. These interventions are designed not only to mitigate current waterlogging and ecological fragmentation but also to restore the cultural and functional integrity of Bengaluru's historic water systems.

A key strategy is to re-map historical drainage and lake interconnectivity using a combination of topographic surveys, archival maps, and satellite imagery. This will help identify lost valley lines and natural flow corridors, enabling planners to align future interventions with the site's inherent terrain. Restoration of lake bunds, along with the construction of spillways and percolation pits, is essential to ensure safe overflow and gradual groundwater recharge. These hydraulic elements must be designed with capacity buffers to handle monsoon peaks while slowing down runoff velocity.

In areas where stormwater drains (rajakaluves) are still accessible, bioengineering solutions such as vetiver rows, bioswales, and vegetative buffers can be introduced. These not only stabilize embankments but also enhance water quality by filtering surface runoff. Additionally, the reintroduction of sacred stepped tanks (kalyanis) at key urban nodes—especially near junctions or institutional gateways—can act as both functional recharge zones and cultural landmarks.

For zones where topography has been significantly altered or blocked by urban infrastructure, injection wells and engineered percolators can be deployed to facilitate artificial recharge. These decentralized systems can work in tandem with restored surface flows to bring back a layered hydrological resilience to the landscape.

The implementation of these strategies is expected to deliver a range of benefits. Hydrologically, such interventions can reduce surface runoff by up to 60%, and enhance groundwater recharge by approximately 30%, based on comparative studies in similar urban catchments. Ecologically, restored wetlands and vegetated edges will foster biodiversity, improve soil health, and create a cooler microclimate within the tech park and adjacent neighbourhoods.

From a cultural and social perspective, the revival of sacred water elements as public commons will enhance landscape quality and civic awareness of Bengaluru's ecological heritage. Integrating water bodies into everyday movement patterns, workplace sustainability agendas, and even local cultural events can reposition hydrology as a visible and valued part of urban life. These strategies collectively frame a regenerative urban design approach that reconnects ecology, culture, and infrastructure in peri-urban Bengaluru.

6. Proposed Strategies for Hydrological Restoration and Resilience

6.1 Reconnecting the Cascading Lake System

Historically, Bengaluru's lake systems were designed as cascades, where excess water from an upper lake would flow into a lower one through natural or constructed channels. In the context of the Manyata Tech Park region, two critical chains are identified for reconnection:

Cascade 1: Rachenahalli → Nagavara → Hebbal

Cascade 2: Doddabommasandra → Allasandra → Jakkur → Yelahanka

(Figure 14- Proposed cascading reconnection map generated through QGIS Toolbox)

These cascading lines, if restored, will allow excess rainwater to move gradually across the terrain, reducing pressure on individual lakes and minimizing waterlogging. Restoration involves desilting of feeder canals, removal of encroachments, regrading of channel slopes, and the addition of vegetative buffers to slow down water movement and promote infiltration. Where direct reconnection is not possible, alternative engineered conduits may be used.

6.2 Integration of Percolation Zones within Hydrological Buffers

In areas where natural streamlines or open canals cannot be restored due to urban development constraints, strategic percolation zones are introduced. These include bioswales, recharge pits, vegetated infiltration strips, and pervious landscape corridors that are integrated within the canal buffer zones and lake surroundings.

These percolation areas are designed to absorb excess surface runoff, reduce waterlogging, and promote slow infiltration into the soil. The buffer widths vary from 6 to 12 meters, responding to local slope, flow intensity, and available space. By mimicking the function of traditional wetlands, these zones offer seasonal water storage, filtration, and cooling**.**

List of native grasses and shrubs of the Bengaluru region (Deccan Plateau ecology) that are excellent for resisting water flow (reduce runoff velocity) and enhancing groundwater percolation, making them ideal for use along lake edges, bioswales, percolation ponds, and sacred wetland buffers.

Grass Species	Botanical Name	Key Functions	Ideal Placement
Khar Grass	Cenchrus ciliaris	Deep-rooted, drought-resistant, reduces runoff speed	Lake bunds, recharge pits
Dhaman Grass	Cynodon dactylon (also sacred)	Dense mat, excellent erosion control and shallow percolation	Tank embankments, open patches
Buffel Grass	Pennisetum ciliare	Slows surface water, survives dry conditions	Check dams, tank footpaths
Kusha Grass	Desmostachya bipinnata	Sacred Vedic grass, retains moisture, stabilizes slopes	Sacred wetland edges
Lemon Grass	Cymbopogon flexuosus	Aromatic, root-binding, reduces flow	Swale sides, bund top edges
Heteropogon Grass	Heteropogon contortus	Native grassland species, slope stabilizer	Valley lines, sloped embankments

Shrub Name	Botanical Name	Function	Ideal Placement
Javanti	Barleria cristata	Fast-growing, forms hedges to slow water	Along bunds, sacred wetland edges
Indian Indigo	Indigofera tinctoria	Nitrogen-fixing, enhances soil structure	Bioswale fringes
Lantana (native variety)	Lantana indica	Dense foliage to slow water, but must be managed	Edges of recharge tanks (cautious use)
Wild Guava	Psidium guajava (local type)	Root system promotes soil porosity	Near sacred groves, bund tops
Karanj	Pongamia pinnata (shrub-tree form)	Bio-oil plant, deep roots, soil stabilizer	Lake edges, check dam nodes

*Table 6: List of ingenious grass and shrubs*

The selection of native shrubs such as Barleria cristata (Javanti), Indigofera tinctoria (Indian Indigo), Psidium guajava (Wild Guava), and Pongamia pinnata (Karanj) serves a dual function in the hydrological landscape of the Manyata Tech Park region. These shrubs are specifically chosen for their deep-rooting systems, ability to stabilize soil, and capacity to increase surface porosity. When planted along lake bunds, bioswale edges, and recharge corridors, they slow the velocity of surface runoff and promote localized infiltration. Moreover, nitrogen-fixing species like Indigofera improve soil structure, which enhances the percolation capacity of the landscape over time.

Shrubs like Karanj and Wild Guava have robust root systems that loosen compacted soil layers, making them especially useful in urban fringe areas where heavy construction has reduced natural permeability. By using these shrubs in strategic linear or clustered planting configurations, runoff is slowed, sediment is filtered, and water is given more time to infiltrate the soil before pooling or causing flooding.
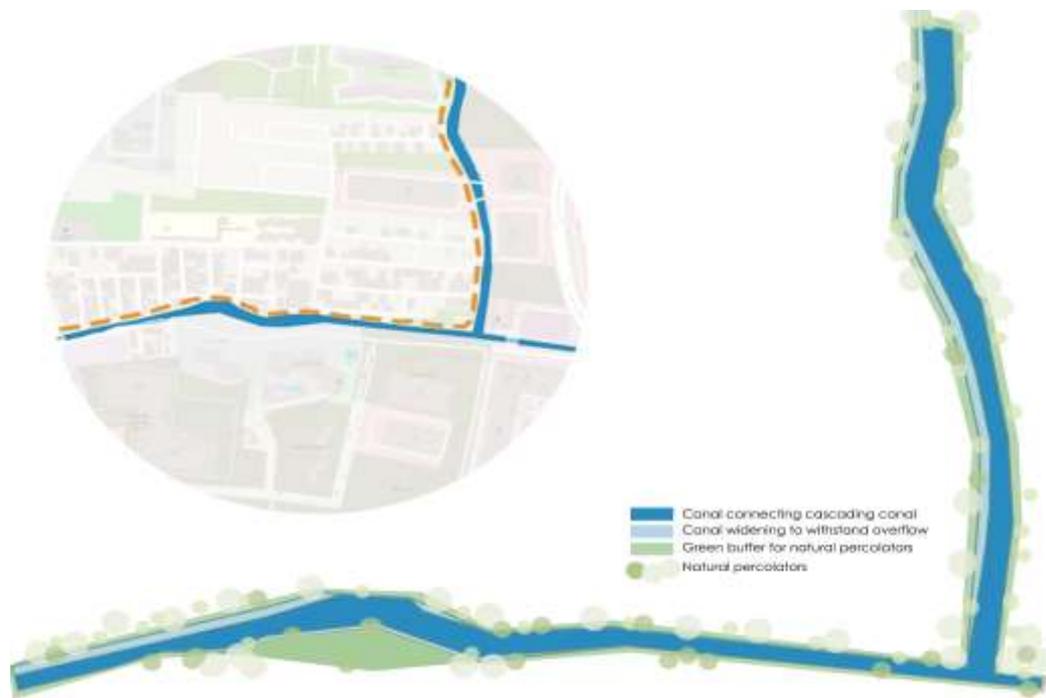
(Figure 15 -Proposed green buffers, canal widening area and implementation of natural percolaters near Manyata tech park neighbourhood) Illustrated through QGIS and photoshop
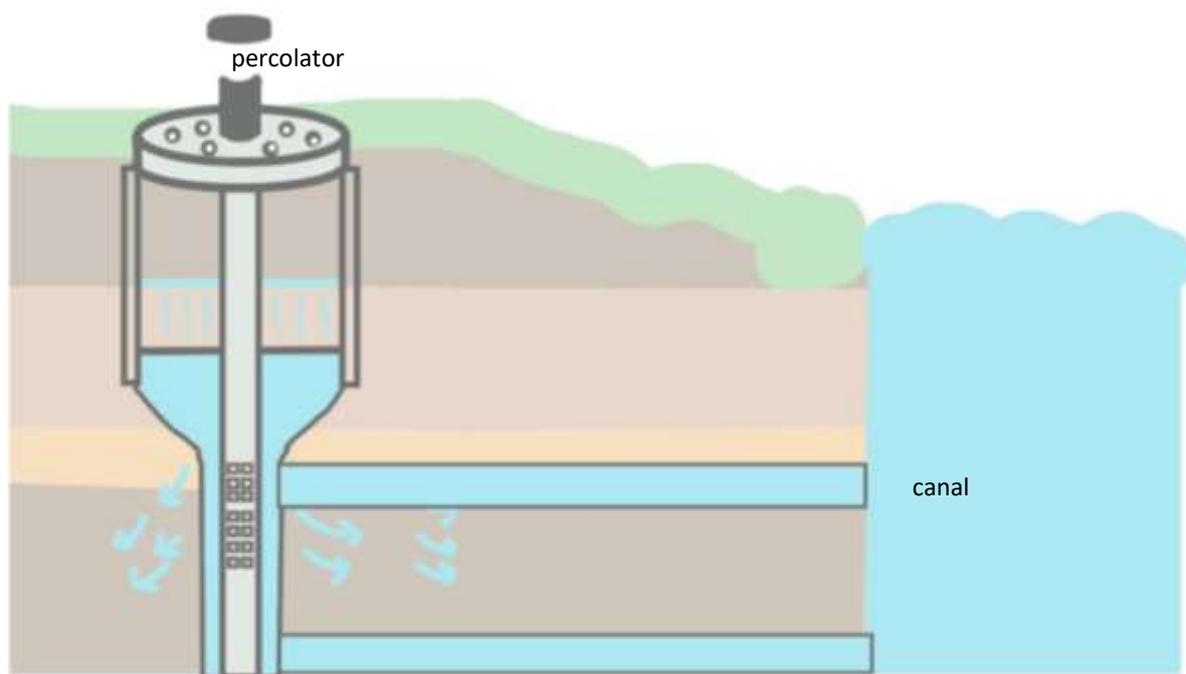*Source- Author drawn*
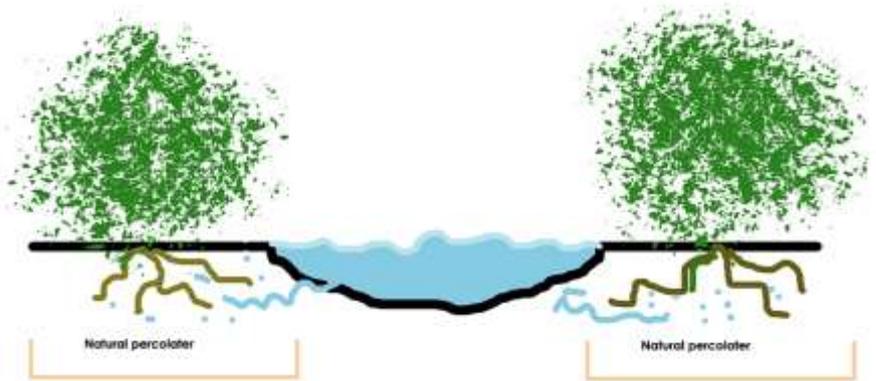
(Figure 16 -Proposed section of green buffers, canal widening area and implementation of natural percolaters near Manyata tech park neighbourhood) Illustrated through QGIS and photoshop
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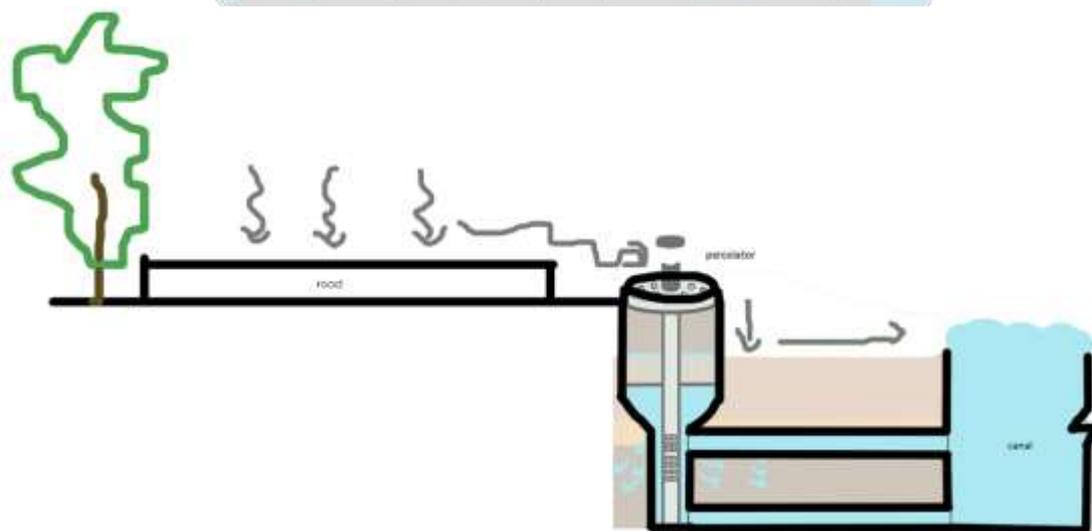## 6.3 Strategic Implementation of Percolators and Engineered Recharge Structures

The natural percolators are strategically integrated within the buffer zones of canals that link the cascading lake system in the Manyata Tech Park area. These percolators play a crucial role in mitigating surface waterlogging by facilitating groundwater infiltration and reducing excess runoff. To accommodate monsoonal overflow and manage high-intensity rain events, the canals are proposed to be widened, with green buffer zones ranging from 6 to 12 meters in width. This variation responds to local topography and hydrological load, enabling controlled overflow, sediment filtration, and ecological restoration along the water corridors. In areas where open canal construction is unfeasible due to space constraints, road crossings, or encroachments, alternative infiltration mechanisms—such as bioswales, gravel beds, and reed-based wetlands—are installed at key discharge points. These systems act as natural filtration units, improving the quality of water entering the lakes by removing silt, debris, and urban pollutants. This layered approach supports both water quality preservation and the ecological health of the interconnected lake network.

The proposed percolation system integrates a hydraulic percolator unit with a smart sensing mechanism, designed to respond dynamically to rainfall-induced surface overflow. Structurally, the system consists of a vertical percolation chamber embedded below ground level, filled with graded gravel, sand, and coarse filter media to allow for sediment filtration and gradual infiltration. At the surface, a sensor module continuously monitors water accumulation in the surrounding area—particularly during high-intensity rainfall events. Once the sensor detects that surface water has exceeded a defined threshold, it triggers a hydraulic valve system, which opens a pipe connection from the chamber to the nearest cascading canal. This allows excess water to be rapidly diverted before pooling occurs, thus preventing localised waterlogging. The percolator not only reduces surface runoff but also maintains hydrological continuity by
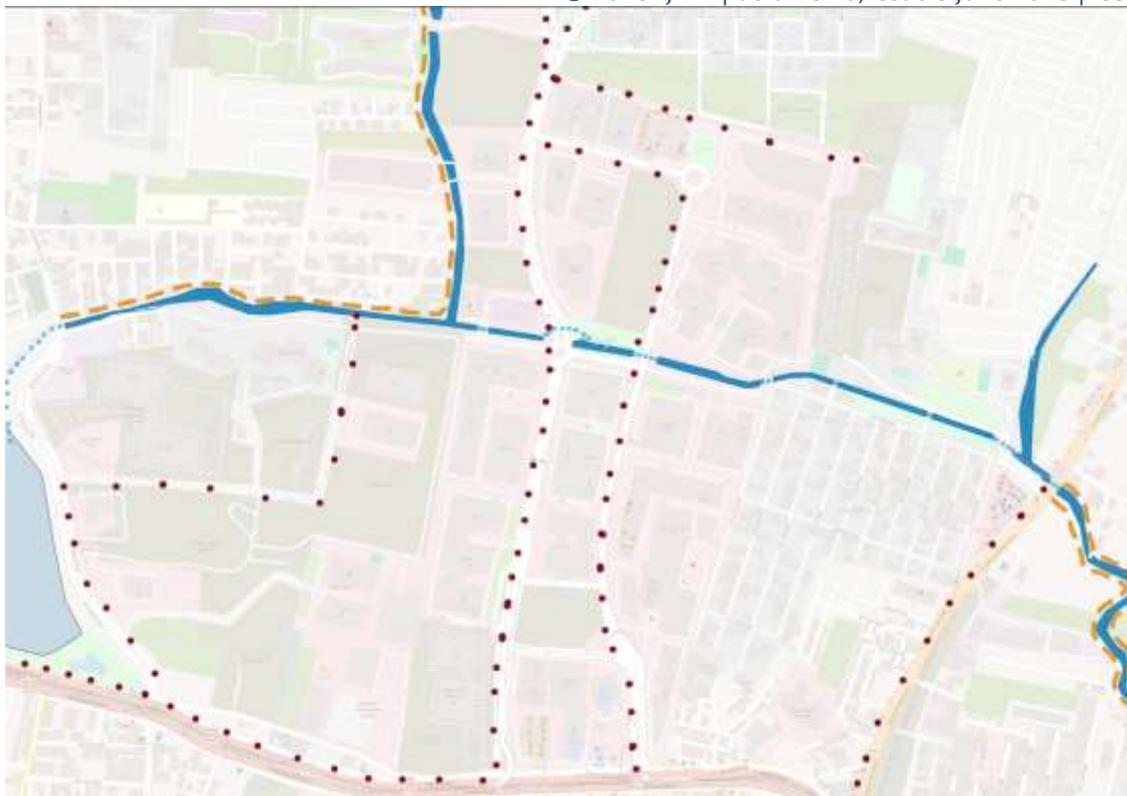
feeding the overflow directly into the larger lake network. This system is particularly useful in urban settings with limited open infiltration zones, as it offers a technologically enabled, decentralized water management solution that functions in sync with natural drainage logic.

(Figure 17 -Proposed engineered percolator inspired by injection well which can be used to connect the cascading canal to reduce overflow of rain water, Illustrated through photoshop
Percolater diagram inspiration - https://www.exportersindia.com/allegiance-water-management/other-products.htm
Source- Author drawn

(Figure 18 -Proposed section engineered percolator inspired by injection well which can be used to connect the cascading canal to reduce overflow of rain water, Illustrated through photoshop
Percolater diagram inspiration - https://www.exportersindia.com/allegiance-water-management/other-products.htm
Source- Author drawn

(Figure 19 - Proposed injection well or hydraulic percolaters placement towards street edge to connect cascading water canal to manage overflow in Manyata tech park) Illustrated through photoshop
Source- Author drawn

The above composite diagram illustrates a strategic intervention aimed at mitigating surface waterlogging and restoring hydrological continuity in the urban context of Manyata Tech Park and its surrounding precincts. The proposed system involves the placement of hydraulic percolators (represented as red dots) along the street-edge periphery, especially in zones where surface runoff tends to accumulate due to road gradients, impermeable surfaces, and disrupted valley lines.

These percolators are conceptually inspired by injection wells, yet adapted to the surface-urban condition through a modular and scalable layout. Each percolator is designed to include a sensing mechanism that detects overflow conditions during peak rainfall. Upon detection, the system facilitates the movement of excess water into a subsurface pipe network, which is directly linked to the cascading canal system (highlighted in blue). This allows the percolated stormwater to be channeled efficiently to the nearest functioning lake or canal without overwhelming the road network or creating localized waterlogging.

The blue lines in the image represent the proposed and existing cascading canal alignments that trace the original valley gradient. These canals are intended to carry treated or filtered stormwater between major urban tanks or lakes. The orange dashed lines indicate major existing roadways that intersect or run parallel to the drainage lines, pointing to critical junctions where surface runoff often accumulates due to topographic depressions or urban blockage.

The spatial pattern of percolator placement (as seen in Figure 19) reveals a grid-based distribution, responsive to road layout and building footprint, ensuring that runoff from multiple micro-catchments is intercepted before it reaches vulnerable low-lying zones. This decentralized, passive system is especially valuable in built-up peri-urban areas like Manyata, where open land for stormwater management is limited.

The proposal not only mitigates flooding but also supports groundwater recharge, water quality filtration, and ecological restoration of the valley network. It represents a fusion of traditional hydrological wisdom and modern technological adaptability, with strong potential for replication across other high-density urban zones in Bengaluru.

7. Environmental Impact of the Integrated System

The proposed integrated water management system in the Manyata Tech Park region offers multiple environmental benefits. It is expected to reduce surface runoff by up to 60% and decrease waterlogged areas by 15–25%, while improving groundwater recharge by 25–35%. Natural filtration through bioswales and wetlands will enhance water quality, removing up to 50% of pollutants. Green buffers and tree belts will help lower local temperatures by 1.5–2.8°C and sequester 2.5–3.5 tonnes of CO_2 per hectare annually. These restored ecological zones will also support native biodiversity, including birds and pollinators, while reintroducing sacred water elements will foster public awareness and community engagement in urban water stewardship.

7.1 Climate Resilience

The proposed Sacred Blue-Green Urbanism model addresses the intensifying effects of climate variability—especially the increased frequency of extreme rainfall events in peri-urban Bengaluru. With average annual precipitation nearing 970 mm, and 72% of it concentrated during the monsoon months (June–September), the region experiences sudden and heavy runoff volumes that overwhelm existing stormwater systems. The model enhances climate resilience by integrating both passive and active flood mitigation techniques. Sacred wetlands and vegetative buffers slow and absorb stormwater, while sensor-enabled hydraulic percolators redirect overflow to cascading canals and lakes. This decentralized and responsive design not only reduces the urban heat island effect but also restores ecological continuity across the valley section. Moreover, by reviving traditional water-holding patterns and coupling them with real-time adaptive infrastructure, the system ensures long-term resilience in the face of erratic monsoons and peri-urban development pressure.

8. Conclusion

The Sacred Blue-Green Urbanism model presents a holistic and replicable solution for managing peri-urban flooding, as demonstrated in the Manyata Tech Park region. By reconnecting cascading lakes, integrating sacred tanks, and introducing percolation-based landscapes, the approach can reduce waterlogging by up to 60% and enhance recharge by 30%. Rooted in traditional wisdom and ecological planning, it not only addresses hydrological challenges but also revives cultural memory and community stewardship, transforming vulnerable urban sprawl into a resilient and meaningful landscape.

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10. Bibiliography

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Figure 1. Spatial growth of Bangalore from 1537 (red) to 2007 (light yellow) (Source data from Census of India. Prepared by H.S. Sudhira and modified by Jerker Lokrantz/Azote. Published with kind permission of ©H.S. Sudhira 2013. All Rights Reserved)

Figure 2- 1930s Map of Bangalore /geomapp.wordpress.com/the-missing-lakes-of-bangalore/

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Figure 4. Some of the larger lake systems of Bengaluru. The networks have been fragmented due to encroachment into lakes and connecting canals/rajakaluves. Map by Shashank Palur.

Source - Well labs

Figure 5. Explaining about the cascading techniques connecting lakes /Lake Systems on the Dynamics of Nutrient Circulation in Catchment Areas/by Angela Kuriata-Potasznik

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(Figure 10 -Waterlogging mapping near Manyata tech park neighbourhood illustrated through red markers in QGIS)

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(Figure 13 -Waterlogging mapping near manyatha tech park neighbourhood)

Source: Google

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Source- Author drawn

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