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Dying Waters: An Ecological and Governance Crisis in Bengaluru's Lakes

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Abstract

Lakes play an active and vital role in managing vast ecosystems, they provide freshwaters, complete the nutrient cycle, help in water purification and recharging groundwater. They moderate floods and droughts, create habitats that sustain rich biodiversity-including fishes, amphibians, invertebrates, and birds-and offer cultural, recreational, and economic services. Their role in carbon storage and climate regulation further enhances ecosystem resilience. Together, these functions underscore lakes as indispensable natural assets for both environmental health and human well-being. Yet, they are often overlooked, grounded for construction and treated as dumping grounds. Many lakes of the Silicon Valley have already become history and many are faced with no care and conservation, all looking towards the same.

Keywords: BBMP, BDA, Bellandur Lake, Bengaluru, Conservation, Hebbal Lake, Lakes, Pollutions, Sewage, Ulsoor Lake, Urbanizations, Varthur Lake, Wastewater Management

Introduction

Bengaluru, previously known as Bengaluru (Fig. 1) is located on the Deccan Plateau, in the state of Karnataka. The city of Bengaluru was known by various names and given various titles such as "Bendakaalooru" (land of boiled beans), "Biliya Kallina Ooru" (city of white quartz stone), "Bengawaluru" (place of the bodyguards), and more recently, "City of Lakes" due to the large number of lakes constructed under the regime of Kings and British and numerous parks and gardens created such as Lalbagh, Cubbon Park, etc. which gave the city the title of "Garden City of India" (Dev, 2021) [9].

Post-Independence, due to rapid industrialization, Bengaluru became home to multiple MNCs and IT companies and is famously dubbed as the Silicon Valley of India. This is why 80% of all the global IT giants have their offices in Bengaluru and the city boasts a GDP of $110 billion, (Sharma, 2025) [25] contributing 87% of Karnataka's total GDP. Yet, on the flip side of a booming economy is the fallen glory of the city – unplanned, unrealistic and irresponsible urbanisation of a hill station.

Water is one indispensable resource for all forms of life, and crucial for the stability of entire ecosystems as well as the development of various industries and agriculture. Owing to increasing industrialization on one hand and exploding population on the other, the demand for water supply has been increasing tremendously. Surface and ground waters are the only major sources of water to meet out the entire requirement. They get contaminated in many ways. Once the groundwater is contaminated, it may remain in an unusual or even in hazardous condition for decades or even centuries.

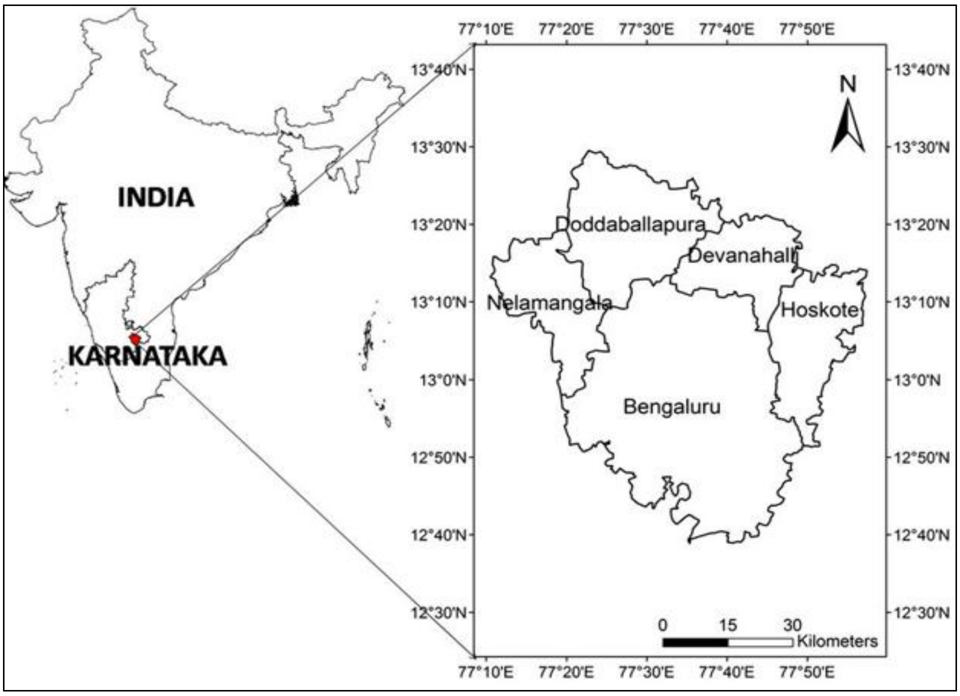

Fig 1: Map of Bengaluru, India (Gurunarayan, 2018)

Bengaluru, once known as the "City of Lakes," had over 1,000 lakes historically. By 1961, only 262 remained, and recent estimates indicate just 81 are still identifiable as lakes. Of these, only 33 are considered ecologically active, primarily because they lie in zones unsuitable for development. The remaining have been lost to unplanned urbanization, infrastructure expansion, and real estate encroachments. Government bodies like the Bruhat Bengaluru Mahanagara Palike (BBMP) and Bengaluru Development Authority (BDA) have been directly or indirectly responsible for the disappearance of over 100 lakes. Dharmambudhi Lake, once maintained by the Hoysalas and Wodeyars, was the first major loss, converted into the Kempegowda Bus Terminus in 1969. Currently, BBMP claims custody of 167 lakes and BDA of 33. Of the 204 lakes under BBMP's jurisdiction, 131 are encroached, and only 20 remain completely free from encroachment. A BBMP report reveals that 159 lakes have been encroached by various government bodies, including jails, roads, and housing layouts. In total, 941 acres of lake land have been encroached, with just 38 acres reclaimed. Activists have helped preserve some key lakes like Hebbal, Halasuru, and Nagavara, but conservation remains minimal and poorly enforced (Raghuram, 2024) [20].

2. Literature Review

2.1 Historical Context and Significance

Bengaluru was once known as the "City of Lakes," with estimates indicating over 1,000 man-made tanks constructed historically to serve irrigation and domestic water needs (Sudhira, 2007) [26]. These lakes, many of which date back to the rule of the Hoysalas, Kempegowda, and the Wodeyars, were integral to the city's hydrology and ecology (Ramachandra T. V., 2017) [23].

2.2 Current Status

The number of lakes has drastically declined due to rapid urbanization. By 1961, Bengaluru had 262 lakes and as per the Environmental Management and Policy Research Institute (EMPRI, 2018) [10], only 81 lakes remain identifiable, and of these, just 33 are considered ecologically viable. A BBMP-commissioned report (BBMP, 2017) identified that of 204 lakes under its jurisdiction, 131 were encroached, and only 20 were fully protected.

2.3 Causes of Lake Degradation

- Unplanned Urbanization and Encroachment: The foremost reason for lake loss is rampant urban expansion. Real estate development, road construction, and illegal housing layouts have replaced many lakes (JNNURM, 2009) (BBMP, 2017) [4].
- Government and Institutional Encroachments: The BBMP's own records admit that 159 lakes have been encroached by government bodies, including jails, tahsildar offices, hospitals, and housing boards (BBMP, 2017) [4].
- Pollution and Sewage Inflow: Untreated sewage and industrial waste entering the lakes have degraded their water quality and led to eutrophication, especially in Bellandur and Varthur Lakes (Ramachandra T. V., 2017) [23].
- Neglect of Conservation: Conservation efforts have been minimal and sporadic. Scientific management plans exist but are poorly enforced, partly due to bureaucratic overlap between BBMP, BDA, and the Karnataka State Pollution Control Board (KSPCB) (Ramachandra T. &., 2009) [21].

2.4 Citizen and Activist Interventions

Despite institutional neglect, citizen movements and legal interventions have played a role in protecting some lakes. Activists and resident welfare associations have helped rejuvenate lakes such as Hebbal, Ulsoor, and Nagavara (ATREE, 2015) [3].

2.5 Policy and Planning Gaps
The lack of an integrated lake management policy and ineffective implementation of existing plans, like the Lake Development Authority (LDA) guidelines, further exacerbates the problem. Moreover, overlapping jurisdiction among civic agencies leads to fragmented lake governance (EMPRI, 2018) [10].

3. Materials and Methodology
Bengaluru is situated in the southeast of the South Indian state of Karnataka. It is positioned at 12.97° N 77.56° E and covers an area of 2,190 square kilometres (850 sq. mi.). A landlocked city, Bengaluru is located in the heart of the Mysore Plateau (a region of the larger Deccan Plateau) at an average elevation of 920 metres (3,020 ft). Bangalore district borders with Kolar and Chikkaballapur in the northeast, Tumkur in the northwest, and Mandya and Ramanagaram in the southeast.

A total of 4 prominent lakes across the city (Table 1) have been taken into consideration for this study. The health of the lakes have been assessed based on physical, chemical, and biological parameters which would allow this study to evaluate water quality, ecological stability, and the presence of potential pollutants or environmental degradation. Finding the root cause for the decline of lake health will help understand various methods of preventive and conservation.

Table 1: List of Lakes considered

Sl. No.	Name of Lake	Location	Control	Area (Ac.)
1	Bellandur Lake	Bellandur	BDA	919.00
2	Varthur Lake	Varthur	BDA	439.00
3	Hebbal Lake	Hebbal	BBMP	150.00
4	Ulsoor Lake	Ulsoor	BBMP	108.00

4. Results and Discussions
4.1 Lake Study
4.1.1 Bellandur Lake
- **Physical parameters:** Average depth ~1.5 m; water temperature ranges ~25–30 °C; turbidity and total suspended solids very high (TDS often > 1000 mg/L, turbidity frequently extreme)
- **Chemical parameters:** pH approx. 7–8.4; DO (dissolved oxygen) frequently drops to 0 mg/L; BOD averages ~22–100 mg/L, COD ~150–200 mg/L; nitrate, phosphate, TDS, and conductivity well above safe thresholds; heavy metals (Cr, Cd, Pb, Ni, Cu) present in elevated levels (e.g., Pb up to 1.7 mg/L) (Prabhudeva K N, 2020) [19].
- **Biological parameters:** Coliform and E. coli counts exceed safe limits; phytoplankton and zooplankton populations are dominated by pollution-tolerant species; heavy eutrophication with persistent algal blooms and macrophyte growth (e.g., water hyacinth covering ~60 % of surface).
- **Issues and status:** Classified as Class-E (worst category) by CPCB; prone to frothing and even fires (2015–2019); essentially anaerobic, biologically dead zones; ongoing encroachments and sewage inflow.
- **BBMP/BDA efforts:** Initiatives include sewage treatment plant installation (since 2017), desilting, macrophyte harvesters, buffer zone enforcement, and froth control measures; most rejuvenation projects are led by IISc, BWSSB, and court directives alongside BBMP involvement (Bellandur and Varthur Lakes Rejuvenation Blueprint, 2017) [6].

4.1.2 Varthur Lake
- **Physical parameters:** Shallow Lake (<3 m), anaerobic near inflows (0 mg/L DO), aerobic zones at outlets during monsoon; elevated TDS, conductivity, alkalinity, and hardness compared to earlier studies.
- **Chemical parameters:** High BOD (~32–175 mg/L) and COD (~50–280 mg/L); nutrients (phosphates, nitrates) are high, supporting eutrophic conditions; pH around 6.9–8.2.
- **Biological parameters:** Algal growth provides some BOD removal (50 % in monsoon), but floating plants inhibit treatment otherwise; anaerobic microbial activity dominates inflow zones (T.V., 2008) [27].
- **Issues and status:** Eutrophic, pollution-laden, with persistent nutrient loading and poor wastewater capture; acts as an anaerobic–aerobic lagoon that intermittently treats sewage; catchment receiving unfiltered inflow.
- **BBMP/BDA efforts:** Part of integrated rejuvenation blueprint (IISc-led) with desilting, weir construction, macrophyte control, and catchment management, in coordination with BWSSB; however, progress remains slow and intermittent (Bellandur and Varthur Lakes Rejuvenation Blueprint, 2017) [6].

4.1.3 Hebbal Lake
- **Physical parameters:** Depth ~1.4 m, temperature within normal range; turbidity and TDS moderate to high; electrical conductivity elevated.
- **Chemical parameters:** pH within 7–8.5; DO moderately low; BOD often exceeds 6 mg/L BIS limit; COD elevated; hardness, TDS, chloride within-or slightly above-norms (Poojashri R Naik, 2019) [18].
- **Biological parameters:** Blooms of water hyacinth and Typha; birdlife remains rich (e.g., pelicans, spoonbills); introduction of biological control (weevils) since 1983; moderate ecological activity but stressed.
- **Issues and status:** Domination by invasive macrophytes with eutrophic conditions; catchment-based sewage inflow; but ecological value persists; moderate restoration success in biodiversity terms.
- **BBMP/BDA efforts:** Public-private partnership since late 1990s (Oberoi Group), includes desilting (2003), boating infrastructure, and continuous macrophyte management; biological control introduced decades ago; citizens have also protested lease arrangements.

4.1.4 Ulsoor Lake
- **Physical parameters:** Average depth ~2.5 m; well-mixed thermal profile; turbidity high; conductivity and TDS elevated; slight alkaline pH.
- **Chemical parameters:** DO varies 0.2–4.5 mg/L; phosphate and nitrogen levels high; heavy metals (Zn, Cd, Cr, Pb, Cu) in sediment and water-significantly elevated. (Anima Upadhyay, 2015) [2].
- **Biological parameters:** Prone to eutrophication-'saprobic', P/R ratio < 1; dominance of toxic blue-green algae (Microcystis); loss of fish diversity; macrophyte

reduction gradual. (Vyshnavi D R, 2020) [29].

- **Issues and status:** Polluted by three drains (slums, Army); has periodic algal blooms; degraded fish and plant life; in need of nutrient load control. (H.K, 2020)
- **BBMP/BDA efforts:** Desilting, silt-trap installation, storm drain redirection, sewage bypass pipelines, aeration, fencing, planting native aquatic species, regulating idol immersion, and anti-dumping measures-all yielding some improvements.

4.2 Data Analysis

The physical condition of Bengaluru's lakes reflects considerable deterioration due to urbanization and encroachments. Most lakes, including Bellandur, Varthur, Hebbal, and Ulsoor, exhibit reduced water depths averaging between 1.4 to 2.5 meters due to sustained siltation. Turbidity levels are generally high, indicating significant suspended particulate matter, especially in sewage-receiving lakes like Bellandur and Varthur. Elevated total dissolved solids (TDS) and electrical conductivity values suggest high mineral and pollutant load. Fluctuations in water temperature (~25–30 °C) are typical, but shallow depths limit thermal stratification, worsening oxygen depletion in bottom layers. These physical impairments compromise the self-purification capacity of the lakes and disrupt their hydrological balance.

The chemical profile of Bengaluru's urban lakes reveals chronic pollution, primarily from untreated domestic sewage and industrial effluents. Dissolved oxygen (DO) levels are consistently low, often nearing zero in Bellandur and Varthur Lakes, indicating anaerobic conditions that are unsuitable for most aquatic life. Biological oxygen demand (BOD) ranges from 22 to 175 mg/L, and chemical oxygen demand (COD) spans 50 to 280 mg/L-both exceeding permissible limits and pointing to high organic load. pH levels are mostly neutral to slightly alkaline (6.9–8.5), but the buffering capacity is insufficient to counteract nutrient inflows. Nutrient concentrations (phosphates and nitrates) are elevated, promoting eutrophication, while heavy metals such as lead, chromium, cadmium, and zinc have been detected above safe thresholds, particularly in sediment samples. These chemical imbalances not only degrade water quality but also pose risks to public health and downstream ecosystems.

Ecologically, Bengaluru's lakes are under severe stress, with most exhibiting characteristics of hypereutrophic or saprobic systems. Aquatic biodiversity has declined sharply, especially in Bellandur and Ulsoor Lakes, where fish kills and reduced phytoplankton diversity are reported. Pollution-tolerant species dominate the plankton community, and native macrophytes have been displaced by invasive species like water hyacinth and Typha. Algal blooms, especially of Microcystis (a toxic blue-green algae), are common, further depleting DO and disrupting trophic dynamics. Coliform and E. coli counts far exceed acceptable levels, reflecting untreated sewage inflow. While Hebbal Lake retains some bird diversity and signs of partial ecological resilience, the overall biological integrity of Bengaluru's lakes has been severely compromised, indicating a shift from functional aquatic ecosystems to stagnant, pollutant-laden water bodies.

From the above specifics, there's no doubt that these lakes and many more, similarly, remain in ill health. In summary (Table 2), all four lakes show degraded health across physical, chemical, and biological metrics:

- Bellandur and Varthur are the most critical, with class-E status, anaerobic dead zones, extreme eutrophication, toxic heavy metals, repeated froth/fires.
- Hebbal is moderately better: some DO and biodiversity persist, but continues to face eutrophication and invasive weeds.
- Ulsoor shows improvement signs, but still suffers eutrophic stress and metal accumulation.

Table 2: Lake Testing and Analysis

Parameter	Bellandur	Varthur	Hebbal	Ulsoor	Rough Average
Depth (m)	~1.5	<3	~1.4	~2.5	~2 m
DO (mg/L)	0–3	0–5 (often 0)	~2–4 (low)	0.2–4.5	~1–3 mg/L (low)
BOD (mg/L)	22–100	32–175	6–15+	(Data likely high)	~30–70 mg/L
COD (mg/L)	~150–200	50–280	moderate (~20–50)	elevated (~50+)	~100–150 mg/L
pH	7–8.4	6.9–8.2	7–8.5	~7–8	Neutral - Slightly alkaline
Pollution Type	Heavy sewage & industrial effluents	Sewage-fed anaerobic	Eutrophic sewage inflow	Eutrophic drains & metals	—

5. Challenges & Gaps

5.1 Governance & Institutional Fragmentation

One of the most significant challenges in lake conservation is the lack of a centralized governance structure. Multiple agencies-BBMP, BDA, BWSSB, Minor Irrigation Department, and KSPCB-operate with overlapping jurisdictions, resulting in coordination failures and accountability deficits (Ramachandra T. A., 2021) [22]. Court-mandated Lake protection committees have been intermittently active, and the absence of a unified lake management authority hinders sustained ecological planning.

5.2 Sewage and Wastewater Inflow

A major driver of lake degradation is the inflow of untreated sewage and stormwater, which often carries solid waste and industrial effluents. Studies by the Karnataka State Pollution Control Board (2023) [16] show that key lakes such as Bellandur and Varthur receive upwards of 400 MLD (million litres per day) of untreated sewage, leading to eutrophication, oxygen depletion, and loss of aquatic life. The delayed or non-functional state of many STPs exacerbates the problem.

5.3 Encroachments and Land Use

Lakebeds, buffer zones, and raja kaluves (stormwater drains) have been extensively encroached upon for construction, reducing catchment capacity and fragmenting aquatic ecosystems (CSE, 2020) [8]. Despite court rulings mandating 30–75-meter buffer zones, enforcement remains weak, and political pressures often stall eviction drives (Lake Protection, 2020) [16].

5.4 Ecological Degradation

Excessive nutrient loading has led to hyper-eutrophication, resulting in invasive species (e.g., water hyacinth, Typha) dominance and frequent algal blooms. Native biodiversity-fish, birds, and plankton-has declined across lakes like Ulsoor and Hebbal (Ramachandra T. V., 2018) [24]. Restoration efforts often prioritize aesthetics (walking paths, fountains) over ecological integrity.

5.5 Lack of Community Integration & Data Transparency

While citizen groups are actively engaged, their efforts are not institutionalized within governmental frameworks. Monitoring data on water quality and biodiversity is rarely made publicly accessible, making it difficult to assess the impact of restoration projects or hold authorities accountable (Citizen Matters, 2023) [7].

6. Conservation Methods and Efforts

6.1 Identified Conservation Methods

6.1.1 Integrated Lake Management Plans

Experts recommend an integrated, catchment-to-lake management approach that includes protection of inflow channels, installation of decentralized wastewater treatment systems, and reforestation of lake bunds and buffer zones (Ramachandra T. V., 2018) [24]. ILMPs promote long-term hydrological and ecological restoration by treating the lake as part of a larger watershed.

6.1.2 Nature-Based Solutions

Constructed wetlands, floating islands, and bio-remediative systems offer sustainable alternatives to conventional chemical or mechanical water treatment. These systems filter pollutants, enhance biodiversity, and require minimal energy inputs (Upadhyay, 2017) [28].

6.1.3 Participatory Governance

Formal inclusion of resident welfare associations (RWAs), local NGOs, and citizen science groups in planning and monitoring is essential. Projects like the Puttenahalli Lake (managed by PNLIT) and Channasandra Lake (revived through crowdfunding) exemplify successful co-management models (India Water Portal, 2024) [13].

6.1.4 Legal and Policy Enforcement

Strengthening enforcement of existing regulations, digitizing lake boundary records, and using real-time monitoring through remote sensing and drones can aid in early detection of violations and encroachments (Ramachandra T. V., 2018) [24]. Consistent legal follow-through on PILs has proven effective in protecting certain lakes (Lake Protection, 2020) [16].

6.1.5 Financial Innovation

To overcome budgetary limitations, BBMP and allied bodies are exploring green bonds, CSR partnerships, and impact funding. These innovative financing tools can ensure sustained investment in infrastructure and ecological maintenance (CSE, 2020) [8].

6.2 Government-Led Conservation Efforts

6.2.1 Infrastructure & Engineering Interventions

Government bodies, primarily the Bruhat Bengaluru Mahanagara Palike (BBMP), Bangalore Development Authority (BDA), and Bangalore Water Supply and Sewerage Board (BWSSB), have undertaken multiple infrastructural projects for lake rejuvenation. These include desilting operations, installation of sluice gates for flood regulation, and diversion of sewage inlets (Ramachandra T. A., 2021) [22]. As of 2024, BBMP announced plans to install sluice gates at 38 lakes at an estimated cost of ₹114 crore to manage stormwater and prevent backflow during heavy rains (Times of India, 2025) [1].

6.2.2 Wastewater Management & Sewage Diversion

To combat the discharge of untreated sewage into lakes such as Bellandur and Varthur, the BWSSB has constructed and proposed several Sewage Treatment Plants (STPs). However, the actual efficiency and timely completion of these plants remain contentious. Many STPs either remain non-operational or fail to meet quality norms (KSPCB, 2023) [16]. Additionally, rainwater harvesting initiatives are being implemented to reduce runoff and recharge groundwater.

6.2.3 Legal & Policy Framework

Following directives from the Karnataka High Court and the National Green Tribunal (NGT), BBMP has demarcated buffer zones and fenced multiple lakes to prevent further encroachment (Lake Protection, 2020) [16] Encroachment clearance drives have been carried out, with over 49 lakes being surveyed and marked for legal protection (BDA, 2022) [5]. Surveillance through CCTVs and appointment of marshals are also among the measures to prevent dumping and encroachment, although lack of coordination and underfunding persist (Citizen Matters, 2023) [7].

6.2.4 Ecological Restoration Methods

BBMP has incorporated ecological elements such as silt traps, constructed wetlands, floating islands, and aeration systems to restore water quality. Projects under the Chief Minister's Nava Nagarothana initiative have funded lakes like Yelahanka and Chikkabellandur with jogging tracks, peripheral plantations, and boating facilities to enhance public access while preserving ecological function.

6.3 Public & Community-Driven Conservation Efforts

6.3.1 Citizen-Led Restoration Projects

Grassroots mobilisation has been central to reviving several lakes. A notable example is the B Channasandra Lake in Kasturinagar, which was revived in 2024 through community funding, without government financial support. Local groups raised over ₹8 lakh and coordinated ecological restoration efforts such as bund strengthening, afforestation, and clean-up campaigns (India Water Portal, 2024) [13]. Similar successes are seen in Puttenahalli and Arekere Lakes through groups like the Puttenahalli Neighbourhood

Lake Improvement Trust (PNLIT) and Arekere Neighbourhood Improvement Trust (ANIT), which work in collaboration with civic authorities (Jalmitra, 2023) [14].

6.3.2 Monitoring and Volunteer Engagement

Volunteers routinely audit lake infrastructure and ecological health by tracking inlets, observing biodiversity, and submitting reports to civic bodies. Digital platforms and WhatsApp groups have become tools for coordination and knowledge sharing. Citizen data has influenced several BBMP lake rejuvenation blueprints (Ramachandra T. A., 2021) [22].

6.3.4 Legal Advocacy and Awareness Campaigns

Public interest litigations (PILs) by environmental activists and NGOs have led to landmark judicial rulings that defined buffer zones, mandated STPs, and curtailed encroachment (Upadhyay, 2017) [28]. Additionally, awareness campaigns such as "Bengaluru Habba" and school eco-clubs have helped promote lake stewardship among younger citizens and urban residents.

7. Conclusion

Lake conservation in Bengaluru is at a critical juncture. While government bodies have initiated structural and policy-level interventions, the scale of ecological degradation and institutional fragmentation has outpaced progress. A paradigm shift toward integrated, participatory, and ecologically sensitive lake management is urgently needed. Strengthening community-government partnerships, enforcing land use norms, adopting nature-based restoration strategies, and ensuring data transparency are central to restoring these vital ecosystems. The future of Bengaluru's lakes depends on collective responsibility, long-term ecological planning, and a governance system that values water security and urban resilience.

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