frontiers in Sustainable Cities

TYPE Original Research
PUBLISHED 21 October 2026
DOI 10.3389/frsc.2026.1920960

Check for updates

OPEN ACCESS

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RECEIVED 26 June 2026
REVISED 30 September 2026
ACCEPTED 05 October 2026
PUBLISHED 21 October 2026

CITATION
Nayak S, Döring M, Bhattacharya S, Ekmekcioglu R, Knieling J and Poschlod B (2026) Institutional dynamics of circular and climate-adaptive water governance in Bengaluru.
Front. Sustain. Cities 8:1920960.
doi: 10.3389/frsc.2026.1920960

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Institutional dynamics of circular and climate-adaptive water governance in Bengaluru

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Introduction: Rapid urbanization and climate change threaten global urban water security, with projections indicating that over 1 billion urban residents will face water short ages. In many Global South cities, water crises are infrastructural as well as institutional challenges rather than merely hydrological ones, yet city-level analyses of these institutional barriers remain scarce. This study addresses this gap by examining the institutional and organizational barriers to effective water management in Bengaluru, India, a city of over 10 million people facing severe water stress despite importing 1,450 million liters of water daily.
Methods: Using an inductive, exploratory qualitative case-study approach, we conducted 12 semi structured interviews with 13 stakeholders, spanning policymakers to engineers, between December 2024 and February 2025, thematically coded using MAXQDA.
Results: Our study identified that Bengaluru's water crisis stems from four interconnected institutional failures: (1) weak governance, marked by capacity deficits and absent regulatory frameworks; (2) siloed administrative processes fragmenting decision making across departments; (3) inertia embedding inefficient systems; and (4) lock-in contributing to mutually reinforcing feedback loops that are resistant to change. These factors operate simultaneously across strategic, operational, regulatory, and financial dimensions, perpetuating unsustainable water management.
Discussion: We propose water circularity as a framework for institutional reform that addresses these barriers across all four dimensions. By grounding institutional theory in city-level empirical evidence, this study extends the largely comparative literature and offers exploratory, key-informant evidence suggesting that institutional transformation and infrastructural investment are essential for urban water resilience and sustainability. While rich, these findings lack statistical generalizability; future research should pursue comparative analyses across South Asian megacities and track how Bengaluru's ongoing governance restructuring reshapes these dynamics.

KEYWORDS
Bengaluru, climate adaptation, lock-in, urban water governance, water-circularity, siloes, inertia

1 Introduction

Urban water crises are expected to occur with increasing frequency (Liu et al., 2017; Intergovernmental Panel on Climate Change (IPCC), 2023), with projections indicating that more than one billion urban inhabitants will face water shortages in the foreseeable future (Greve et al., 2018). Water scarcity directly impacts the health and wellbeing of urban populations, quality of urban environments, and trajectory of socioeconomic development (Krueger et al., 2019; McDonald et al., 2014). Over the next three decades, population growth, urbanization, and socioeconomic development are anticipated to lead to a 50%–80% increase in urban, industrial, and domestic water demand (Flörke et al., 2018). Addressing these challenges requires social and technical solutions, alongside flexible and robust institutions capable of sustainably managing urban water systems.

While the physical dimensions of urban water scarcity have received considerable scholarly attention in the recent decade, growing evidence suggests that water crises are as much institutional as they are hydrological (Ekmekcioğlu et al., 2022; Shemer et al., 2023). The ability of urban areas to handle water resources sustainably relies on the presence of infrastructure and the efficiency of % the institutions overseeing them (Dong et al., 2020). This includes regulatory frameworks, organizational structures, and governance norms that determine the allocation, management, and upkeep of water (Prakash et al., 2025). In numerous urban areas, the presence of fragmented institutional structures and arrangements with overlapping responsibilities among various agencies hampers the coordination of sustainable water management efforts (Zhou et al., 2025). Additionally, the inadequate enforcement of regulations diminishes accountability throughout the supply chain (Ledeunff et al., 2025). These difficulties are further exacerbated by institutional legacies that are dependent on historically established path dependencies (Moharaj et al., 2026), which will influence urban water governance in the near future. This influence often does not align with the current realities and needs of urban environments. Beyond infrastructure investment, stakeholder perspectives suggest that institutional arrangements may play an important role in shaping responses to urban water shortages, a relationship this study explores through 13 expert interviews.

Urban water governance faces considerable institutional challenges in rapidly growing Global South cities, where infrastructure development lags behind population, economic, and spatial growth (Arku and Marais, 2021). The governance of urban water systems is further complicated by formal and informal supply systems, socioeconomic access disparities, and climate-stress water resources (Beard and Mitlin, 2021). Colonial legacies often result in fragmented jurisdictions, ambiguous state-municipal responsibilities, and regulatory frameworks that are mismatched to urban needs (Verdini et al., 2025). As these areas expand, administrative and regulatory capacity has not kept pace with governance requirements, pointing to a continued need for institutional reform to support sustainable urban development.

Institutional and infrastructural challenges to water management have been documented across Indian cities amid hydrological pressures from climate change and urbanization. In India, modeling indicates that changing rainfall intensities necessitate reassessing conventional stormwater control design assumptions (Sabut et al., 2026). Similarly, land use and land cover changes interacting with climate variability alter streamflow and water availability in reservoir catchments, such as the Mahanadi Basin in Chhattisgarh (Verma et al., 2023). Reviews of India's water policy highlight the gaps between design and implementation, including availability estimates, groundwater depletion, and fragmented governance (Singh and Goyal, 2025). A policy review argues that circular water management and reform are needed (Kumar and Goyal, 2025), and studies indicate that drainage components must evolve to support stormwater infrastructure and flood resilience (Bhat et al., 2025). Positioning Bengaluru within this context suggests that the institutional challenges analyzed here reflect governance fragmentation which may resonate with patterns documented elsewhere in urbanizing India.

Despite the scientific literature on urban water governance, empirical studies of institutional barriers to effective water management in growing Global South cities remain limited, with much of the research relying on comparative, review-based, or framework-oriented analyses rather than detailed city-level empirical studies (Yasmin et al., 2023). Existing research mainly focuses on the technical and infrastructural dimensions of water supply or addresses governance from comparative perspectives, leaving institutional dynamics in urban environments almost unexamined (Abera et al., 2025). While water circularity and institutional reform have gained traction in policy debates, their application in cities marked by institutional fragmentation and path dependency remains insufficiently theorized and empirically investigated (Lasseur et al., 2025; Yasmin et al., 2023). Our study addresses these gaps with an exploratory analysis of the institutional challenges in Bengaluru's water system and the role of circular water management principles that can improve water sustainability.

Our research explores the institutional and organizational obstacles within Bengaluru's urban water system that can hinder progress toward sustainable, resilient water governance. Utilizing qualitative case study research, this study answers the following questions: What primary institutional challenges hinder effective urban water management in Bengaluru? Furthermore, our study provides an exploratory expert perspective on institutional dynamics in one of South Asia's expanding cities, while conceptually linking institutional analyses to the emerging discourse on circular water systems as a framework for urban water transition.

2 Theoretical framework

Diversifying water sources and structures reduces reliance on overburdened freshwater and enhances adaptability through reuse and efficient water management. However, effective urban water system resilience depends on city management, governance, and the resolution of urban water-related challenges. Research suggests that increased institutional flexibility and coordination can unlock improvements in adaptive urban water management (Bakker et al., 2008), yet many cities face mutually reinforcing patterns of institutional challenges (Groen et al., 2023). These mutually reinforcing patterns of institutional challenges (see Figure 1.) may lead to frictions in urban water governance, which arise from a complex interplay of weak governance arrangements, siloed decision-making or implementation processes, institutional and organizational inertia, and systemic lock-in, which collectively impede improvement and change.

Given these institutional challenges, we explore the feasibility of implementing urban water circularity in Bengaluru (see Figure 1).

Weak governance refers to public institutions that lack capacity (sufficient staff, technical expertise, and reliable funding), so that formal rules and policies are not consistently implemented or enforced

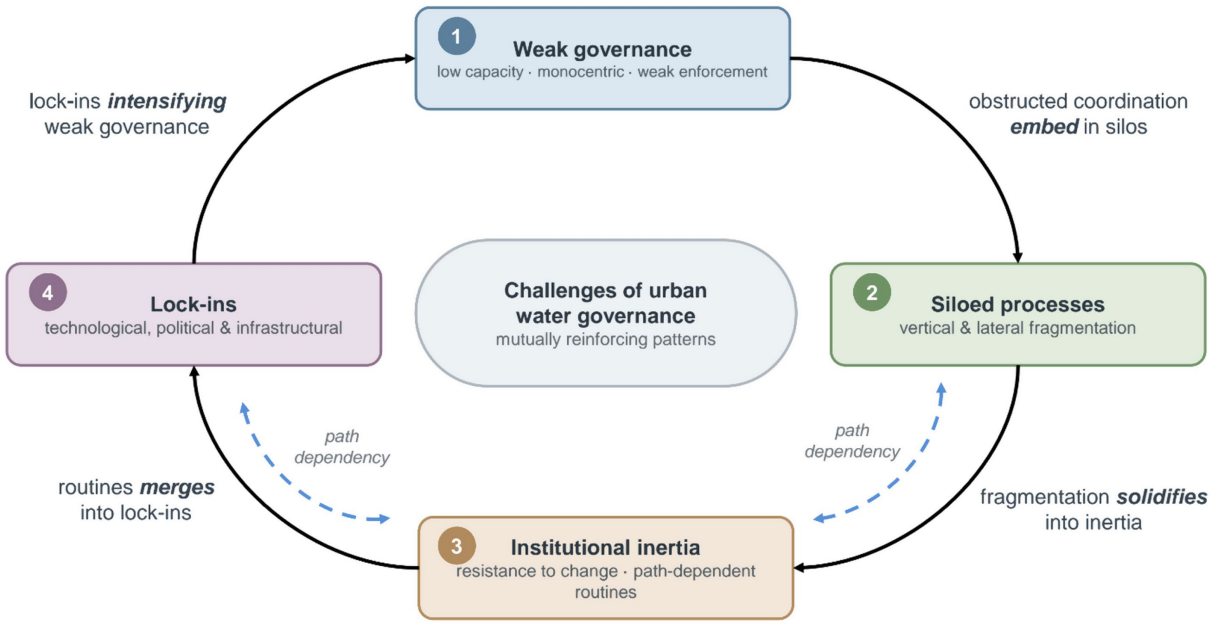


FIGURE 1
Schematic diagram of mutually reinforcing patterns within the institutional dynamics of urban water governance as described by key informants in Bengaluru.

(Bakker et al., 2008; Koop et al., 2017; Raja Ariffin et al., 2023). It manifests as low administrative effectiveness and poor provision of basic services, which together undermine sustainable development, disaster risk reduction, and climate adaptation. In the Bengaluru case study, weak governance is understood as limited staffing, finances, technical expertise and coordination across separate municipal departments responsible for stormwater, drinking water, and wastewater, coupled with inadequate regulatory and financial frameworks for segregated infrastructure of rainwater and greywater systems (Goldman and Narayan, 2019). These governance weaknesses and infrastructural deficits contribute to an over-reliance on pumped river water and consequently expose the city to recurrent droughts and floods, as adaptation measures remain fragmented and poorly enforced, contributing to institutional fragmentation across sectors.

Siloed processes in water governance refer to a fragmented institutional arrangement where decision-making, authority, and information flow are compartmentalized both vertically (Arjomandi et al., 2024) and horizontally, preventing the integrated management that water systems require (Scott and Gong, 2021; Varis et al., 2014). This fragmentation is compounded by the absence of formal coordination mechanisms or boundary-spanning roles capable of bridging departmental divides. In urban water governance organizations, vertical silos prevent multilevel coordination, whereas horizontal silos isolate water management from land use planning, climate change adaptation, and broader policy integration.

Institutional inertia refers to the tendency of institutions to resist change and thereby stabilize policies, driven by five distinct interrelated mechanisms: cost, uncertainty, path dependence, power, and legitimacy, which create distinct bottlenecks for climate action (Munck af Rosenschöld et al., 2014). Froy and Giguère (2010) show that strong inertia in the management of systems make the process of cooperation and coordination difficult. In this study, this inertia manifests at the organizational level mirroring institutions (North, 1990) showing siloed arrangements among water governance bodies maintain their own internal structure and continuity, rather than reflecting the persistence of formal rules alone. Kösters et al. (2020) highlighted that in cities like Surabaya (Indonesia), institutional inertia is a key obstacle in urban water management toward water sensitivity. Water governance bodies, operating in isolation, consistently make infrastructural and regulatory decisions following established patterns during reform phases. In the case of urban water governance, path dependency acts as the conceptual connection between institutional/ organizational inertia and siloed processes, creating a repeated reliance on familiar routines, which reinforces fragmentation over time and contributes to the formation of mutually reinforcing patterns and self-contained lock-in.

Lock-in arise when previous decisions and established structures create a path dependency so robust that significant alterations are either structurally or materially blocked or achievable only at a substantial structural, administrative, social, and economic expense (Buzási and Csizovszky, 2023). Lock-in emerges as a distinct but related phenomenon from inertia, characterized by self-reinforcing mechanisms that make it increasingly difficult to abandon established pathways (Sydow et al., 2009). Institutions become incapable of alteration without causing significant disruption. In the case of urban water governance, lock-in may appear in the technological, institutional, political, and infrastructural domains in such a way that an existing way of functioning manifests itself for decades as necessary without any alternatives (Kuhn et al., 2024). This sometimes makes lock-in the structural mechanism that considerably contributes to institutional/ organizational inertia.

In situations where lock-in exist within a governance framework already marked by low accountability, inadequate coordination, and restricted state capacity, they do more than just hinder progress (Food and Agriculture Organization of the United Nations and World Bank Group, 2018). They actively perpetuate and intensify these weaknesses and establish mutually reinforcing patterns. Although technical

solutions for urban water issues are becoming more accessible, their adoption is consistently hindered by complex institutional interactions (Nayak et al., 2026).

Water circularity, involving resource recovery, nature-based solutions, and treated wastewater reuse, increases the resilience of the water sector to climate change. By reimagining the water cycle, circular management reduces dependence on freshwater, boosts drought resilience, and helps urban areas manage heat and flood risks using green infrastructure. Embracing water circularity can enhance adaptive capacity (World Bank Blogs, 2025). The water in circular economy and resilience (WICER) framework outlines actions for outcomes such as resilient and inclusive water services, reduced waste and pollution, and preserved natural systems (Delgado et al., 2024). Sustainable Development Goal (SDG) 6, "Clean Water and Sanitation," promotes water-use efficiency, integrated resource management, and wastewater reuse for sustainability and resilience (Cullen et al., 2025). Circular water systems effectively adapt to climate change by mitigating urban water supply vulnerabilities to climate variability and extreme weather conditions.

3 Methods

3.1 Methodological approach

This study uses an inductive, exploratory qualitative case-study approach that is conceptually based on iterative movement between theory and empirical data to refine the overall analysis, as this process is particularly effective for theory development in single-case studies (Fereday and Muir-Cochrane, 2006). The methodological approaches applied are thematic analysis and qualitative content analysis, as we wish to apply a low level of interpretation with a 'factist' perspective to the data collected through semi-structured interviews (Vaismoradi et al., 2013). The authors cooperatively developed an interview guideline (see Supplementary material A1) based on existing research in the field and informed by document analysis of both scientific literature and reports. The research question is framed to fit the inductive/ exploratory tradition and political, economic, social, technological, legal, and environmental themes were collectively developed and investigated. In line with this thematic, exploratory stance, themes and sub-themes were prioritized according to their analytical salience and cross-cutting relevance to the research question, although frequencies are reported alongside quotes to show how widely each view is shared.

3.2 Data collection

We conducted 12 interviews with 13 interviewees between 3rd Dec 2024 and 12th Feb 2025, basing our sample size on saturation of thematic content analysis (Ahmed, 2025). Thematic saturation was pursued iteratively throughout the data collection process and was observed after approximately 10 interviews. Continuing with the final three interviews deepened the evidence base for the already identified patterns. We selected stakeholders through purposive (Palinkas et al., 2015) and snowball sampling (Lewis-Beck et al., 2004), targeting actors with direct knowledge of Bengaluru's water governance system across institutional levels. We prioritized including interview partners with various professional associations and backgrounds in urban water systems for the city of Bengaluru with at least five years of working experience with various government agencies to gain a holistic picture of the institutional dimensions within the water governance landscape. All interviewees were professionals, comprising internal municipal staff from top-level decision-makers to engineers, boundary-spanning (Williams, 2002) academics, researchers, and government advisors collaborating through their non-governmental organizations (NGOs), and external urban planners involved in pilot projects with independent researchers. Classifying the sample by positionality shows that 10 of the 13 interviewees (3 internal actors in addition to 8 boundary-spanning actors) had sustained or structurally embedded access to internal agency processes, while the remaining 3 are external observers (see Table 1). As Table 1 shows, the sample was composed primarily of researchers, technical advisors, and government-affiliated professionals; it did not include informal sector workers, women's groups, or residents of underserved peripheral wards.We employed a combination of manual note-taking during the interviews and audio recording for each interview to enrich the recorded content with contextual impressions and aspects of the interviews. The recorded audio was transcribed using *HappyScribe* (HappyScribe, 2025), an online transcription platform, and was subsequently proofread by the authors.

3.3 Data analysis

We used MAXQDA (VERBI Software, 2024) to develop the code structure for the interviews. The coding of interviews was supported by developing a deductive codebook (Simula, 2018), which was developed based on existing literature, keeping the research question as the background, and refining it further by identifying inductive patterns that emerged during the process of data analysis (see Supplementary material A2). Two authors independently coded the full interview corpus. Disagreements in code assignment were resolved through discussion and consensus, rather than formal intercoder reliability metric. Because coding began from this deductive codebook, the four overarching institutional/ organizational challenge themes were fixed in advance rather than derived from the data; only the sub-codes nested within them remained open to inductive refinement. This constrains the study's exploratory scope: the analysis can elaborate and evidence these pre-specified themes but is not designed to surface institutional dynamics that fall outside them.

We calculated the occurrence frequencies of the different codes and their subcodes. These codes and sub-codes were categorized (Chenail and Constas, 2008) according to the four theoretically derived themes established in our deductive codebook: weak governance, siloed processes, institutional inertia, and lock-in (see Table 2). We used this framework to situate our study within the understanding of circular water systems as mechanisms for closing the water loop, fulfilling SDG 6 and SDG 11, and climate change adaptation capacities. Subsequently, we included codes and sub-codes with $n \geq 5$ within each analytical theme or merged multiple sub-codes wherever necessary, assigning them to primary themes and, where relevant, secondary themes in cases of overlap (see Supplementary material A3).

Based on the interview data, we analyzed descriptive language that suggests a possible correlation, such as 'because of' or 'this leads to' within the interviews to establish the broader theme of the study. This process led us to discover that the patterns emerging within the language are interconnected rather than purely hierarchical or sequential, contributing to a mutually reinforcing pattern when analyzing institutional challenges within the theoretical framework.

TABLE 1 Interview partners with their domain expertise and institutional affiliation.

Interview no.	Interview partner roles	Domain expertise	Institutional affiliation (type)	Positionality
1	Researcher	Urban climate action	Academic	External researcher
2	Engineer/advisor/scientist	Engineering and water management	Independent advisory	External advisor
3 and 4	Urban development consultants/ researchers	Adaptation, community systems	NGO and advisory	External consultants
5	Engineer/scientist	Water quality, treatment	NGO	External advisor
6	Urban planner/researcher	GIS, field operation	NGO and advisory	External researcher
7	Engineer—government	O&M, distribution	Water utility	Internal
8	Direct authority—government	Municipal service governance	Municipal corporation	Internal
9	Researcher/planner	Urban planner	Academic/advisory	External researcher
10	Researcher/practitioner	Adaptation, community systems	NGO and advisory	External researcher
11	Researcher	Water resource management and governance	Academic	External researcher
12	Engineer—government	Engineer field operations	Municipal corporation	Internal
13	Researcher/planner	NbS and urban planning	NGO and advisory	External researcher

While the four themes overlap in practice, we suggest that each captures a distinct analytical dimension of institutional misalignment. For example, coordination failure appears under both weak governance and siloed processes through different mechanisms: under weak governance, coordination fails because of capacity constraints and regulatory ambiguity; under siloed processes, it fails because of structural design. These are distinct causes that produce similar surface outcomes. Consistent with an inductive, theme-based approach, the findings are presented together with their theoretical interpretations.

4 Case description

Bengaluru[1] is the capital city of Karnataka state in India, with a population of over 10 million (Prakash et al., 2025) people, considering the last census was in 2011 and 720 square kilometers of territory[2] (see Figure 2). The city is located on a mound at an elevation of 900-930 m above mean sea level and has a semi-arid environment with an average annual rainfall of approximately 900 mm, the majority of which occurs during the summer monsoon between June and September. The Bengaluru Water Supply and Sewerage Board (BWSSB), a parastatal agency responsible for water utilities, was established in 1964 to procure and supply water to the city under the Cauvery Water Supply Scheme (CWSS) from the Cauvery River[3], approximately 100 km away. The surface water supply has not been able to match the demands of the rapid growth and expansion of the city. As a result, groundwater extraction provides a large portion of the city's water demand, which is not accounted for due to a lack of effective regulations (Sekhar et al., 2018). Thus, Bengaluru faces several critical urban water challenges: more than 30% of water is lost through leakage and unauthorized consumption (Paul et al., 2018), while intensive encroachment, including illegal occupation of wetlands and filling of lakes for residential construction, has obstructed the city's natural stormwater drainage system (Bindal et al., 2022). Stormwater is still not recognized as a viable water source, nor is there a systematic management system for its collection, processing, and use (Banerjee et al., 2022).

The BWSSB currently imports 1450 MLD (million liters per day) of surface water from the Cauvery River, which is 75% of the average rainfall over the city (Sekhar et al., 2018), with a 5th phase extension commissioned in December 2024 to increase the imports by 775 MLD to the surrounding 110 villages now forming the wards of the Bruhath Bengaluru Mahanagara Palike (BBMP) (JICA, 2024). At the time of data collection and analysis, Bengaluru's urban governance functions operated under the BBMP; a transition to the Greater Bengaluru Authority (GBA), alongside five corporations, was underway but remained incomplete, and this study accordingly reflects governance arrangements under the BBMP-era structure. This coverage is unlikely to be complete, making water supply to these areas uncertain, with dependence on groundwater extraction until project completion, likely intensifying with growth and rising demand.

According to the Bengaluru Climate Action and Resilience Plan, Bengaluru's water systems face systemic, structural, and operational issues, both as a resource and as a service. The interconnected and cascading lake systems, which were once the main source of water for the city, have been under severe threat owing to the city's unregulated growth (Bhattacharya et al., 2023).

1 Bengaluru was previously known as Bangalore. Both names are prevalent and used in research. In this research we have decided to use the official name, Bengaluru.

2 This was the area of the Bengaluru Municipal Corporation limits (erstwhile Bruhat Bengaluru Mahanagara Palike) as of May 2025, before the Greater Bengaluru Governance Act 2024 came into effect.

3 Also known as the spelling of the Kaveri River. In this research we have decided to use the name Cauvery due to its connection with the Cauvery Water Supply Scheme.

TABLE 2 Analytical codebook summary: institutional challenges in Bengaluru's urban water governance.

Themes	Sub-themes	Code definition	Coded segments (*n*)
Weak governance	Institutional weakness	Statements describing generalized systemic incapacity, governance failure, or coordination breakdown not attributable to a single mechanism	114 (*n*/13)
	Capacity deficits	References to shortages of staff, technical expertise, financial resources, or data infrastructure	142 (*n*/12)
	Regulatory gaps	References to absent, unclear, or unenforced legal frameworks, technical standards, or definitional inconsistencies	32 (*n*/12)
	Strategic weakness	Descriptions of reactive, ad hoc decision-making, absent long-term planning, or misaligned funding incentives	53 (*n*/12)
Siloed processes	Fragmented mandates	Statements describing separated departmental responsibilities, budgets, or data systems	75 (*n*/13)
	Value misalignment	References to divergence between operational staff and senior decision-makers on reform priorities	65 (*n*/11)
	Contested ownership	Statements about unclear accountability or diffuse responsibility across agencies	26 (*n*/10)
	Performative engagement	Descriptions of stakeholder participation as sporadic, project-driven, or not institutionally embedded	70 (*n*/11)
Inertia	Operation and maintenance neglect	References to failure to maintain, monitor, or operationalize infrastructure and technology over time	74 (*n*/11)
	Hierarchical decision-making	Descriptions of vertical structures concentrating decisions at senior levels, preventing adaptive action	41 (*n*/8)
	Short-termism	Statements about reactive, crisis-driven responses rather than long-term sustainability planning	66 (*n*/11)
	Path dependency	References to historically established organizational routines, cultural norms, or prior institutional choices that constrain current decision-making and reproduce existing governance arrangements, including mistrust in government and public resistance to change	47 (*n*/10)
Lock-in	Under-pricing of water utility	Statements about tariffs set below cost recovery, cross-subsidization failures, or political resistance to reform	39 (*n*/5)
	Chronic investment gap	References to insufficient funding for infrastructure renewal, technology, or monitoring	24 (*n*/10)
	Negative ecological impact	References to deterioration of lakes, rivers, and urban ecology as consequence of institutional failures	16 (*n*/5)
	Technology and data gap	References to absence of modern monitoring, scientific data, or NbS evidence base	27 (*n*/9)
	Unregulated urbanization	References to urban growth outpacing planning, regulation, and infrastructure capacity	39 (*n*/11)

5 Bengaluru's waterscape: historical and hydro-social context

5.1 Historical water base

The initial hydro-social regime consisted of wells, lakes, and tanks interconnected by channels and embankments built by local inhabitants, rulers, and the colonial administration (Mathur and Da Cunha, 2006). Located 900 m above sea level on a plateau without a perennial river, the city added a piped system that pumped water upward from the Cauvery River, marking a water-management shift tied to a development model driven by public sector industries and loans from bodies like the World Bank (Goldman and Narayan, 2019). Since its formation, the BWSSB has expanded its piped water supply coverage and capacity in stages. However, several peripheral parts of Bengaluru, mainly erstwhile villages added to the city limits in 2005, still lack piped water from BWSSB. This was a recurring theme: 10 of 13 respondents attributed the problem to infrastructure planning that failed to keep pace with the growth of the city. As one BWSSB senior engineer put it in our interview:

> *'Even before rules and regulations came into place, the city developed in a rapid way…it is now impossible to superimpose any kind of [water]sensitivity as the area has already developed without it' (Interviewee 12).*

5.2 Water as a crisis: urbanization and its consequence

Over eight to nine years, public media discourse on Bengaluru's water shifted from a shortage to an actual crisis, although scarcity affected the city for decades, drawing on the work of hydrologists,

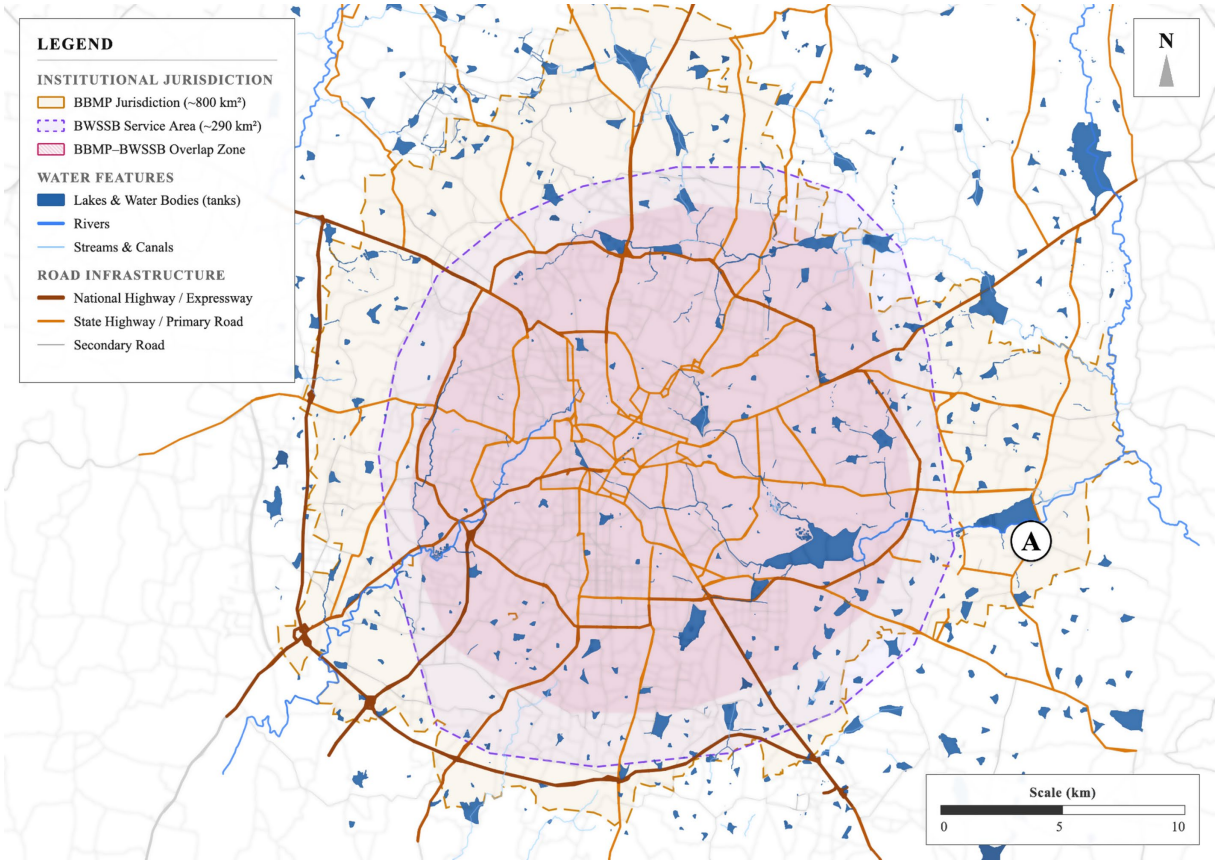


FIGURE 2
Spatial and institutional jurisdiction of Bengaluru water ways and roads (A: Varthur Lake). Data sources: OpenStreetMap contributors (OdbL); BBMP ward boundaries from DataMeet; BWSSB jurisdiction approximate (Kulranjan et al., 2023). BWSSB boundary is indicative. DataMeet India Community (n.d.), Karnataka Bangalore Water Supply Sewerage Act. 1964, OpenStreetMap contributors, (2026).

historians, and geographers (Lele et al., 2013; Mehta et al., 2013). This reframing draws on analyses of the city's governance and economic structures (Hommes et al., 2019) and Bengaluru's transformation from a mid-sized town into the 'Silicon Valley of India' (BBC Audio, 2023). In early 2018, the city was identified as second only to Cape Town in the risk of running short of drinking water, while *Varthur Lake*, one of the largest lakes, repeatedly caught fire due to toxins and dumped waste (Goldman and Narayan, 2019). We identify three interlinked drivers that underlie this crisis through our interview partners: rapid urbanization and rising water demand; sealing of the urban surface, with its consequences for runoff and groundwater recharge; and a changing climate expressed through increasingly erratic monsoon patterns compared to past experiences.

Over the last 50 years, the built-up share of the city rose from approximately 8% in 1973 to 93.3% in 2023 (Moharaj et al., 2026). Over the same period vegetation cover declining by an estimated 66%, and 80% of the city's 105 water bodies were encroached upon and converted from dry lake beds to real estate, and lake catchments used as dumping yards (Tv et al., 2012). The city now depends heavily on rapidly diminishing groundwater and the Cauvery River for potable water, with transmission and distribution losses compounding the pressure (Satpathy and Jha, 2022). One interviewee drew attention to the ineffectiveness of current practices for enforcing rainwater harvesting:

> *'A dummy structure exists, where either they're not capturing and storing properly or not using it or not maintaining it…To get your building sanctioned, there's a structure, but not necessarily it's functional' (Interviewee 13).*

Although legal mandates require all new buildings to install functioning rainwater harvesting systems (Karnataka, *BWSS Act, 1964*, § 72-A) that store and infiltrate water during heavy rainfall or reuse it within the building complex, the operation and maintenance of these structures fall short of the required standards as gathered from 10 of 13 interviewees.

The same urban expansion as mentioned above has sealed surfaces that once absorbed rainfall and recharged aquifers. Approximately 64% of newly built developments have occurred in high and very high recharge-potential zones (Goswami et al., 2022), simultaneously lowering groundwater recharge and increasing surface runoff. Combined with the depletion of blue-green spaces (Mukherjee and Takara, 2018) and an aging drainage network, this has contributed to pluvial flooding in formerly dry areas, underlining the flooding issues (Kulranjan et al., 2023). 12 of 13 interviewees framed flooding as primarily an infrastructure and planning failure rather than a hydrological inevitability:

> *'I would say pluvial flooding was not an issue for the city earlier, they have been emerging slowly, since the past 20 years. The areas where flooding is happening with a strong rainfall event are the new areas that have developed' (Interviewee 10); 'It's not pluvial flooding as much as the back design of infrastructure …. the roads and the drains are not there…And it's always a question of*

> *catching up in a city which is growing so fast…. But it's also pluvial water logging, not as much as flooding' (Interviewees 3 and 4).*

5 of 13 interviewees highlighted the mismatches between development and drainage capacity was a recurring concern:

> *'Do you think the infrastructure has the capacity to hold so much outflow and inflow? …There's a lack of connection between the development plan and the actual infrastructure…It's a huge task for the government and they are struggling too.' (Interviewee 11).*

Outdated and stressed water, stormwater, and sewage infrastructure compounds these effects, adding to resource wastage and inefficient service delivery (Prakash et al., 2025).

5.3 A changing climate and an erratic monsoon

A shifting climate is superimposed on these urban drivers. South India, and Bengaluru in particular, have experienced notable changes in rainfall patterns in recent decades (Nandi and Swain, 2023), with evidence of declining average rainfall and alongside more frequent extremes such as prolonged dry spells and intense rainstorms (Pavithra et al., 2021). The monsoon, once a dependable source for replenishing the city's supply, has become increasingly erratic, and frequent dry spells pose a growing threat to the water security. As discussed in Section 5.2, 8 of 13 interviewees framed urban flooding as a failure of infrastructure and planning rather than a consequence of climate change, for instance, one interviewee stated:

> *'Flood in Bengaluru is not really an effect of climate change. I think it's more of an urban development issue' (Interviewee 13).*

This framing extended to broader perceptions of climate urgency, even among interviewees (5 of 13) who did recognize climate change as a driver of water stress, this recognition rarely translated into implemented action:

> *'People are trying to plan the projects, considering climate change there. But if you see in reality, has anything been implemented? I think 'it's a long way to go. Right now, nothing is implemented as such. But yes, people are recognizing the importance of climate change' (Interviewee 1).*

Whether framed as a climatic or governance problem, erratic monsoon patterns add a further layer of uncertainty to an already strained water-management system.

5.4 Water as a political and social entity

Cauvery water is shared between the two states of Karnataka and Tamil Nadu, and conflict over its distribution intensifies during droughts, as the state of Karnataka relies heavily on Cauvery water for irrigation, including the city of Bengaluru (Suresh et al., 2010). Rising urban and industrial demands have heightened this interstate rivalry (Vanham et al., 2011), leaving Bengaluru particularly vulnerable to flow fluctuations and political disputes (Moharaj et al., 2026). Besides the political conflicts of Cauvery's water, Bengaluru's water distribution lacks equity, access, and justice in its piped connections (Meyer et al., 2023). The city's problems are further aggravated by major losses in its water distribution system, with an estimated 40–50% of water being lost due to leaks and illegal connections (Satpathy and Jha, 2022). Illegal coping strategies among the socially and economically weaker sections of society are a direct consequence of weak governance and structural inequality (Ranganathan, 2014), which has been supported by 8 of 13 interviewees and highlighted a senior engineer in the urban water sector and an advisor to the municipal government:

> *'This is the lopsided perverse subsidies that are operational….if I were to pay the true cost of water, …then I would be paying the BWSSB to get me the water to my home, but then also to collect the sewerage and treat it and release it to the environment. So, it's a full ecological cost of water.' (Interviewee 2).*

Goldman and Narayan (2019) present in their research that the Cauvery water system follows a cost-recovery model favoring large consumers and loans over most urban residents. Despite scientific evidence of the river's declining volume and flow stability, city planners and developers are continuing to project future income from increased water volumes rather than managing within catchment and lake infrastructure limits (Goldman and Narayan, 2019).

6 Results: institutional challenges in urban water governance for the future of Bengaluru

6.1 Weak governance

A predominant category identified in the interview data, based on Koop et al.'s (2017) governance framework, was weak governance, reflecting a lack of robust frameworks as interviewee perception to guide unified action in addressing urban water issues. We assigned interview text to four sub-themes from our codebook through content-related clustering and analytical salience, i.e., institutional weakness, capacity deficits, regulatory gaps, and strategic weakness. Institutional weakness emerged as one of the most salient sub-themes (see Table 2). We coded institutional weakness with 13 out of 13 interviewees, spanning all four sub-themes, manifesting in two distinct ways: as a generalized sense of systemic incapacity or governance failure that is not attributable to a single discrete mechanism, and as fragmented coordination among agencies coupled with institutional/ organizational inertia. 8 of 13 interviewees highlighted the systemic incapacity and an urban development scientist working with the municipality illustrated it as follows:

> *'In terms of the built environment that has been created … I think we don't have that level of efficiency in our systems, which will make the early warning system worth it.' (Interviewee 13).*

7 of 13 interviewees including a Geographic Information System (GIS) consultant highlighted fragmented coordination:

> *'It is a tedious job, but it has become at least in terms of the financial convenience now that if the city writes or the state agency's write to the meteorological department, then guess this data can*

> *be procured.…it generally lies in the mercy of the institutions and the dynamics between these institutions.' (Interviewee 6).*

Participants (12 of 13) consistently highlighted an inability to act on urban water governance mandates with adaptive capacity due to insufficient human, technical, and informational resources. Interviewees raised in 12 of 13 interviews in 142 coded segments as expert shortages, lack of staff, and knowledge gaps as most prominent aspects mentioned and can also be found in the following quotes:

> *'We need more people to work in this area to implement many such things on ground.' (Interviewee 1);*
>
> *'We lack capacity for real-time information processing. It requires huge infrastructure and system investments and workforce investments, which we do not have right now, given that the city itself doesn't have that much of a budget to support.' (Interviewee 6);*
>
> *'We don't know what embedded knowledge is. We don't know what traditional knowledge is …. These are part of lived experience and scientific knowledge.' (Interviewee 9).*

Although legal frameworks exist, their enforcement is inconsistent or entirely absent as described by the 10 of 12 interview partners, leaving regulatory requirements largely aspirational. This gap can show up in the area of nature-based solutions (NbS): one interviewee expresses that without legal definitions or technical standards, procurement and oversight become intractable in the following quote:

> *'For its lack of standardization, that itself is one challenge. Now, if you have a non-standard system, how do you tender for it? How do you then get contractors to work for it? Who will monitor the contractors? Does BWSSB have staff who understand the system to know if the contractor is doing the right thing… All sorts of gaps in there. I think part of the challenge is coming from there.' (Interviewee 10).*

A similar disconnect between legal mandate and functional incentive emerged around rainwater harvesting. Although rainwater harvesting structures are formally required as part of the building approval process, interviewee described this requirement as decoupled from any genuine incentive to actually capture or store water. As one interviewee put it,

> *'You're not incentivized to store or capture water' (Interviewee 13).*

The only functional driver of compliance, they noted, was administrative:

> *'The only incentive to make a rainwater harvesting pit is to get clearance for building that.' (Interviewee 13).*

This absence of incentive is compounded by Bengaluru's heavily subsidized water tariffs set at approximately seven rupees per thousand liters against an estimated true cost of ninety (see Section 6.4) leaving little financial reason to maintain or actually use the structure once approval is secured. The mandate appears to function primarily as a singular permitting formality, rather than as an actively enforced or monitored water-management practice and compliance is attained upon approval, without any institutional mechanism to ensure the subsequent maintenance or utilization of the structure as described by 10 of 13 interviewees.

Furthermore, 9 of 13 participants frequently described their institutionalized organizations operating reactively rather than strategically or even proactively, with no overarching vision to guide water-related decision-making. One interviewee explained the complicated funding demands coming from corporates:

> *'CSR (corporate social responsibility) funding also seeks immediate results. It's not there for the long haul. If they invest money, they need to see results within a year for visibility, then they go on to do the next project…money is poured in, everything is done, and then you're just off.' (Interviewee 11).*

The absence of a strategic orientation meant that resources and efforts were dispersed across ad hoc responses rather than channeled toward coordinated, long-term goals as described by interviewee 11.

This gap between intent and action was framed by interviewees not as a capacity shortfall but as weak accountability that to go unaddressed. 12 of 13 interviewees also highlighted that the absence of planning, weak strategy, and implementation failures resulted in water insecurity and heightened vulnerability among communities dependent on the system. Critically, one participant framed this not as a product of institutional inaction:

> *'If I have a large roof, then my ability to harvest rainwater is greater. If I have a small house, then my ability to harvest rainwater is limited. If the quality of my roof is very good, then the rainwater that I can harvest is much better. If the quality of my roof is asbestos sheet or mango tile roof, then my quality of rainwater harvesting ability is far inferior. The economically weaker section should have first rights on the Cauvery water…' (Interviewee 2).*

Resource scarcity reflects both capacity limits and broader political economy dynamics, as highlighted by 6 of 13 interview participants:

> *'This is not sustainable in the long term. We need to be financially independent with our institutions to be able to manage our own water supply… So, it's a clear governance issue, not a water issue.' (Interviewee 2).*

Collectively, these subthemes create an environment where coordination is obstructed. Weak governance here stems not from a single cause but from lack of infrastructure and system investments, capacity deficits, absent regulatory frameworks, and lack of strategic orientation, producing structurally generated rather than accidental resource scarcity.

6.2 Siloed processes

A recurring (13 of 13 interviewees) structural issue across the interview data was the division of water governance into departmental silos, with mandates, data, and decision-making kept separate among agencies. This fragmentation manifests as distinct budgets, reporting lines, and data systems in public sector (Wawi and Özerol, 2025). All interview participants discussed the lack of connection between

entities such as water utilities, urban planning, and municipal drainage authorities in the following words:

> *'It is very fragmented because every department, every agency has their own mandates to follow, and each one leads to making Bangalore a very water sustainable city, but it is not in coherence with each other …. There is never space for all these actors to come together and start talking. I think that space needs to be created.' (Interviewee 11).*

Looking beyond administrative boundaries to protect water sources was observed by almost all the external interviewees (10 of 13) as essential but systematically absent:

> *'Well… looking at water, you need to go beyond administrative boundaries. You need to look at the source of the water. And you can do whatever you want to in Bangalore. Unless you don't protect its source there's not going to be much of it. You won't look at systemic change. So, for example, in the policy framework, what are some of the source level protection strategies? How do we start to look at that?' (Interviewee 9).*

Stormwater management exemplifies spatial fragmentation (Ranganathan, 2015). Government policy requires buffer zones adjacent to stormwater drains, which differ according to stream order, with the aim of preserving drainage corridors and enhancing natural water retention (Ramachandra et al., 2012; Government of Karnataka, 2015, sec. 4.12.2 (ii)). One interviewee noted that these buffer zones are not maintained in practice, given the absence of space in Bengaluru's built-up areas:

> *'If you look at the government policy for stormwater drain, both sides should have 15, 13, and 75 m of buffer zone. So that buffer zone doesn't exist… Because in Bangalore, there is no space for any expansion. So, the only spaces we have is parks, like BBMP parks.' (Interviewee no.5).*

These structural and regulatory fractures may also be observed in relation to deeper institutional mechanisms, such as misaligned values, contested ownership, and a lack of scientific knowledge exchange. At the operational level 11 of 13 interviewees indicated value misalignment which means that business-as-usual persisted even when senior decision-makers understood the necessity for change:

> *'For the state to work in collaboration, I think it has to start with understanding the multidimension of the problems presenting themselves. The water problem is not just a water problem. Urban problem is an urban problem alone. They're all connected.' (Interviewee 9).*

In cohesion, the mechanisms as suggested by interviewees, the fragmentation remained in the path of least resistance. In the following case, the misalignment of values discussed occurred at the operational level due to a lack of guidance and scientific knowledge exchange, which circles back to weak governance. As highlighted by one participant:

> *'Sometimes at operations level, if people don't see the value of it, then they just do business as usual. Even though the big decision-makers understand the importance of climate adaptation.' (Interviewee 13).*

Implementation consequently depends on individual champions rather than institutional design as depicted in the following:

> *'It depends on the person who is guiding the technical team as well…. If the proposal clicks to the person, then he or she would definitely push for it …. Sometimes people are busy with the regular ways and they are not so welcoming. It depends on timing. It depends on who the person is, who's taking the decision.' (Interviewee 8).*

Unclear ownership and scattered accountability appear to allow coordination failures to persist without triggering changes in rationales or even reforms. Although awareness and engagement are increasing in Bengaluru, they are not institutionally driven as described by our 5 of 13 interview partners. Instead, they are compelled by unreliable access to water-related services and infrastructure, primarily addressed by civil society groups:

> *'So there's always a peak on a low. So how do we then manage sustained intervention from the citizen groups as well? … I won't say nothing is happening, but there needs to be more awareness and more interactions and more long-term planning with engaging citizens.' (Interviewee 11).*

11 of 13 interviewees often characterized stakeholder engagement as sporadic and project-driven rather than embedded in regular governance procedures. This approach appears to stem from the disjointed nature of the institutional framework rather than a deliberate engagement strategy. As highlighted by one interviewee:

> *'It is very important to build a connection… Rather than fewer people, bird watchers and people coming to the lake, we should have larger communities who know that these are the benefits I'm getting from the lake. It is very important for us to protect the lake.' (Interviewee 5).*

Bengaluru's inertia may stem from lack of a third tier of elected representatives, as elections have not occurred since 2015 (Vyshnavi, 2024).

6.3 Institutional inertia

Many interviewees (11 of 13) described institutional/ organizational inertia in the neglect specifically of the operations, maintenance, and monitoring of infrastructure or technology for urban water collection and reuse. Interviewees identified fragmented operational practices detached from strategic goals as a clear sign of inertia:

> *'When we have conversations with the different sections of people within the government, while their understanding is clear about NbS or harvesting systems, I think just in terms of navigating and making sure it operates, that's where the biggest challenge is.' (Interviewee 13);*
>
> *'A lot of reforestation projects, especially smaller urban ones that are happening. Survival rates are low. What happens in two years…Nobody's doing the long-term tracking. No monitoring as the CSR money is not designed for that either.…It's very challenging.' (Interviewee 10).*

Decentralized wastewater reuse illustrates a similar pattern of informal adaptation in the absence of institutional direction described by 7 of 13 participants. One interviewee described how, without a mandated dual-plumbing system to separate wastewater streams, treatment and reuse at the building level currently happen only as an improvised workaround:

> *'Our office building doesn't have a dual pumping system. So, everything is mixed up, then it goes to the anaerobic tank from there, it gets treated and we use it for gardening.'*

The same interviewee identified the underlying regulatory gap, noting that mandatory dual-plumbing requirements for apartments could shift this dynamic in future,

> *'but it will definitely increase the cost.' (Interviewee 5).*

Comparative studies on water challenges under varying institutional conditions have shown that silos create operational implementation gaps (Banerjee et al., 2022). Many interviewees (8 of 13) highlight how hierarchical structures within these organizations where decision-making appears concentrated at higher levels, may limit the extent to which frontline monitoring data reaches to the relevant actors:

> *'The state is structured as a hierarchy.… These are vertical hierarchies. We never imagine something that is horizontal. At best, we imagine through a board or a working group which gets members from different departments, … they're called steering committees. That does not help because the conversation again stays at the steering committee level. That's one of the…challenge we have, where the state is structured as a hierarchical entity.' (Interviewee 9).*

This structural setup encourages short-term, reactive decision-making over long-term sustainability, making it difficult to adopt circular water practices (Buylova et al., 2025), also expressed by this interviewee:

> *'We're only talking about if it's flooding in this area.… But what happens after that? We're not talking about long-term.… we are concretizing the whole city.' (Interviewee 11).*

The combined impact of these interconnected obstacles results in inefficient systems that maintain the status quo, even when participants (10 of 13) acknowledge the necessity for change, with resource constraints reinforcing the impasse:

> *'We need to deploy people … constantly monitor them, which gives us a lot of financial burden which again, we cannot afford.' (Interviewee 12).*

6.4 Lock-in

Interviewees frequently characterized unregulated urbanization, unequal water access, chronic investment gap, and underpricing of water utilities as interconnected factors (see Table 2) to the technology gap and negative ecological impact, which their comments suggest perpetuated the same governance shortcomings over time. Our interpretation from interview data suggests, that these dynamics do not function as isolated issues; instead, they form feedback loops that progressively solidify organizational lock-in. Unregulated urbanization serves as a crucial entry point in exacerbating current governance limitations, where urban growth has consistently outpaced planning, regulation and infrastructure capacity as described by 11 of 13:

> *'We are not succeeding because of rapid urbanization. There are so many people moving into the city that the capacity of sewage control is not happening in a successful way. Generally, when we would expect a population of 10 to 12 people living in a property. But there are people up to 20 who are living there.' (Interviewee 12);*

> *'It's very difficult in a metropolitan city because the population grows and densifies very quickly and you cannot estimate the population density in the area where it's going to come in.' (Interviewee 2). 'Maybe they could have planned better. This is a huge enterprise for them to undertake…I would say that how urban development has happened and the policy and political decisions that were taken because of it have definitely added to the burdens of the water supply board (BWSSB).' (Interviewee 10).*

Underpriced water utilities structurally sustain investment gaps (Goldman and Narayan, 2019; Prakash et al., 2025). When water tariffs are set far below operational costs (seven rupees per thousand liters against a true cost of ninety), utilities like BWSSB struggle to generate revenue (Gangadharan, 2025), hindering their ability to expand or maintain infrastructure:

> *'How can the agency ensure that infrastructure is upgraded, infrastructure is provided to newer areas?' (Interviewee 11).*

In our interviews, participants linked urban water service inequality in Bengaluru to unregulated urbanization and described it as sustained by underpriced water utilities. The interviewees consistently described stark disparities in water service provision across neighborhoods (see Table 2). The interview data attributed toward low pricing of water utilities limiting investment in utility infrastructure, which perpetuates unequal service, and suppresses the political appetite for tariff reform. This lock-in disproportionately harms marginalized households, as outlined by this interviewee:

> *'There is no democratic appetite to charge the true cost of water. Now, if …. the rich would pay their fair share and not ask and avail themselves of the subsidy. For, e.g., I pay seven rupees for a thousand liters of water. So, if I take 20,000 L of water, my bill is 140 rupees (1.27€) a month. The marginalized who don't have a formal connection, they go to an RO plant and pay five rupees for 20 L. They're paying 250 rupees (2.28€) a kilo liter. The poor are paying a higher price than the rich in the name of subsidies.' (Interviewee 2).*

10 of 13 interviewees highlight thatchronic underinvestment, in turn, produces a technology and scientific data gap. Without adequate funding, utilities cannot adopt modern monitoring, leakage management, or treatment systems:

> *'In the global south, or south Asia specifically, we do not have the science established behind it [NbS].' (Interviewees 3 and 4).*

This finding is consistent with Wawi and Özerol (2025).

> *'They've been trying to do this but they need people, technical support, expertise, infrastructure investments, and the heavy downpour of money to really solve everything.' (Interviewee no.6).*

Interviewees (5 of 13) from the water supply board and the municipality also linked these resource and capacity constraints to negative ecological outcomes:

> *'Because of unplanned urbanization in Bangalore city and its surroundings, …rivers are already dried.' (Interviewee no.7); 'Lake is a different ecosystem. The lake should sustain aquatic life, migratory bird life. These things are disturbed…our lakes had peacocks at one point of time.' (Interviewee no.12).*

7 Discussion

Beyond describing the challenges in Bengaluru's water system, this study considers how climate-adaptive and circular water governance might be realistically positioned within it. Rather than being a universal solution, water circularity emerges as a conditional pathway, shaped by limited institutional/ organizational capacity, operational constraints, and unequal governance relations. The discussion situates the findings in relation to theory, examines circularity as a meaningful pathway, and turns to the implications of these challengesfor the conceptual framework of the study. Read together, Bengaluru's institutional challenges (weak governance, siloed processes, inertia, and lock-in) do not appear to unfold as isolated or linear problems; we interpret them instead as forming a contingent feedback loop, in which each challenge conditions and reinforces the others depending on context. By grounding this interpretation in key informant interviews from Bengaluru, this study offers an empirical contribution to the literature on South Asian urban water governance, addressing a gap noted by Abera et al. (2025) and Yasmin et al. (2023).

Moreover, this article points to institutional dimensions of Bengaluru's water crisis, as described by interviewees, alongside hydrological factors that this study was not designed to assess. These institutional dynamics resonate with Bakker et al.'s (2008) broader discussion of "governance failure" as a lens on urban water crises. The granularity of the interview data illustrates this institutional picture further where interviewees describe challenges across strategic, operational, regulatory, and financial dimensions, rather than restricted to a single domain or organization. Institutional capacity gaps create strategic-operational disconnects in water governance implementation (Raja Ariffin et al., 2023). This disconnection reflects a path-dependent organizational culture in which departments prioritize narrow mandates over system effectiveness, reinforcing siloed processes and feeding back into the wider cycle of institutional challenges (Wan Rosely and Voulvoulis, 2023; Pichardo-Velázquez et al., 2026). Notably, interviewees predominantly (Section 5.2) characterized flooding as a failure of infrastructure and planning rather than attributing it to climate change. This finding has direct implications for the communication, justification, and execution of adaptation policies for both practitioners and the public. This pattern extends beyond India; modeling in the Bicol River Basin, Philippines, found that urbanization-driven demand shifts can outweigh climate change in water stress (Bañares et al., 2024), while projections in Tehran anticipate water shortages due to urban growth and climate variability (Moghaddam et al., 2025).

Across interviews, actors articulated capacity and coordination-related failures, more readily than corruption, which surfaced occasionally and without prompting. This may reflect institutional problems in Bengaluru's water sector, but also actors' reluctance to discuss corruption in interviews. Distinguishing between these possibilities would require a research design to probe this question, such as anonymized surveys or triangulation with sources like audit reports or corruption perception data, beyond the present study. Rather, the problem may lie in failures of decision-making and coordination that prevent fragmented information from being synthesized into forward-looking infrastructure planning. These paradigmatic interview excerpts mirror broader findings in the water governance literature, where understaffing is identified as a persistent constraint in low-capacity municipal contexts (Abera et al., 2025), and where resource deficits and knowledge gaps between actors produce institutional lock-in Global South cities (Yasmin et al., 2023). This case diverges from the accountability-focused narratives in the governance failure literature, which has been well-documented as a'problem of many hands,' creating an accountability paradox despite increased formal accountability mechanisms (Thompson, 2014; Willems and Van Dooren, 2011). A study of a community-led water utility in Faisalabad, Pakistan, found that the weak enforcement of collective action design principles allowed corruption to undermine a promising decentralized governance model (Altaf and Goetzke, 2025).

Institutional inertia, when combined with existing silos and weak governance, is associated with a mutually reinforcing pattern that embeds inefficient systems and shortsighted decisions into institutional arrangements, raising the cost of departing from established pathways (Pierson, 2000). Interview data highlights inertia thus becoming structurally entrenched, transitioning into lock-in.The institutional dynamics have direct consequences for water circularity. The WICER framework and the targets of SDG 6, which serve as the normative horizon for this study, assume the existence of integrated mandates, inter-agency coordination, enforceable standards for nature-based solutions (NbS), sustained investment, and community involvement. Interviewees describe that these conditions are largely absent in Bengaluru. Consequently, water circularity operates less as a pre-packaged "solution" and more as a diagnostic tool, highlighting the institutional prerequisites that remain unfulfilled.

Several specific circularity pathways exemplify this issue: rainwater harvesting, stormwater reuse, and wastewater-based lake rejuvenation each carry real technical potential which is an estimated 25–60% of Bengaluru's wastewater alone could be repurposed for non-potable uses (Narayan et al., 2026). However, they are undercut by a shared pattern in which legal mandates or technical opportunities exist on paper without the monitoring, enforcement, or organizational scaling needed to operationalize them. Interviewees described this directly as the rainwater harvesting mandate functions as a one-time compliance step tied to building approval, and interviewees noted that no organizational mechanism exists to ensure these structures' ongoing maintenance or use (see Section 6.1). Stormwater, similarly, is not institutionally recognized as a viable resource (Banerjee et al., 2022) and regulatory buffer zones for drainage corridors go unenforced amid Bengaluru's space constraints, with retention functions instead informally displaced onto park land governed under a separate

TABLE 3 Pathways of water circular practices that exemplify institutional challenges.

Circular water practices	Associated theme	Mechanisms supported by empirical evidence
Rainwater harvesting	Weak governance (regulatory gap)	Legal mandate exists but functions as a one-time building-clearance formality rather than a genuine incentive to capture water; lacks monitoring capacity and enforcement standards beyond initial approval (Interviewee no.13)
Stormwater reuse	Siloed process	Stormwater is not institutionally recognized as a resource across relevant agencies; regulatory buffer zones for drainage corridors go unenforced amid space constraints, displacing retention onto park land governed under a separate mandate (Interviewee no.5)
Wastewater reuse or lake rejuvenation	Inertia	Absence of mandated dual-plumbing infrastructure and long-term monitoring/O&M investment leaves reuse dependent on ad hoc, building-level arrangements rather than systematized infrastructure (Interviewee no.5)
Nature-based solutions (NbS)	Weak governance (regulatory and capacity)	No legal definitions, technical standards, or procurement frameworks exist—without which tendering, contractor selection, and monitoring become unworkable (interviewee no.10); terminology mismatch with Global South contexts creates additional implementation gaps
Water utility tariffs and financing reform	Lock-in (underpricing)	Political economy of subsidies and short-term electoral cycles prevents cost-reflective pricing tariffs at seven rupees/1000L against a true cost of ninety (Interviewee no.11), disproportionately burdening informally connected households (Interviewee no.2) a financial prerequisite for circularity investment

mandate (see Section 6.2). This can be interpreted as a symptom of governance design that never anticipated the need for integrated water management.Wastewater reuse remains similarly constrained and dependent on informal, building-specific arrangements rather than systematized citywide infrastructure, absent organizational scaling and mandated dual-plumbing investment (see Section 6.3). Prior research confirms that stakeholder involvement is typically an improvised practice rather than an institutionally formalized procedure (Kujala et al., 2022). However, in Bengaluru, this is not due to civic pressure, where communities increasingly lead lake rejuvenation, with or without government partnerships. This raises concerns about ownership and the state's role, as neither government action without stakeholder engagement nor community action without partnership is sufficient.This indicates that the binding constraint across pathways is governance and infrastructure investment spanning policy, permitting, implementation, and monitoring, not treatment technology itself.

However, as a "first world approach" against the city's institutional baseline, there can be tension between ambition and readiness. Similarly, NbS and blue-green infrastructure are hampered by limited evidence in the Global South (Chausson et al., 2020), inadequate integration of local water knowledge (Olago et al., 2024), and the lack of institutionally embedded terminology and concepts (Gómez de Salazar and Aguado-Moralejo, 2026). This aligns with the growing scholarly recognition that traditional 'predict and act' governance models are structurally ill-suited to NbS, which require adaptive, flexible decision-making that accounts for ecological variability (Hafferty et al., 2025). Interviewees specifically highlighted the absence of technical standards as an impediment to downstream processes such as tendering, contractor selection, and quality oversight, which rely on a standardized system for effective operation (see Section 6.1). Even though some interviewees attributed this incapacity to unpredictable urban growth and policy and political decisions burdening the BWSSB, our findings suggest that the problem lies in investment and planning rather than unpredictability. Fragmentation is worsened by the contested status of land-use planning: Bengaluru operates under the outdated Revised Master Plan (RMP) 2015, while piecemeal amendments allow exceptions without reassessing the city's growth direction and character (Deccan Herald, 2023), affecting public supply systems such as water supply. Consequently, the city lacks accountable corporators, hindering the integration of civic issues into governance and reform. Big-ticket infrastructure projects signal "intent" rather than a comprehensive assessment. Consistent with the earlier point that growth itself is not unpredictable, this perspective of unregulated urbanization that overburdens municipal water utilities is congruent in the comparative urbanization literature (Aliyu and Amadu, 2017; Buzási and Csizovszky, 2023) and produces path dependence as bureaucratic routines and investment choices reinforce unsustainable water provision models (Table 3).

Furthermore, the findings call attention to a central politicaland economic tension. While cost recovery and tariff reforms are essential to finance circularity investments, entrenched factors hinder them, including resistance to tariff increases and subsidy structures favoring wealthier, already connected users. Interviewees reported households lacking formal connections paid costs through informal RO plants, unlike connected households benefiting from subsidized rates (see Section 6.4). This is reinforced by populist political narratives promising blanket subsidies across services such as water, electricity and transport to win elections (Bijukumar, 2004; Krishnan and Gupta, 2018), where political uncertainty favors short-term populism over rational policy (Srinivasan, 2014), rapidly depleting state finances and leaving little room for new investment (Comptroller and Auditor General of India, 2025). Drawing on this literature and the interview data, we infer that underpricing may have contributed to locking water utilities into a path-dependent cycle of unequal service, at times pushing residents toward informal coping strategies such as unauthorized groundwater extraction. Therefore, circularity pathways must consider political and social dimensions along with cost-recovery. This is complicated by a transferability challenge: models like "sponge city" and Nature-based Solutions (NbS) developed in China and the Global North cannot be applied where 40%–50% of water is lost to leakage (Satpathy and Jha, 2022), infrastructure is incomplete, and ecology varies. This indicates that distributional equity and infrastructure repair should be prioritized before circularity-related innovations are introduced.

These dynamics indicate concrete innovations. Some interviewees emphasized the need for "space for all these actors to come together and start talking," implementing boundary-spanning platforms or urban water councils that transcend silos could represent

initial steps to be taken. Empirical evidence from previously colonized Global South cities indicates that institutional silos correlate with duplicated efforts, conflicting priorities, and reduced accountability, with coordinated governance showing 5–10% higher productivity than fragmented systems (Salsabila et al., 2026; Yasmin et al., 2023). Similarly, hierarchical structures are obstacles; interviewees suggested cross-sectoral working groups rather than advisory committees as a remedy. Multiple interviewees highlighted operations and maintenance, rather than project design, as the critical gap, indicating that investment should enhance monitoring capacity and secure long-term maintenance contracts. The ambiguity in terminology is not solely semantic; it may hinder interaction, coordination, and implementation. Conversely, there is a strong aversion to adopting terminologies stemming from the Global North in the Global South, as they do not resonate locally, creating a communication gap that leads to an implementation gap, consistent with critiques of colonial knowledge hierarchies in governance (Kehinde et al., 2025; Kasuri et al., 2026).This suggests that South-to-South exchanges with Chennai, Hyderabad, Dhaka, Lahore, Jakarta, or Colombo may offer applicable lessons over Global North models. Interviewees also identified that implementing progressive tariff structures, which separate subsidy reform from austerity narratives, could simultaneously enhance equity and the financial viability of the BWSSB. Similarly, aligning CSR incentives with multi-year monitoring commitments and public co-financing mechanisms could facilitate longer-term investment strategies instead of the current short-term funding strategies. Building on these dimensions, we argue that the fundamental requirement is institutional and organizational with infrastructural investment as a co-requirement: BWSSB's achievement of financial sustainability through cost-reflective pricing should be treated as a prerequisite for effective water governance, rather than as its eventual outcome. This has a specific implication for multilateral funders such as the Asian Development Bank (ADB): in our view, funding should prioritize sustained infrastructural investment with institution-building over short-term pilot projects. Several interviewees described a recurring cycle of short-term pilot interventions in Bengaluru's water sector that failed to produce lasting change; we read this pattern as evidence that pilot-style funding is unlikely to succeed without sustained investment in institutional capacity (see Table 2). In summary, these feedback loops suggest the initialization and intensification of weak governance. The system expanded faster than regulatory frameworks could adapt, resulting in persistent inequities (Goldman and Narayan, 2019) and infrastructure deficiencies (Ramachandra et al., 2023) that have rendered infrastructural reforms increasingly costly (Angel, 2023). Furthermore, the ongoing replication of identical policy, fiscal, and infrastructural deficiencies has obstructed potential remedial measures in the sector (Pierson, 2000; Sydow et al., 2009).

Collectively, these findings suggest that benefits may accrue from transitioning from a "predict and act" governance model to a "monitor and adapt" paradigm, as proposed by Hafferty et al. (2025). This approach is structurally aligned with the variability of Nature-based Solutions (NbS) and the unpredictable paths of a changing monsoon. In essence, the constraints faced by Bengaluru are not solely technical or infrastructural but are fundamentally rooted in political-economic factors, with the underpricing trap being the most evident manifestation of this. Consequently, reform strategies must directly address the political economy of urban water, in addition to its technical and institutional aspects. Bengaluru's water situation exemplifies water to be a political and social entity, highlighting disputes over access, visibility, and accountability in an unequal, growing city. This underlines the necessity of water circularity, a complementary robust governance system, and a coherent and binding climate adaptation plan.

8 Limitations

This study has several limitations that warrant acknowledgment. First, the findings, although rich, lack statistical generalizability as this is a single case ($n = 1$) and the results reflect key-informant perceptions. They are specific to Bengaluru's institutional configuration, and comparative studies with other South Asian megacities, such as Chennai, Dhaka, and Lahore, would strengthen the validity and assess whether the identified feedback loops such as weak governance, silos, inertia, and lock-in, apply across contexts in South Asia. Second, the interview sample (see Table 1) was dominated by researchers, consultants, and government advisors; because groups such as informal sector workers, women's groups, and residents of underserved peripheral wards often directly experience institutional failure, their underrepresentation may have shaped the prominence of some challenges and priorities. Third, non-government actors predominate among interviewees; their accounts of internal dynamics, while informed by their professional proximity to government processes, are still filtered through an intermediary rather than a purely internal vantage point. Fourth, the study offers only a temporal snapshot, with interviews conducted between December 2024 and February 2025, soon after the BWSSB's Phase 5 expansion; longer-term institutional and organizational dynamics, including adaptation or failure to adapt, could not be captured. Fifth, the framework's four categories (weak governance, silos, inertia, and lock-in) were analytically useful but conceptually overlapping in nature. Real-world organizational mechanisms resisted clear categorization, supporting our interpretation that these challenges operate as a feedback loop and not as discrete or independent phenomena. Finally, because coding proceeded against a pre-established code book, the analysis could only surface findings within the topics that code book defined; the design is oriented toward descriptive pattern identification within these predefined categories rather than theory-testing, and it cannot claim to reveal insights lying outside the code book's boundaries.

9 Conclusion

This study explored the institutional barriers to sustainable water governance in Bengaluru and how these barriers may interact to shape governance outcomes. The findings suggest that institutional dynamics play a significant role in Bengaluru's water crisis, alongside hydrological factors that this study was not designed to assess. Interviewees' accounts point to patterns of weak governance, siloed administrative processes, inertia, and lock-in, forming mutually reinforcing patterns that contribute to a feedback loop rather than representing a set of discrete problems. Critically, this weak governance is characterized by institutional incapacity, infrastructure investments deficits and fragmented coordination, which drives the persistence of these challenges.

These dynamics have direct implications for water circularity. Rather than offering a ready-made solution, circularity conceptually

functions as a diagnostic lens that exposes the institutional prerequisites and lacunae, such as integrated mandates, enforceable standards, sustained financing, and inter-agency coordination, which are currently appear to be lacking in Bengaluru. Among interviewees, tariff underpricing emerged as the clearest manifestation of this gap, illustrating that the city's water challenges are political-economic as much as institutional, and that reform may need to address financial sustainability and distributional equity as a precondition for circularity, not merely as a co-benefit.

By empirically and qualitatively grounding institutional theory in city-level evidence, this study extends the literature that has largely remained comparative or framework-oriented, illustrating how key-informants perceive institutional challenges manifesting across strategic, regulatory, and financial dimensions within a single case. Given the sample composition and the temporal and organizational snapshots captured here, future research should pursue comparative analyses across South Asian megacities and track how Bengaluru's ongoing governance restructuring reshapes these dynamics. Within Bengaluru specifically, our findings suggest that advancing circular water management may depend less on technical innovation than on infrastructural investment and organizational rebuilding capable of reshaping the feedback loop between weak governance and lock-in.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by HafenCity University Doctoral Commission Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

SN: Methodology, Data curation, Investigation, Writing – original draft, Formal analysis, Visualization, Conceptualization. MD: Supervision, Conceptualization, Writing – review & editing. SB: Writing – review & editing, Resources. RE: Investigation, Writing – review & editing, Data curation. JK: Funding acquisition, Writing – review & editing. BP: Writing – review & editing, Visualization, Supervision.

Funding

The author(s) declared that financial support was received for this work and/or its publication. This study is a contribution to project 'C1: Sustainable Adaptation Scenarios for Urban Areas – Water from Four Sides' of the Cluster of Excellence 'CLICCS - Climate, Climatic Change, and Society' (EXC 2037, Project Number 390683824) at HafenCity University and the Department of Earth System Sciences, Faculty of Mathematics, Informatics and Natural Sciences, Earth and Society Research Hub (ESRAH), University of Hamburg, Hamburg, Germany. It is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy. Open-access publication supported by HafenCity Universität Hamburg.

Acknowledgments

We are grateful to all 13 of our interview partners for their collaboration, hailing from urban water municipalities, utilities, and communities in Bengaluru, India. Of these, 11 have given explicit consent to be named here, and we thank them individually: Vishwanath S of Biome Environmental Trust; Rajesh Ramamoorthy and Radhika Sundaresan of WELL LABS; Arvind Lakshmisha of Azim Premji University; Anjali K Mohan of INDE; Sahana Goswami, Priya Narayanan, and Bhanu Khanna of WRI-India; Nidhya Nadarajan of the Bengaluru Science and Technology Cluster, Indian Institute of Science; Priyanka Jamwal of the Ashoka Trust for Research in Ecology and the Environment; and Preeti Gehlot, Special Commissioner, Bruhat Bengaluru Mahanagara Palike. The remaining two interview partners preferred to remain anonymous, and we respect and honor that choice. We thank all of them equally for their significant time and insight.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was used in the creation of this manuscript. During the preparation of this work, the author(s) used Claude (Anthropic Claude Opus 4.8, source: https://claude.ai) and Perplexity (source: https://www.perplexity.ai) for assistance with limited, non-substantive aspects of manuscript preparation. Specifically, these tools were used to assist with the creation and refinement of figures, and to support grammar, language, and the clarity and readability of the writing. The use of generative AI was strictly limited to editorial and presentational assistance. It was not used to conduct any aspect of the research itself, including study design, data collection, data analysis and coding, interpretation of findings, or the development of the arguments and conclusions presented in this paper. All research, intellectual contributions, and substantive content are entirely the work of the author(s). The author(s) reviewed and edited all AI-assisted content, verified that the figures accurately reflect the data presented in the manuscript, confirmed that all content is free from plagiarism, and take(s) full responsibility for the content and integrity of the published work.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2026.1920960/full#supplementary-material

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