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Environmental Justice and Smart Environmental Governance: Reimagining Urban Ecological Commons in Bengaluru

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Abstract

Bengaluru's transformation from India's celebrated "Garden City" into a rapidly urbanizing metropolis has been accompanied by the systematic depletion of its interconnected lake systems, historically the ecological and hydrological backbone of the region (Nagendra, 2016; Ramachandra, 2023). This paper extends an ongoing sociological inquiry into the relationship between lake depletion, air quality degradation, and urban environmental change by situating Bengaluru's ecological crisis within the broader conceptual terrain of environmental justice and smart environmental governance. Building on the premise that urban lakes function as ecological commons — shared resources sustaining both environmental and social equilibrium (Ostrom, 1990) — the paper argues that their degradation is not merely an ecological failure but a manifestation of institutional fragmentation, weak accountability, and unequal distribution of environmental risk (Ranganathan, 2015; Sen & Nagendra, 2021). Drawing on Environmental Sociology, Environmental Justice Theory, Urban Political Ecology, and Ostrom's Commons Theory, the paper develops an integrated framework to explain how urbanization, governance failure, and social inequality intersect in the loss of Bengaluru's ecological commons. It further examines the emerging discourse of smart environmental governance — digital monitoring, data-driven regulation, and technologically mediated citizen participation — not as a technical solution but as a governance instrument whose outcomes are shaped by questions of access, representation, and accountability (Meijer & Bolívar, 2016; Kitchin, 2014). Adopting a qualitative research design grounded in document analysis, policy review, and thematic synthesis of peer-reviewed and institutional literature, the paper critically interrogates whether smart environmental governance can meaningfully advance environmental justice or whether it risks reproducing existing exclusions under a veneer of technological modernization (Cardullo & Kitchin, 2019; Datta, 2015). The paper's contribution is an integrated governance framework that positions participatory legitimacy, institutional accountability, and social inclusion as preconditions for smart governance to serve, rather than undermine, environmental justice — extending Environmental Sociology's engagement with digital governance discourse in rapidly urbanizing cities of the Global South.

Keywords: Environmental Justice; Smart Environmental Governance; Urban Ecological Commons; Environmental Sociology; Urban Political Ecology; Bengaluru; Lake Depletion; Sustainable Urban Futures

1. Introduction

India's urban trajectory over the past three decades has been defined by the compression of decades of demographic and economic change into a few intense cycles of growth. Cities that once regulated their relationship with the surrounding ecology through slow, cumulative adaptation have instead undergone abrupt structural transformation, in which infrastructural expansion, industrial concentration, and real-estate-driven land conversion have outpaced the institutional capacity to govern them (Ramachandra, 2023; Sussman et al., 2019). Bengaluru is among the most visible instances of this pattern. Once known as the "Pensioners' Paradise" for its temperate climate and extensive tree and lake cover, and later celebrated globally as the "Silicon Valley of India," the city's growth has been accompanied by a parallel and less celebrated transformation: the steady conversion of its interconnected lake systems, wetlands, and green commons into built infrastructure (Nagendra, 2016).

This paper begins from a doctoral synopsis that documents this transformation in sociological terms — as a shift "from Garden City to Concrete City" driven by urbanization, lake depletion, and consequent deterioration in ambient air quality. That foundational work establishes, through an extensive review of ecological and public-health literature, that Bengaluru's environmental decline is well evidenced at the level of pollutant concentration, land-cover change, and aerosol patterning (Guttikunda et al., 2019; Sussman et al., 2019), and that its social consequences — while less studied — are unevenly distributed across class, occupation, and locality (Sen & Nagendra, 2021; deSouza et al., 2023). The present paper does not repeat that empirical groundwork. Instead, it takes the sociological diagnosis as settled and asks a governance question that follows directly from it: if Bengaluru's ecological commons have been eroded by a combination of unplanned growth and institutional fragmentation, what forms of governance might restore them, and under what conditions could such governance be just rather than merely efficient?

The governance discourse that has come to dominate this question, in Bengaluru as in many rapidly urbanizing cities, is that of "smart" environmental governance — the use of sensor networks, real-time air-quality and water-body monitoring, geospatial dashboards, and digital citizen-reporting platforms to inform regulatory and planning decisions (Praharaj et al., 2018). This discourse promises precision, transparency, and responsiveness. Yet a substantial body of critical urban scholarship cautions that smart governance initiatives, when designed without explicit attention to distributive and procedural justice, tend to reproduce or even deepen existing inequalities, privileging those already equipped with digital access, institutional voice, and property-based claims to the city (Cardullo & Kitchin, 2019; Datta, 2015; Vanolo, 2014). This is the central tension this paper interrogates: the same technological apparatus that could, in principle, make ecological degradation visible and governable in ways that serve marginalized communities could equally become an instrument of exclusion if deployed uncritically.

Situating this tension in Bengaluru's specific context of lake depletion and air-quality decline is sociologically significant for two reasons. First, lakes in Bengaluru are not simply ecological infrastructure; they are historically shared commons whose management, encroachment, and restoration have long been entangled with questions of caste, class, and land tenure (Mundoli et al., 2015; Ranganathan, 2015). Second, air quality is an unusually apt lens for environmental justice analysis precisely because its burdens are experienced involuntarily and unevenly by residents according to occupation and residential proximity to pollution sources (Stewart, 2015; deSouza et al., 2023), while the instruments now used to monitor and govern it are unevenly accessible. The paper therefore extends the doctoral synopsis's environmental-sociological diagnosis of Bengaluru into a critical, theoretically integrated analysis of whether and how smart environmental governance can serve environmental justice and restore urban ecological commons, rather than merely modernizing their management.

2. Review of Literature

The literature relevant to this paper's argument clusters around five interlocking themes: urbanization and ecological transformation; air quality and pollution governance; lakes as ecological commons; environmental justice and inequality; and the emerging, more contested body of work on smart and digital urban governance. Rather than treat these as separate strands, the review reads them thematically to identify where existing scholarship converges, where it leaves gaps, and where a sociological reading of smart governance becomes necessary.

2.1 Urbanization and Ecological Transformation

Remote-sensing and land-cover research on Bengaluru consistently documents a rapid, radial pattern of urban expansion along transport corridors, accompanied by measurable rises in surface temperature, loss of vegetation, and altered aerosol regimes (Sussman et al., 2019). This literature is valuable because it establishes that the city's environmental decline is not impressionistic but empirically traceable to specific patterns of infrastructure-led growth. Complementary land-use studies show a dramatic increase in paved and built-up surface area alongside a corresponding decline in vegetative and water-spread cover over recent decades (Ramachandra, 2023), reinforcing the argument that ecological loss is structurally embedded in the city's growth model rather than incidental to it.

2.2 Air Quality and Pollution Governance

A parallel body of work traces the technical drivers of Bengaluru's air-quality decline. Source-apportionment studies attribute particulate pollution substantially to vehicular transport, road dust, construction activity, industrial emissions, and open burning (Guttikunda et al., 2019). Longitudinal

monitoring going back nearly a decade shows that particulate pollution has been a persistent, rather than newly emergent, urban problem (Chinnaswamy et al., 2016), while more recent monitoring confirms continuing, spatially uneven concentrations of particulate and gaseous pollutants across the city (Sangeetha et al., 2024) and an expanding relevance of air-quality data to public-health and infrastructure planning (Devi et al., 2025). This literature is technically rich but governance-thin: it identifies what pollutes and where, but has comparatively little to say about who governs exposure, through what institutions, and with what accountability to affected residents.

2.3 Lakes as Ecological Commons

A distinct and sociologically richer strand of research treats Bengaluru's lakes not merely as ecological features but as commons — shared resources whose use, access, and governance are structured by social relations. Work on peri-urban lake accessibility shows that urbanization has restructured who can use lakes and for what purpose, often at the expense of long-standing agrarian and livelihood-based claims (Mundoli et al., 2015). Ranganathan (2015) extends this into an explicitly political-ecological register, showing how water and lake marginalization at Bengaluru's urban fringe is inseparable from questions of environmental justice and uneven infrastructural investment. Sen and Nagendra (2021) demonstrate that the impacts of urbanization on lake-adjacent communities are differentiated by class, caste, occupation, and locality — a finding that anchors this paper's claim that lake depletion is a distributive, and not merely ecological, phenomenon. More recent ecological studies confirm that lake cover and condition vary sharply along an urban-to-rural gradient (Sourav et al., 2024) and that Bengaluru's historically interconnected lake series is under systemic, cascading pressure from unsustainable urbanization rather than isolated, site-specific encroachment (Mampilamthoda & Chinnasamy, 2024).

2.4 Environmental Justice and Social Inequality

Environmental justice scholarship provides the conceptual bridge between ecological description and sociological analysis. Foundational work in this tradition establishes that environmental burdens and benefits are patterned by race, class, and social position rather than distributed neutrally by geography (Bullard, 1990), a claim later broadened into a multidimensional theory encompassing distributive, procedural, and recognitional justice (Schlosberg, 2007). Applied to urban air pollution specifically, this scholarship shows that exposure is socially patterned and that disadvantaged groups typically bear a disproportionate share of the health burden (Stewart, 2015). In the Indian context, deSouza et al. (2023) provide direct empirical support for this claim, showing that caste, religion, poverty, and access to amenities significantly shape PM_{2.5} exposure nationally — a finding with clear relevance to Bengaluru's spatially uneven pollution burden. More recent environmental-justice scholarship has also broadened its scope from

narrowly distributive questions toward everyday life, community, and "just sustainabilities," a shift relevant to understanding how residents experience and narrate ecological decline rather than merely bear its measurable costs (Agyeman et al., 2016).

2.5 Urban Political Ecology and the Theoretical Bridge

Urban political ecology supplies the connective theoretical apparatus between these strands. Zimmer (2010) frames urban environments as co-produced through power, infrastructure, and political-economic decision-making rather than as a neutral backdrop to urban life, while Angelo (2023) argues that urban sociology has historically under-engaged the natural environment, and that urban inequality must be studied together with ecological process rather than alongside it. Mehta and Karpouzoglou (2014) apply this lens directly to Bengaluru's water infrastructure, describing a "metabolic urbanism" in which the city's water and lake systems are shaped by, and in turn reproduce, environmental injustice. Taken together, this literature supports reading Bengaluru's ecological decline as a political and institutional outcome rather than a purely technical or climatic one.

2.6 Smart and Digital Environmental Governance

The final strand — smart urban governance — is comparatively recent and, notably, largely absent from the Bengaluru-specific literature reviewed above. At a conceptual level, smart governance is often defined as the use of information and communication technologies to improve the functioning, transparency, and responsiveness of urban institutions (Meijer & Bolívar, 2016). Early proponents framed this primarily as a technical and administrative efficiency question (Hollands, 2008), but a substantial critical literature has since emerged. Kitchin (2014) argues that "real-time city" governance built on continuous data streams tends to prioritize measurable, sensor-legible problems over the harder-to-quantify lived experience of urban residents. Gabrys (2014) extends this into an explicitly governmental register, describing citizen sensing and environmental monitoring as new modes of "environmentality" that can discipline as much as empower. Vanolo (2014) similarly characterizes smart-city discourse as a form of "smartmentality" that recasts political and distributive questions as technical ones to be optimized rather than contested. Datta (2015), writing on India's own smart-city programme, shows how "entrepreneurial urbanization" framed as smart and sustainable can in practice marginalize existing communities and informal claims to land and resources — a caution of direct relevance to Bengaluru, where lake-adjacent and peri-urban populations already face marginalization (Ranganathan, 2015; Sen & Nagendra, 2021). Cardullo and Kitchin (2019) further distinguish between "smart citizenship," in which residents are treated as data sources and service consumers, and genuine citizen participation in shaping governance priorities — a distinction this paper treats as central to evaluating whether smart environmental governance can serve environmental justice.

On the more constructive side, Bulkeley and Castán Broto (2013) show that cities increasingly govern climate and environmental problems through localized "experiments" that can, under the right institutional conditions, expand participatory capacity rather than foreclose it — suggesting that the outcome of smart governance is contingent on design and accountability rather than fixed by the technology itself.

3. Research Gap

Read together, these five bodies of literature leave a specific and consequential gap. The ecological and technical literature on Bengaluru establishes, in considerable empirical depth, that urbanization has degraded lake systems and air quality (Guttikunda et al., 2019; Ramachandra, 2023; Sussman et al., 2019). The commons and environmental-justice literature establishes that these losses are experienced unevenly across class, caste, occupation, and locality (Sen & Nagendra, 2021; deSouza et al., 2023; Ranganathan, 2015). What remains largely unexamined — in the Bengaluru context specifically, and in Indian environmental sociology more broadly — is the governance question that logically follows from these two bodies of work: as cities like Bengaluru turn increasingly to smart, data-driven instruments to monitor and manage exactly these degraded commons, what happens to the distributive and procedural injustices already documented in the pre-digital governance regime?

The global smart-governance literature is theoretically well developed but is rarely brought into direct conversation with place-specific environmental-justice findings of the kind available for Bengaluru. Conversely, Bengaluru's environmental-sociology literature is empirically rich but has not yet engaged critically with the smart-governance instruments increasingly deployed in the city's air-quality monitoring and lake-rejuvenation programmes. This paper's contribution is precisely to close that gap: to ask, using Bengaluru as a case, whether smart environmental governance can function as an instrument of environmental justice and ecological-commons restoration, or whether — absent explicit attention to participatory legitimacy and institutional accountability — it risks reproducing the same exclusions documented in the city's existing environmental-injustice literature under a new technological guise.

4. Research Objectives

1. To examine, building on existing sociological evidence, how rapid urbanization has transformed Bengaluru's ecological commons, with particular reference to lake depletion and air quality decline.
2. To critically analyse how this ecological transformation has produced or deepened forms of environmental injustice across class, occupation, and locality.
3. To evaluate the theoretical and practical potential of smart environmental governance to contribute to the protection and restoration of urban ecological commons.

4. To interrogate the conditions under which digital and data-driven governance can strengthen, rather than undermine, environmental justice and democratic participation.
5. To propose an integrated governance framework balancing ecological restoration, technological innovation, and social inclusion for Bengaluru and comparable rapidly urbanizing cities.

5. Research Questions

1. How has rapid urbanization transformed Bengaluru's ecological commons, and what does this transformation reveal about the relationship between infrastructural growth and ecological loss?
2. How has environmental degradation — specifically lake depletion and declining air quality — contributed to new or intensified forms of environmental injustice in Bengaluru?
3. What role can smart environmental governance realistically play in protecting and restoring urban ecological commons?
4. Under what institutional and social conditions can digital governance strengthen, rather than weaken, environmental justice?
5. What governance framework can balance ecological restoration, technological innovation, and social inclusion in Bengaluru's specific institutional context?

6. Theoretical Framework

This paper integrates five theoretical traditions rather than applying them in sequence, because Bengaluru's environmental transformation cannot be adequately explained by any one of them alone.

Environmental Sociology supplies the foundational premise that environmental conditions and social structure are mutually constitutive rather than separate domains of inquiry (Catton & Dunlap, 1978; Hannigan, 2014). This licenses treating air quality and lake depletion not as background ecological facts but as social outcomes requiring sociological explanation.

Environmental Justice Theory adds the distributive and procedural dimension. Its central claim — that environmental burdens and the capacity to influence environmental decision-making are unevenly distributed by social position (Bullard, 1990; Schlosberg, 2007) — directly explains why Bengaluru's air pollution and lake loss are experienced differently by residents in traffic-dense, industrially adjacent, or lake-fringe localities than by residents elsewhere (Stewart, 2015; deSouza et al., 2023). Applied to governance rather than only to outcomes, this theory raises a further question this paper foregrounds: who is invited to participate in, and who is rendered legible or illegible to, new governance instruments.

Urban Political Ecology situates this distributive pattern within processes of power, infrastructure, and political-economic decision-making (Zimmer, 2010). It explains why lakes were encroached, green cover

reduced, and roads expanded — not as accidents of growth but as outcomes of land-use decisions that systematically privileged particular forms of urban value creation over ecological maintenance (Ranganathan, 2015; Mehta & Karpouzoglou, 2014). This framework is essential for connecting Bengaluru's air-quality crisis to its urban development trajectory rather than treating it as a discrete technical failure.

Commons Theory, drawing on Ostrom's (1990) analysis of institutions for collective resource governance, reframes Bengaluru's lakes not simply as ecological infrastructure but as commons requiring functioning institutions of collective management to avoid degradation. Ostrom's (2009) later social-ecological-systems framework adds that the sustainability of such resources depends on the interaction between resource characteristics, governance arrangements, and the users themselves — a formulation that usefully accommodates the addition of digital governance instruments as a new element of that interacting system, rather than as an external fix applied to it.

Smart Environmental Governance, finally, is treated in this paper not as a neutral technical layer but as a governance instrument whose distributive consequences must be theorized rather than assumed (Meijer & Bolívar, 2016; Kitchin, 2014). Critical smart-city scholarship warns that such instruments can convert political and distributive questions into technical optimization problems (Vanolo, 2014), and can position residents as passive data sources rather than participants in governance (Cardullo & Kitchin, 2019). Read through commons theory, this suggests that smart governance's contribution to ecological-commons restoration will depend on whether it is designed as a Ostromian institutional innovation — expanding legitimate collective monitoring and rule-enforcement capacity — or whether it functions instead as a centralizing, exclusionary layer imposed over existing unequal access.

Together, these five traditions allow the paper to move from description to explanation: they show how urbanization produces ecological loss (political ecology), how that loss is unevenly distributed (environmental justice), why collective resources like lakes are vulnerable to this pattern absent robust institutions (commons theory), and what conditions would need to hold for a new governance instrument — smart environmental governance — to correct rather than compound this pattern (environmental sociology and smart governance scholarship combined).

7. Research Methodology

This paper adopts a qualitative, document-based research design appropriate to its conceptual and policy-analytical aims. It draws on thematic and policy analysis of peer-reviewed academic literature, institutional and government reports, and publicly available environmental data published by bodies including the

¹Central Pollution Control Board (CPCB), the Karnataka State Pollution Control Board (KSPCB), the Bruhat Bengaluru Mahanagara Palike (BBMP), the Ministry of Environment, Forest and Climate Change (MoEFCC), the World Health Organization (WHO), and the United Nations Environment Programme (UNEP). No primary survey, interview, or field data are presented in this paper. Where the broader doctoral research programme from which this paper extends involves primary data collection — including structured questionnaires, semi-structured interviews, focus group discussions, and field observation across the Bengaluru Metropolitan Region — that work is explicitly identified here as forthcoming, parallel empirical research rather than as evidence presented in this paper.

The analytical approach is thematic rather than descriptive: literature and policy documents are read for what they reveal about governance capacity, institutional accountability, and distributive outcomes, rather than simply summarized. This is consistent with the paper's aim of extending an existing empirical diagnosis of Bengaluru's environmental decline into a theoretically grounded evaluation of governance alternatives, rather than generating new empirical claims about resident perception or exposure, which remain the proper domain of the primary fieldwork this paper builds toward.

8. Bengaluru's Urban Ecological Transformation

Bengaluru's environmental trajectory since the early 1990s illustrates a pattern common to many Indian metropolitan regions, but with particular intensity given the scale and speed of its information-technology-led growth. The city's historic identity rested substantially on an engineered network of interconnected lakes, originally constructed to manage a plateau region with no major perennial river, supplemented by extensive tree cover that regulated local temperature and supported groundwater recharge (Nagendra, 2016). Land-cover analyses show that this ecological infrastructure has been steadily converted into built surface: paved area has expanded sharply while vegetative and water-spread cover has correspondingly contracted (Ramachandra, 2023), a pattern that recent land-use studies confirm continues along a radial pattern following major transport corridors (Sussman et al., 2019).

Critically, this transformation should not be read as an unplanned accident of growth so much as an outcome of a specific development model in which real-estate value creation, transport infrastructure, and industrial-technological expansion were institutionally prioritized over ecological maintenance (Ranganathan, 2015). Lake-specific studies documenting the transformation of the city's interconnected lake series show that this pressure is systemic rather than confined to a small number of high-visibility encroachment cases (Mampilamthoda & Chinnasamy, 2024), while gradient analyses show that ecological condition varies sharply between urban-core, peri-urban, and rural-fringe lakes — with core-area lakes bearing the most acute pressure precisely where population density and resource demand are highest (Sourav et al., 2024).

The consequences of this transformation extend beyond the lakes themselves into the city's broader air-quality regime. The loss of vegetative and water-body cover removes natural buffering capacity against particulate accumulation and local heat effects, compounding the direct pollution load generated by the same infrastructural growth that displaced the lakes — principally vehicular emissions, construction dust, and industrial activity (Guttikunda et al., 2019). This connects the two headline concerns of the underlying doctoral research — lake depletion and air quality — into a single ecological-transformation narrative: the built environment that has replaced Bengaluru's lakes and tree cover is simultaneously the primary source of the pollutants degrading its air.

Table 1. Drivers of Urban Ecological Transformation in Bengaluru

Driver	Mechanism of Ecological Impact	Illustrative Evidence
Rapid infrastructural and real-estate expansion	Conversion of lake beds, wetlands, and green cover into built surface	Ramachandra (2023); Sussman et al. (2019)
Vehicular growth and transport corridor expansion	Rising vehicular emissions and road dust as major PM sources	Guttikunda et al. (2019)
Industrial and construction activity	Direct particulate and gaseous emissions	Guttikunda et al. (2019); Sangeetha et al. (2024)
Institutional fragmentation across land, water, and pollution authorities	Weak enforcement and overlapping jurisdiction enabling encroachment	Ranganathan (2015); Mehta & Karpouzoglou (2014)
Peri-urban land conversion	Loss of lake accessibility and livelihood-based commons use	Mundoli et al. (2015); Sen & Nagendra (2021)

9. Environmental Justice and Urban Ecological Commons

Reading Bengaluru's lakes as ecological commons in Ostrom's (1990) sense clarifies why their degradation constitutes an environmental-justice problem rather than a purely ecological one. Commons require functioning institutions — clear rules of access, credible monitoring, and legitimate mechanisms of enforcement — to avoid the depletion associated with open or poorly governed access. Bengaluru's lakes historically functioned within exactly such institutional arrangements, embedded in agrarian and community-based systems of tank irrigation and shared use (Mundoli et al., 2015). Rapid urbanization did not simply add ecological pressure to these commons; it displaced the institutions that had previously governed them, replacing localized, accountable management with fragmented jurisdiction across multiple, often uncoordinated municipal, revenue, and pollution-control authorities (Ranganathan, 2015).

The consequence, as Sen and Nagendra (2021) demonstrate, is that the loss of lake access and lake quality has not been experienced uniformly. Communities whose livelihoods and daily lives were most directly tied to lake-adjacent land — often lower-income, occupationally exposed, or historically marginalized groups — have borne a disproportionate share of the loss, while the economic gains generated by the same land conversion have accrued disproportionately elsewhere. This is a textbook instance of what environmental justice scholarship terms distributive injustice: the misalignment between who bears environmental cost and who captures economic benefit (Bullard, 1990; Schlosberg, 2007).

A parallel injustice operates through air quality. deSouza et al. (2023) show, at national scale, that exposure to PM_{2.5} in India is significantly patterned by caste, religion, poverty, and access to amenities — a finding consistent with Stewart's (2015) broader argument that urban air pollution exposure is rarely socially neutral. In Bengaluru specifically, this implies that the same infrastructural growth that displaced lake-adjacent commons communities is also disproportionately burdening residents in traffic-dense, industrially adjacent, and densely built localities with the resulting air pollution — populations that frequently overlap with those least equipped, institutionally or economically, to contest planning decisions (Angelo, 2023).

Procedural injustice compounds this distributive pattern. Environmental-justice theory's procedural dimension concerns not only who bears environmental cost but who has meaningful voice in the decisions that produce it (Schlosberg, 2007). Bengaluru's institutional fragmentation across lake, water, transport, and pollution-control authorities has historically offered few accessible, coordinated channels through which affected residents — particularly those without formal land title or political access — can influence decision-making about lake rejuvenation or air-quality regulation (Mehta & Karpouzoglou, 2014). This procedural gap is precisely the point at which the paper's central question becomes urgent: as governance of these same commons is increasingly reorganized around smart, digital instruments, does this procedural gap close, persist, or widen?

Table 2. Dimensions of Environmental Justice Applied to Bengaluru's Ecological Commons

Dimension	Definition	Manifestation in Bengaluru
Distributive justice	Fair distribution of environmental benefits and burdens	Disproportionate pollution and lake-access loss borne by lower-income and occupationally exposed groups (deSouza et al., 2023; Sen & Nagendra, 2021)
Procedural justice	Fair and meaningful participation in environmental decision-making	Fragmented institutions with limited accessible channels for affected residents (Ranganathan, 2015)

Recognitional justice	Recognition of diverse identities, knowledge, and claims to commons	Marginalization of lake-adjacent livelihood and community claims in planning processes (Mundoli et al., 2015)
Capabilities / everyday-life justice	Capacity to live well within a healthy environment	Reduced liveability and health stress associated with declining air quality (Stewart, 2015; Agyeman et al., 2016)

10. Smart Environmental Governance

Smart environmental governance has emerged as the dominant contemporary response to precisely the kind of institutional fragmentation documented above. In principle, its appeal is straightforward: real-time air-quality sensor networks, satellite and drone-based monitoring of water bodies, geospatial dashboards tracking encroachment, and citizen-reporting applications could make Bengaluru's ecological commons newly visible and governable in ways that fragmented, paper-based administration could not (Meijer & Bolívar, 2016). Read optimistically, such instruments could function as an Ostromian institutional innovation — providing the credible, continuous monitoring that effective commons governance requires (Ostrom, 1990, 2009), and, if paired with accessible reporting and grievance mechanisms, could in principle widen rather than narrow procedural participation.

However, the critical smart-city literature cautions against treating this potential as automatic. Kitchen (2014) argues that "real-time city" governance built around continuous sensor data tends to privilege problems that are technically measurable — pollutant concentration, encroachment area, flow rate — over the harder-to-quantify lived experience of exposure, displacement, and loss that environmental-justice analysis foregrounds. This creates a risk that smart environmental governance in Bengaluru could optimize for what its instruments can see, while remaining blind to who is bearing the resulting costs. Gabrys (2014) extends this concern by describing citizen sensing and environmental monitoring as a mode of environmental governmentality: a system that disciplines behaviour and structures what counts as legitimate environmental knowledge, often in ways that favour technically literate, digitally connected residents over others. Vanolo (2014) frames this more sharply still, arguing that smart-city discourse frequently recasts what are fundamentally political and distributive questions — whose lake access is protected, whose neighbourhood receives monitoring investment — as neutral technical-optimization problems, thereby depoliticizing decisions that environmental-justice theory insists must remain contestable.

These concerns are not abstract for Bengaluru. Datta's (2015) analysis of India's national smart-city programme documents how "entrepreneurial," technologically framed urban development can, in practice, marginalize existing informal and livelihood-based claims to land and resources — precisely the claims

that Sen and Nagendra (2021) and Mundoli et al. (2015) identify as already vulnerable around Bengaluru's lakes. Cardullo and Kitchin's (2019) distinction between "smart citizenship" — in which residents function primarily as sources of data and consumers of digitally delivered services — and substantive citizen participation in setting governance priorities is directly applicable here: an air-quality dashboard that displays pollution levels to residents is not equivalent to a governance process in which affected residents help determine where enforcement resources are directed or which lake-rejuvenation priorities are funded.

At the same time, the literature does not suggest that smart governance is inherently exclusionary. Bulkeley and Castán Broto (2013) show that cities increasingly govern environmental and climate problems through localized institutional "experiments," and that such experiments can expand, rather than foreclose, participatory capacity when designed with explicit attention to inclusion and accountability. This suggests the determining factor is not the technology itself but the institutional design surrounding it: whether monitoring data is paired with accessible grievance and participation mechanisms; whether digital platforms are designed for multilingual, low-connectivity access rather than assuming smartphone and data-plan ownership; and whether the resulting data informs accountable enforcement against politically powerful encroachers as readily as it flags informal, less powerful land users.

Table 3. Governance Challenges Underlying Bengaluru's Ecological Commons Crisis

Challenge	Description	Consequence
Institutional fragmentation	Overlapping jurisdiction across BBMP, KSPCB, revenue, and lake-development authorities	Weak, uncoordinated enforcement against encroachment and pollution (Ranganathan, 2015)
Data and monitoring gaps (pre-digital)	Inconsistent historical monitoring of lake condition and air quality	Difficulty establishing accountability and long-term trend evidence
Limited procedural access	Few accessible channels for affected residents to influence planning decisions	Procedural injustice compounding distributive injustice (Schlosberg, 2007)
Risk of technocratic capture in digital governance	Smart instruments designed around measurable variables and digitally literate users	Marginalization of informal claims and non-digital residents (Kitchin, 2014; Datta, 2015)
Depoliticization of distributive questions	Framing resource-allocation decisions as technical optimization	Contestable political choices removed from public deliberation (Vanolo, 2014)

Table 4. Smart Environmental Governance Framework: Conditions for Justice-Enhancing Design

Design Condition	What It Requires	Justice Function
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Participatory data governance	Community involvement in setting monitoring priorities and interpreting data	Procedural justice — voice in what gets measured and why
Inclusive access design	Multilingual, low-connectivity, non-smartphone-dependent reporting channels	Prevents exclusion of digitally marginal residents (Gabrys, 2014)
Institutional accountability linkage	Binding connection between monitoring data and enforcement action	Prevents monitoring from becoming symbolic without consequence
Recognition of informal and livelihood claims	Explicit safeguards for lake-adjacent and informal-settlement communities in digital planning tools	Recognitional justice (Mundoli et al., 2015)
Transparent, contestable algorithmic and dashboard design	Public explanation of how data informs decisions, with avenues to contest outcomes	Counters depoliticization of distributive choices (Vanolo, 2014)

11. Discussion

The analysis developed above suggests that smart environmental governance holds genuine, non-trivial potential to address the institutional fragmentation that has enabled Bengaluru's ecological-commons decline, but that this potential is conditional rather than automatic. The commons-theory reading of Bengaluru's lakes indicates that what has been missing historically is not primarily technical capacity to measure ecological decline — much of that capacity already exists in the ecological and remote-sensing literature reviewed above (Sussman et al., 2019; Ramachandra, 2023) — but rather the institutional infrastructure to translate monitoring into accountable, enforced, and socially legitimate rule-making (Ostrom, 1990; Ranganathan, 2015). Smart governance instruments could, in principle, supply exactly this missing translation layer, provided they are designed as extensions of accountable institutions rather than as substitutes for them.

The environmental-justice reading, however, complicates any straightforwardly optimistic conclusion. Because Bengaluru's existing distributive and procedural injustices are already well documented — uneven exposure by class and occupation (deSouza et al., 2023; Stewart, 2015), and limited procedural access for lake-adjacent and informal communities (Mundoli et al., 2015; Sen & Nagendra, 2021) — a governance instrument introduced without explicit corrective design is more likely to reproduce than resolve these patterns. Kitchin's (2014) and Vanolo's (2014) warnings about the technocratic and depoliticizing tendencies of smart urbanism are directly relevant here: an air-quality dashboard or lake-encroachment monitoring system that is technically sophisticated but procedurally closed does not, on its own, constitute environmental-justice progress. It may instead simply make existing inequities more precisely quantifiable without making them more contestable.

This suggests that the central sociological question is not whether Bengaluru adopts smart environmental governance — this trajectory is already underway across India's major cities (Praharaj et al., 2018) — but under what institutional conditions it does so. The paper's synthesis of the critical smart-governance literature with Bengaluru's specific environmental-justice evidence points to a consistent answer: smart governance advances environmental justice only where digital monitoring is explicitly coupled with participatory data governance, inclusive and non-digital access channels, binding accountability linking data to enforcement, and deliberate recognition of informal and livelihood-based claims that formal land records and sensor data alone will not capture (Cardullo & Kitchin, 2019; Bulkeley & Castán Broto, 2013). Absent these conditions, the risk articulated by Datta (2015) in the broader Indian smart-city context — that technologically framed urban development marginalizes existing informal claims under a language of modernization — applies with particular force to Bengaluru's already-vulnerable lake-adjacent communities.

A further implication concerns the relationship between technological innovation and the pace of institutional reform. Digital monitoring can be deployed relatively quickly; the institutional accountability structures needed to make its outputs meaningful — coordinated jurisdiction, enforceable rules, accessible grievance redress — take considerably longer to build (Ranganathan, 2015; Mehta & Karpouzoglou, 2014). A governance strategy that races ahead with monitoring technology while leaving this institutional foundation unreformed risks precisely the symbolic-without-consequence outcome flagged in Table 3: highly visible dashboards that document ongoing degradation without altering the underlying dynamics that produce it.

12. Policy Framework

Building on this discussion, the paper proposes an integrated policy framework structured around five priorities, summarized in Table 5. First, monitoring and data infrastructure investment — expanding air-quality and lake-condition sensing — should be paired, as a design requirement rather than an afterthought, with participatory mechanisms determining what is monitored and why, so that instrumentation reflects community-identified priorities rather than only administratively convenient variables. Second, institutional consolidation is a precondition for smart governance to matter: without a coordinated authority structure linking BBMP, KSPCB, lake-development bodies, and revenue authorities, monitoring data will continue to identify problems that no single accountable institution is positioned to act on (Ranganathan, 2015). Third, inclusive-access design should be treated as a justice requirement: digital platforms for environmental reporting and grievance redress must accommodate multilingual, low-literacy, and low-connectivity users, rather than assuming smartphone- and data-plan-based access, if they are not to

reproduce the digital-divide exclusions documented in the broader smart-city literature (Gabrys, 2014; Cardullo & Kitchin, 2019). Fourth, recognitional safeguards should formally incorporate lake-adjacent and informal-settlement livelihood claims into digital land-use and lake-rejuvenation planning tools, addressing the recognitional-justice gap identified by Mundoli et al. (2015) and Sen and Nagendra (2021). Fifth, accountability linkage mechanisms should bind monitoring outputs to enforceable consequences — including against politically influential encroachers — with public, contestable reporting on how data has informed (or failed to inform) enforcement action, directly addressing the depoliticization risk raised by Vanolo (2014).

Table 5. Integrated Policy Recommendations for Justice-Oriented Smart Environmental Governance in Bengaluru

Priority Area	Recommended Action	Expected Justice Outcome
Participatory monitoring design	Involve lake-adjacent and pollution-exposed communities in setting sensor placement and reporting priorities	Improved procedural justice and data relevance
Institutional consolidation	Coordinate BBMP, KSPCB, revenue, and lake-development authorities under a unified accountability structure	Closes the enforcement gap between monitoring and action
Inclusive digital access	Multilingual, low-connectivity grievance and reporting channels alongside app-based platforms	Prevents exclusion of digitally marginal residents
Recognitional safeguards	Formal incorporation of informal and livelihood-based lake-commons claims into digital planning tools	Protects vulnerable communities from technocratic erasure
Transparent accountability linkage	Public, contestable reporting connecting monitoring data to enforcement outcomes	Counters symbolic-only governance and depoliticization

13. Conclusion

This paper has extended a doctoral sociological diagnosis of Bengaluru's transformation from "Garden City" to "Concrete City" into a critical evaluation of the governance instruments now being proposed to address that transformation. Building on well-established evidence that urbanization has degraded Bengaluru's lake systems and air quality (Guttikunda et al., 2019; Ramachandra, 2023; Sussman et al., 2019), and that these losses are experienced unevenly across class, caste, occupation, and locality (Sen & Nagendra, 2021; deSouza et al., 2023), the paper has argued that Bengaluru's ecological commons crisis is as much an institutional and distributive failure as an ecological one (Ostrom, 1990; Ranganathan, 2015).

Smart environmental governance, the paper has shown, is neither an inherent solution nor an inherent threat to this crisis. Its contribution to environmental justice and ecological-commons restoration depends entirely on institutional design choices that are too often treated as secondary to technological deployment: participatory data governance, inclusive access, binding accountability, and explicit recognition of informal and livelihood-based claims (Cardullo & Kitchin, 2019; Datta, 2015; Vanolo, 2014). Where these conditions are absent, smart governance risks reproducing — with greater precision and less contestability — the same distributive and procedural injustices already documented in Bengaluru's pre-digital governance regime.

The paper's contribution to Environmental Sociology is therefore twofold: it extends the discipline's engagement with digital governance discourse beyond generic claims about technology and efficiency into a place-specific, justice-oriented evaluation grounded in an established empirical case; and it links environmental-justice theory explicitly with commons theory to show that restoring ecological commons requires institutional legitimacy as much as technical capability. For Bengaluru specifically, and for comparable rapidly urbanizing cities of the Global South more broadly, the paper's central conclusion is that sustainable urban futures will depend less on the sophistication of environmental monitoring technology than on whether the institutions surrounding that technology are built to be participatory, accountable, and socially inclusive. Future empirical research — including the primary fieldwork toward which the broader doctoral research programme is oriented — will be essential to test how residents across Bengaluru's socio-economic spectrum actually perceive, access, and are affected by the smart environmental governance instruments increasingly being deployed in the city.

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