Design Considerations for building Digital Public Infrastructure for Water: Lessons from Urban Governance

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Original Abstract

Effective water management is crucial for ensuring reliable, inclusive, cost-effective, and sustainable water services for citizens. In India, this responsibility is distributed across multiple levels of government, involving a range of institutions, including central, state, and local agencies. Central government bodies like the Ministry of Jal Shakti, the Central Water Commission (CWC), and the Central Ground Water Board (CGWB) play pivotal roles in water resource planning, policy formulation, and regulation. State agencies, such as the Water Resources Departments and Public Health Engineering Departments (PHED), are responsible for implementing water infrastructure projects and maintaining water supply systems within their jurisdictions. At the local level, Municipal Corporations, Panchayati Raj Institutions (PRIs), and community institutions like Village Water and Sanitation Committees (VWSC) and Water User Associations (WUAs) manage the distribution and quality of water services.

This paper examines the federated system architecture in other domains and explores how a Digital Public Infrastructure (DPI) approach can be applied to improve service delivery by engaging with society (Samaaj), government (Sarkaar), and the market (Bazaar). The architecture, design, governance, and rollout of the DPI system offer important lessons for solving complex public service delivery challenges. We then discuss how these lessons can be applied to address the multifaceted challenges of water management. By leveraging digital technologies to enhance institutional capacities, the DPI approach facilitates the seamless exchange of data in a secure, reliable, and trusted manner, easing coordination among various agencies. The paper will also highlight the need for a unified and coordinated approach to ensure that water services are delivered efficiently and equitably to all citizens, ultimately fostering sustainable water governance in India.

Extended Abstract

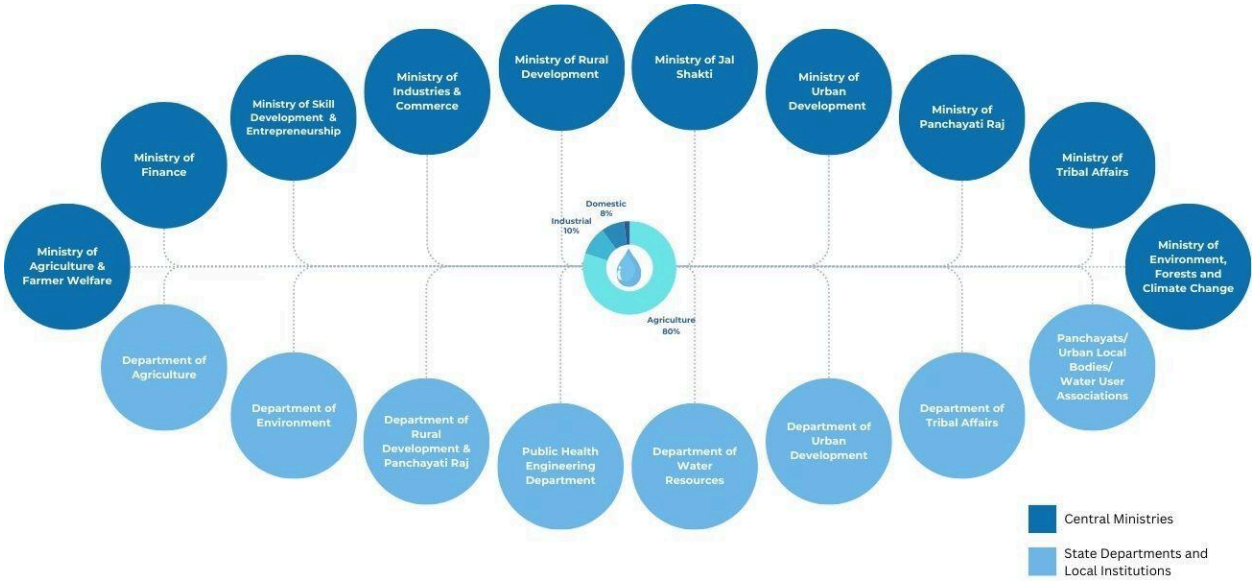
Introduction

The governance of water bodies and watersheds is necessarily a collaborative endeavour. Ostrom (1990) provides examples of how institutions and arrangements evolve to govern such common pool resources[1]. Multiple entities, across *sarkaar* (the state), *bazaar* (the market), and *samaaj* (society or communities) must collaborate for effective water governance, towards ensuring reliable, inclusive, and sustainable access to water for all.

In India, these entities include multiple tiers of government:

- Union: Ministry of Jal Shakti (MoJS), Central Water Commission (CWC), Central Ground Water Board (CGWB), etc.;
- State: Water Resources Departments (WRD), Public Health Engineering Departments (PHED), etc.;
- Local: Urban Local Bodies (ULBs) and Panchayati Raj Institutions (PRIs), Village Water and Sanitation Committees (VWSCs), Water User Associations (WUAs), etc;
- Various other entities whose work impacts water bodies or watersheds, or is impacted by them.

Fig. 1: Water Ecosystem (Union & State Government)



[1] Ostrom (1990), *Governing the Commons*

This is within *sarkaar* itself; the full range of actors also encompasses *bazaar* and *samaaj*. The task of collaborative decision-making and action thus becomes complex. Decisions are taken with incomplete information, often in a context of information asymmetry and low trust in both data and institutions. Actors' interests may not be aligned *a priori*, making negotiations a necessity, and even negotiated agreements may be contingent on various factors. Thus, even where broad parameters - e.g. accessibility, sustainability, etc. – are agreed upon, the collective action problems Ostrom studied are likely to emerge.

In this paper, we draw on our experience with supporting the management of another complex adaptive system – cities / ULBs in India – to suggest key principles that can be followed in the case of water governance. In particular, we look at the role that digital technology has played in urban governance reforms, and propose a Digital Public Infrastructure for water governance, which could address challenges of coordination, capacity, data quality, and trust.

Our Work in Urban Governance

eGov Foundation was founded in 2003, with a mission to enable more citizen-centric, efficient, and transparent local governance by leveraging open-source software. We began working with ward revenue officers in Bangalore, looking at how property tax systems and property records could be improved. In partnership with the Government of Karnataka, this work spread to multiple ULBs in the state, supporting cities to enhance their own revenues and transition to accrual-based double-entry accounting.

In 2008, we began working with the Greater Chennai Corporation, creating an integrated city ERP system. A wide range of use cases and applications have been developed as part of this system, which is in use today, covering not just revenue but also service delivery (e.g. water connections, sewerage connections, public grievance redressal), public works management, and registration / licences / certificates.

We shifted to working at a state-wide scale in 2015, in Andhra Pradesh. Creating digital tools and capabilities for the wide range of contexts across the state sparked new learning for us. Drawing on these experiences, we developed the DIGIT platform – a set of modular, interoperable, and extensible digital building blocks, connected through APIs[2], which could be composed into various solutions, and configured for diverse

[2] Postman | What is an API? A Beginner's Guide to APIs

urban contexts and use cases. In today's language, DIGIT is a DPI for urban governance.

DIGIT is open source, under the MIT License[3]. We advise governments, and train and enable implementation partners to customise, configure, deploy, and maintain their own software systems, built on the DIGIT platform – whose modular and reusable building blocks reduce the effort involved in creating new applications. To illustrate how this could be done, we developed reference applications for some of the most widely-used services[4].

Taken together, these shifts dramatically reduced the cost and time for setting up a digital urban governance system, compared both to commercial / subscription-based software or to developing new software from scratch. In Punjab, we demonstrated this contrast in 2018, when a set of modules was taken live across 100 ULBs in the state in three months, and across all 167 ULBs of the state within a year. This was done at a fraction of the costs quoted in previous procurement attempts, and led by an in-house team of the state, with extensive training and enablement from our teams.

We had also been engaging the Union Ministry of Housing and Urban Affairs (MoHUA); based on evidence from Andhra Pradesh and Punjab, MoHUA decided to introduce a new national initiative for digital urban governance, known at that time as the National Urban Innovation Stack (NUIS)[5]. NUIS envisioned a number of platforms (an urban "stack") being provided to cities and towns across India, accelerating the adoption of digitally-enabled urban governance.

The NUIS vision has since been operationalised as the National Urban Digital Mission (NUDM)[6], anchored by the Centre for Digital Governance at the National Institute of Urban Affairs. We have continued to support NUDM, with the DIGIT platform being selected as the base for NUDM's platform for citizen-centric service delivery. The first statewide implementation this platform was launched this year, as "K-SMART" in Kerala[7].

Key Lessons: DPI as an Enabler

Cities need dynamic and responsive governance, which ULB administrators often

[3] Open Source Initiative, The MIT License
[4] eGov Foundation, DIGIT Urban | Products & Modules
[5] NIUA (2019), National Urban Innovation Stack - Strategy and Approach
[6] Ministry of Housing and Urban Affairs, Government of India | https://nudm.mohua.gov.in/
[7] Information Kerala Mission (2024), "K-SMART: the smart revolution for Local Self Government Institutions"

struggle to provide, due to a lack of real-time visibility into their city, as well as capacity challenges (insufficient financial and/or human resources). We have seen urban DPI address these challenges by providing reliable data, enabling ULB-level coordination, and augmenting the capacity of ULB employees.

DPI Enabling ULB-level Coordination

The building blocks of a DPI can be further classified into data infrastructure (registries) and service infrastructure (services).

- Any ULB process can be modelled as a workflow (a series of tasks done by designated persons/roles).
- Each task both requires and generates data, which can be read from and recorded in registries.
- APIs enable registries and services to communicate and perform predefined tasks, thus automating some of the work done by employees.

Tasks that involve searching for, recording, or sharing data can be largely automated. This simultaneously reduces employee workload and enhances data quality. Subject to "transactional hygiene"[8] (i.e. employees doing all their work on the digital system only), the DPI records real-time transactional data, which is not subject to error or manipulation. The provenance of any data point can be tracked precisely; the ability to modify it can be limited to specific persons; if it is modified, the system will record when and by whom it was modified, creating non-repudiability.

To illustrate urban DPI in action, consider city revenue maximisation.

- The largest source of revenue for cities is property tax. ULB offices maintain a property tax register, with records of assessments, demands, and payments. However, such records may not cover all properties in that jurisdiction, leading to lower collections.

- Records of all properties in a city are with the Property Registrar (under the State Department of Stamps & Registration). Relevant information may also be held by the Real Estate Regulatory Authority (RERA), again a parastatal. A shared property registry, which these entities update periodically, can provide more comprehensive coverage. When the Property Tax Registry is based on the Property Registry, coverage will improve.

- Additional layers of data from the ULB and utility providers, on trade licences, electricity, water, and sewerage, can enable anomaly detection, e.g. if

[8] Batra, Naik,and Thiagarajan (2021), *E-governance Maturity Framework*.

commercial ventures are run from a property being assessed at residential rates. (City-level GST data would enable an additional layer of verification.)

- A registry of property transactions, over time, provides a basis for revising tax rates themselves, enabling a move from fixed-value (i.e. property dimensions-based) to capital-value (i.e. property price-based) taxation. It would also help determine fair value if the ULB decides to lease / sell its own properties. It can also provide an accurate estimate of revenue foregone by the ULB through tax exemptions.
- Accurate property records can help plan other forms of proactive maintenance, e.g. scheduled desludging of septic tanks, which has public health benefits.
- As cities develop climate action plans, property records (plus geological and meteorological data) can help identify sites for rainwater harvesting, rooftop solar panels, etc. If cities update building codes to include such measures, then the property registry can include such attributes.
- This unified view is useful to city residents: it simplifies monitoring and timely payment of taxes and fees, and reduces verification costs in property transactions, as digital registries are difficult to manipulate, and impossible to manipulate without leaving an auditable trail.

By implementing some of these measures (property and property tax registrar, unified billing, online payments, anomaly detection, and more recently capital value taxation), Andhra Pradesh was able to more than double property tax revenues, from ~Rs. 924 crore in 2016-17 to ~Rs. 2000 crore in 2023-24.

DPI Enabling Local Agency

When a national mission brings new goals and platforms to a pre-existing dynamic system, it adds to the complexity. We live in a federal system, and must respect the mandates and autonomy of actors at different tiers.

For instance, in NUDM's design phase, a key debate was on how states and cities were expected to adopt the platform. NUDM decided to offer three adoption models[9]:

- A SaaS-like model, where states become tenants on a centrally-hosted instance,

[9] https://nudm.mohua.gov.in/wp-content/uploads/2023/07/Implementation-Guidelines-for-NUIS-CCSG-v3.pdf

saving on infrastructure costs. This was seen as most suitable for states with limited digitisation (“greenfield”) who want to get started quickly.

- An open-source model, where states fork the platform code to create their own instance. While they must procure or provide infrastructure and implementation services themselves, they have greater control over platform customisation. This was seen as most suitable for states with some existing systems, infrastructure and technical capacity already in place (“brownfield”).
- A data-sharing model, where states that already have operational systems share specific data / indicators on an agreed frequency, ideally through APIs. This was seen as most suitable for states with mature digital systems.

States can make granular choices, differentiating which modules are adopted in which mode, or adopting modules in some cities and sharing data from others. This approach preserves the agency of state and city-level actors, rather than imposing a single platform upon them. Each state’s roadmap – developed in consultation with NUDM – will be unique.

In practice, no state has chosen the SaaS model yet. Kerala created its own instance; so far, other potential adopter states also prefer this. States with mature systems do prefer the data-sharing model – however, the question of what data or KPIs will be shared is a subject of negotiation. States have questioned how this data will be used, how it will be sourced from other states, and why they are obliged to share it. These are exactly the kinds of negotiations one should expect in a federal system.

DPI Enabling Accountability through Data

These negotiations point to a third key aspect of any digitally-enabled reform: the role of data in enabling accountability and transparency, as well as the concerns that arise around such visibility through data.

Raja Chelliah is credited with saying, “Everybody loves decentralisation, but only to his level.” Similarly, everybody loves visibility – but only into the levels below them. For the levels above, including in the federal structure, they would prefer to control what is visible. As DPI improves data quality and timeliness, and demonstrates the value that can be generated through data-sharing (especially with registries and APIs), the political economy of accountability comes into ever-sharper focus.

DPI holds great promise for counteracting information asymmetry, making negotiations

more equal and transactions more efficient. As with any market failure, though, there will be entrenched players benefiting from it, and they will be reluctant to see their advantage eroded; if they can prevent this by withholding data, such resistance is predictable.

More broadly, data – especially data about who has access to what services or resources, who has accessed which services, and who has or has not paid what taxes or fees – is inherently political. Much of politics in India involves making claims on the state (e.g. Auerbach, 2019; Sharan, 2021)[10]; when such claims are based on data certified as valid by the government, it will empower many groups to demand reallocation of resources, or reforms to the allocation processes and authorities themselves.

Distinctions from the Water Sector

While we believe a transfer of learning from the urban context to water governance is possible, especially as it pertains to the potential role of DPI and digital tools, we recognise that there are many nuances specific to the water / WASH sector. Indeed, one of the strengths of the DPI approach is that it aims to boost local capacities to address local needs and challenges, rather than replicating "proven" solutions in new contexts[11].

We notice two distinctions which will potentially make water an even more complex domain than cities. First, administrative boundaries tend to be clearly demarcated in the urban context. For instance, while there may be differences between an urban ward, revenue ward, and constituency, a given property can be located in only one urban ward, one revenue ward, and one constituency. Water bodies, aquifers, and watersheds are likely to cross many administrative boundaries, and thus will involve many more administrative entities than in the urban case. The boundaries of the water resource itself may be harder to establish than those of a given plot of land.

Second, responsibilities and funding in government hierarchies are clearer for cities. The line ministry at the Union level, line departments at the State level, and ULBs themselves at the third level, each have clear mandates and funds. Even parastatal regulators or utility / service providers have defined territorial and functional jurisdiction.

[10] Auerbach (2019), Demanding Development: The Politics of Public Goods Provisions in India's Slums; M R Sharan (2021), Last Among Equals: Power, Caste, and Politics in Bihar's Villages.
[11] Naik and Ravichander (2022), Distributing the Capacity to Solve: Digital Public Goods for Iterative Adaptation in Governance and Service Delivery, *ICEGOV 2022.*

National missions can set objectives and targets for each of these entities. With water, as seen in Fig. 1, there are many more entities involved, and the relevance and applicability of their mandates may be more contested. (To be fair, with the creation of the Ministry of Jal Shakti, it is possible that a greater unification of mandates will be created, at least at the Union level.)

Other nuances will no doubt emerge as more efforts are made to apply digital tools to water governance.

Conclusion

While water resources and cities seem distinct, they share similar governance challenges as complex adaptive systems. Lessons from urban governance can be effectively applied to water governance, given the need for coordination across geographic and administrative boundaries. Establishing data standards is crucial for ensuring stakeholders work with a unified reality, facilitating informed decision-making. Implementing federated registries and APIs provides a reliable source of truth, allowing secure data sharing and enhanced analysis. Lastly, robust data policies play a pivotal role in overcoming human and political barriers, fostering trust and clarity in data management and sharing practices.

- Coordination across geographic and administrative boundaries: Natural and human systems do not respect administrative boundaries; water (and the people that use it) flow across these, and interact with multiple government entities, communities and service providers. To be effective, any governance system will have to be able to pull together these multiple entities – or at least make data sharing, coordination, and collective decision-making easier.

- Data Standards for information exchange: At a minimum, stakeholders must agree on the reality they are working on; at a technical level, this requires data-sharing standards, which define what data will be shared, in what format, at what frequency, through what channels, etc. Recording and exchanging data in a standardised manner facilitates analysis, management, and decision making.

- Registries and APIs as gold standard: A shared, federated registry, updated by the entities who actually engage with the residents or resources being recorded, is the best way to create a single source of truth for stakeholders. APIs enable granular differentiation in access to this data and provide autonomy to the agencies – i.e. who can view, who can modify, who can / must verify a given data point or approve a modification, etc. – as well as create auditable trails of such viewing, modification, verification, and approvals. They also enable layers of

analysis and intelligence to be built on top of the data, which can further improve capacity and policymaking.

- Data policies as a key enabler: The main hurdles to data sharing are not technical but human and political; they boil down to a lack of trust. Publishing and enforcing data policies can address this challenge, by providing clarity on what data is collected, how it will be used, whom it will be shared with, etc. – and most importantly, for what purpose any of this will be done. The technical capabilities to manage and audit access already exist; data policies are needed to specify how these capacities are applied.

We believe that the DPI approach, as well as a water DPI, hold considerable promise. While the quest for reliable data is perennial, DPI are most effective at creating shared and reliable data, reducing information asymmetries, bolstering capacity by reducing administrative load, and improving multi-entity coordination. These are all capabilities that will serve the water domain well.