Urban Groundwater in India: The Role of Information in Effective Governance

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Introduction

Groundwater use has been largely left unmonitored and unregulated, especially until the mid-twentieth century. Demographic, technological and economic changes in the past several decades have had tremendous impact on groundwater systems around the world, yet information about these systems has been lacking. India is the leading groundwater user globally. Estimated at 250 km^3/yr [1], its use is more than that of the US and China combined. Although the agricultural sector uses the largest proportion, almost all urban areas in India depend on groundwater substantially, because utility supplied surface water is not sufficient to meet any city's entire demand [2,3]. As a result, residents, businesses and institutions regularly pump groundwater all over the country. In Bangalore alone - where the population grew from 5.7 million to 8.5 million in 10 years [4] – a 2013 survey has found that households use as many as 18 different means to secure water, and more than 60% of households use groundwater in one way or the other[1].

Over the past decade, there have been several attempts at national and state level to pass groundwater policy and legislation, even as the topic has gained increasing attention of scholars and practitioners[2]. Box 1 provides a summary of key national attempts at water and groundwater policy. One emerging refrain calls for contextualizing groundwater management within integrated water management considering groundwater as an inseparable component of the overall hydrologic balance (e.g. [4–7]).

India's urban population – at 370 million-plus – is *greater than the total population of all countries except China* [6]. Given the increasing dependence of such a high population on groundwater, and combined with groundwater's common pool, 'invisible', and relatively little-known characteristics on groundwater, we believe that urban groundwater management in India needs its own focus, albeit within a larger, integrated water resources management context. The role of information is crucial to the integrated water resources management method.

[1] Source: Bangalore Urban Metabolism Project, 2017. URL: http://bangalore.urbanmetabolism.asia/2016/07/19/bengalurus-water-insecurity-is-manifested-in-the-diversity-of-its-household-water-supply-portfolio/

[2] See for example, the Economic and Political Weekly's special issue on water governance (Vol. 51, Issue No. 52, 24 Dec, 2016) for several articles covering national and state attempts at groundwater governance reform.

Box 1 Groundwater Governance Reforms in India

Federal vs. State Groundwater Authority:

- India's division of power between the Federal Union (the Centre/Government) and States accords State power over groundwater [9]. However, the Centre still has some formal control over groundwater resources as a result of a 1997 Supreme Court ruling which held that the Centre could create a groundwater management authority for the regulation of groundwater management in order to assure the resource's long-term sustainability [9]. As a result, the Central Groundwater Authority (CGWA) was created as a subordinate office of the Ministry of Water Resources (MoWR) to provide a degree of administrative oversight and water monitoring within States [9].
- In Bangalore, The Karnataka State Groundwater Authority has regulatory control over groundwater resources [10].
- Most states utilize a well-by-well basis in order to regulate well depth, and zoning arrangements around wells used for drinking water. This obfuscates an integrated approach to regulation. Comprehensive provisions for controlling groundwater development and quality are also typically lacking [9].

National Water Policy of 2012:

- The policy recommends that groundwater be managed as a community resource entrusted to the state, under the public trust doctrine for the objectives of food security, livelihood protection, and equitable/sustainable development for all. It acknowledges the importance of good governance and transparent decision-making and recommends national framework legislation for water [9].
- It envisages Water Users Associations for irrigators being accorded statutory powers to collect water charges and set rates, utilizing instruments such as tariffs and differential pricing as conservation methods [9].

Model Bills:

- The Centre first circulated a 1970 Model Bill which has since been updated in 1992, 1996, and in 2005, after the creation of the Central Groundwater Authority. It was most recently updated in 2011 and 2016 [9].
- The 2011 Model Bill is one of the most recent of increasingly progressive Model Bills. It introduced approaches such as declaring the State a public trustee and naming groundwater a common heritage. It designates groundwater protection zones and security plans and it also names water as a basic human right, designating minimum allocation amounts, per individual, of sufficient drinking quality [9].
- The 2016 Bill emphasizes the necessity of integrating surface and groundwater regulation; however, it has been criticized for not clearly defining contentious concepts such as "sustainable water use" [7].

Relevant Documents & Initiatives

- Draft National Water Framework Bills of 2013 and 2016. [11,12].
- CGWA's Revised Guidelines from 2015 [13].
- The Twelfth Five-Year Plan [14].
- There are also National Water Policy Documents from the MoWR from 1987 and 2002 [7].

In this paper, we focus on the particular role of information in making groundwater governance effective, motivated by the following quote from a global effort on groundwater governance [8, p 34]:

"Fundamental to groundwater governance is a correct and sufficiently detailed understanding of the local groundwater resources, its use and the overall setting":

We start with illuminating this role of information in general, and then illustrate its practice with a case study from Bangkok. We then move to current challenges in Bangalore, and present novel, non-traditional efforts to information generation. We conclude with insights on legitimacy, science-policy interfacing, and participatory decision-making.

Water Governance and Management

Management is a process usually initiated by governments that allows for a controlled use of aquifers while also providing adequately for its protection. It is an *active* process that must be fitted to local situations, using a variety of tools like monitoring, legal and regulatory instruments, local participation and engagement, and incentives/disincentives. Like in any management context, a management goal needs to be articulated. These needs place management – at a local level - in a broader, governance context. Governance can be seen as "the operation of rules, instruments and organizations that can align stakeholder behavior and actual outcomes with policy objectives" [9]. It requires the economic, political, social, and administrative means of ensuring the equitable, efficient and sustainable allocation of water [10]. Operating at multiple scales, it requires the coordination of administrative actions and decision making between and among different jurisdictional levels.

Integrated Water Governance Framework

An integrated water governance framework illustrates the relationship between legislative/regulatory agendas, management institutions, and information. Though distinct from information in certain aspects, forms of knowledge function to better understand the role of information in governance. Legislative and regulatory institutions create water policy agendas, often stemming from a national level and geared towards influencing state legislation [10]. Agendas identify objectives and which methods to use to meet the objectives. Legislative and regulatory institutions also create management institutions, dictate their mandates and ascribe them powers and enforcement instruments [9]. Consequently, an agenda will also define jurisdictional units for management, e.g., design unique institutions able to best manage the specific properties of an area. These spatial units of management might include hydrological properties such as groundwater bodies versus, aquifers, or river basins versus aquifers [8]; however, they should also include social variables such as demographic or socio-political knowledge, see Figure 1.

An integrated framework critically depends on the generation of multiple forms of knowledge. Ideally, each management institution will generate information respective to the conditions in which it was designed to operate in. In conjunction to generating specialized knowledge/information, these institutions should actively circulate the information between themselves in order to supplement otherwise obscure puzzle pieces. Importantly, while each management institution will have unique functions/mandates, they will also have common responsibilities. For instance, each institution should have participatory functions for the public and for stakeholders in order to shape

policy/management objectives, but also for policy implementation buy-in. Such functions need to be transparent and provide user-friendly versions of information to the public [9]. It is important to build capacity by not duplicating management functions between institutions. Knowledge, capacity and investment form a feedback loop, wherein investing in knowledge in turn identifies which problems need to be addressed via regulation, and regulation in turn requires the capacity to implement, enforce and generate fees necessary for self-sustenance.

This framework has decentralized components. Dependent on their function, for instance, it might be necessary that some institutions be consequently in an oversight position, placing them at different locations along a vertical spectrum. Likewise, participatory management in particular requires that management institutions be easily accessible in multiple horizontal locations to diverse stakeholders. Importantly, by requiring public participation at each institutional level, and by circulating information, each institution remains grounded in bottom-up levels of detail. Institutions are well positioned to distribute the responsibility of enforcement, and information collection. Additionally, building institutional capacity can very well be facilitated at the national level. A case study from Bangkok, Thailand illustrates the connections between information, governance and (management) action with particular attention paid to institutional investment.

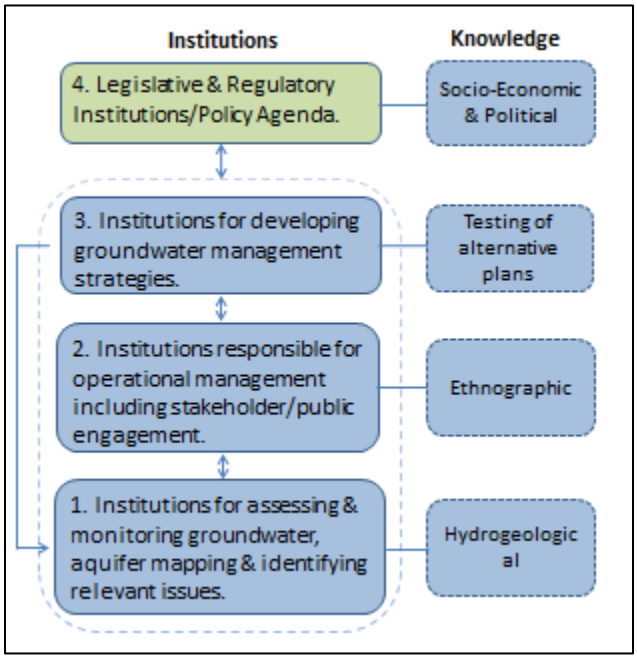
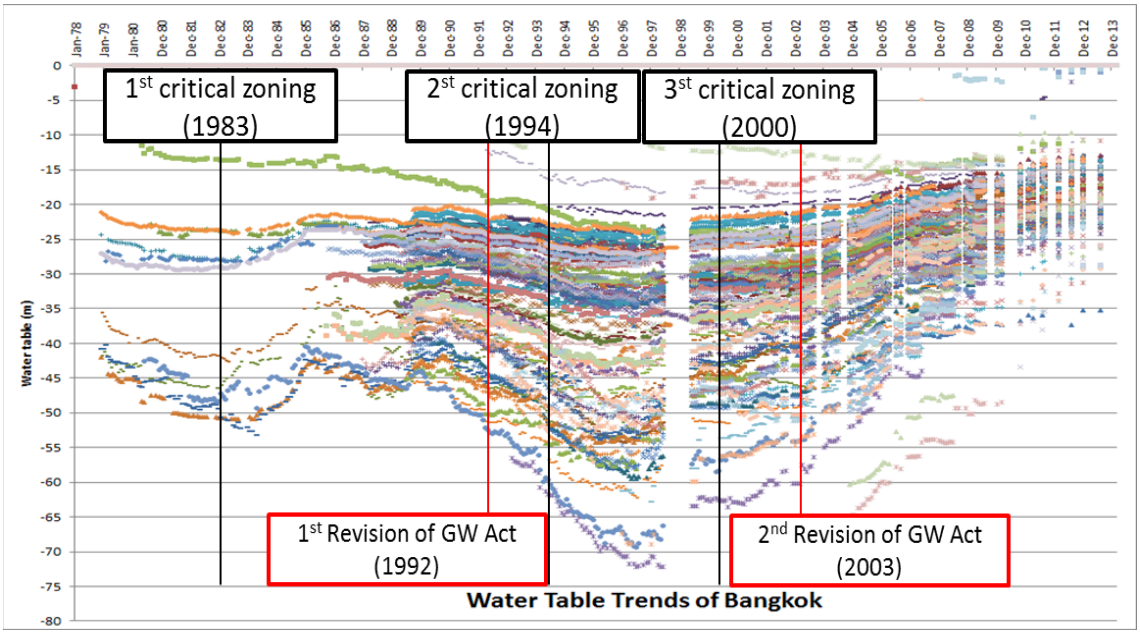


Figure 1 Institutions have distinct functions, with some exceptions such as participatory venues for stakeholders/the public. Each institution generates its own form of knowledge/information, but also relies on the knowledge production of its neighboring institution. Coordination between all institutions is essential, though there may be periods where one coordinates more with another, e.g., institutions 1 and 3 or 2 and 3.

Bangkok, Thailand: An example of effective urban groundwater governance

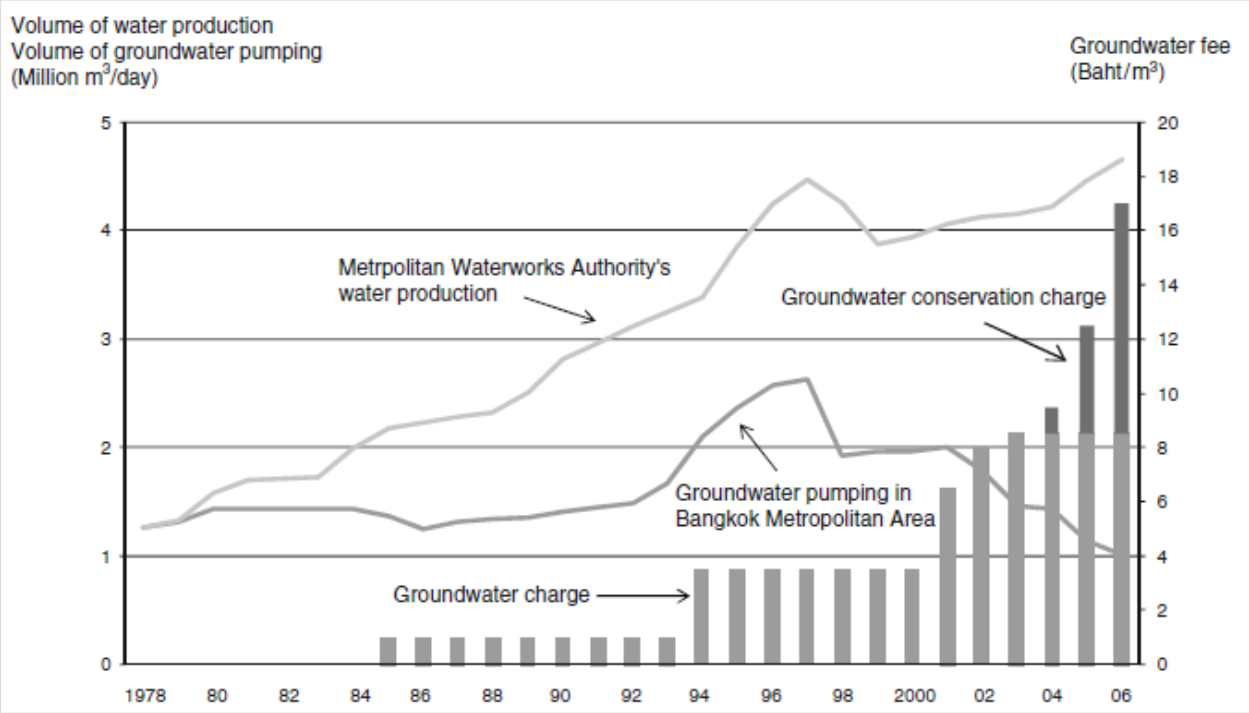
The most significant and dramatic change for Bangkok's water supply has been in the realm of groundwater use. Despite substantial groundwater resources, increasing extraction since the 1950's led to a negative mass balance for the aquifer, with pumping between 1970's and 2002 exceeding the estimated safe yield of 1.25 million m3/d (1250MLD) [11]. Consequences of this changed groundwater balance included dropping groundwater levels of as much as 40m in the mid-1990's, and land subsidence of 5-10cm/yr since 1978.

The problem was so acute, that it spurred a national government intervention in the form of a Cabinet resolution to reduce groundwater pumping in critical zones that ordered the water supplier, Metropolitan Water Authority, to stop using groundwater. Groundwater was established as a public good (Groundwater Act, 1977, revised 1992 and 2003), and landowners were required to get permission for drilling. Mandatory monitoring and reporting of groundwater extraction was enforced. A 3-tiered institutional structure for administration was put in place: - Minister of Environment, a Groundwater Board made up of multiple government agencies and industry, and the Department of Groundwater Resources was vested with the authority of permitting. In 1985, installation of well meters was enforced. In 1992, violations were made a criminal act. Permits were not renewed in critical zones. A groundwater conservation fund was set up, using a conservation tax as an instrument to study and research groundwater. Over time, groundwater use was made more expensive than surface water. To illustrate an example of coordination between different city agencies: Bangkok City Planning moved new industries to the suburbs. Since 2005, the public water supply, MWS does not supply groundwater. As MWA phased out groundwater supply, it also completed a new water source from the Mae Klong river in 2002. Although Bangkok's water challenges are not completely resolved, as a result of these policies and management actions, in several parts of Bangkok, groundwater levels are recovering.



Policy milestones and groundwater response in Bangkok: 1978-2013

As a result of policy changes and groundwater regulation, relocation of industries, and market based approaches (including imposition of preservation charges on private groundwater use), and the availability of a surface water substitute, groundwater levels have recovered in several parts of Bangkok. One of the highlights in Bangkok has been the longstanding monitoring of groundwater quantity and quality, with information going back to 1965, and a groundwater monitoring network of 60 observation wells in 1978 collecting information water levels



Bangkok's water supply portfolio (1978-2006), with evolution of groundwater fees. *Source: Fig 14.9, page 283 in "Sinking Cities and Governmental Action"*[17]

The case of Bangalore

Demand exceeds utility supply in Bangalore, India. Approximately half of Bangalore's water demand is estimated to be met through groundwater; its use is most common in the peripheries of the city, where the piped supply infrastructure is less developed than it is in the central district. This has afforded central areas more consistent access and enhanced quantity and quality, demonstrating the nature of its currently unequal supply. In the peripheral areas of the city, conservative estimates place the extraction rate of groundwater at almost 2.7 times greater than the rate of recharge [12]. One of the most salient aspects of this issue is a lack of systematically collected data accounting for the number of private wells, aquifer characteristics, and, perhaps most importantly, the precise total water demand of the city's inhabitants [4]. Groundwater extraction has been facilitated by easily adoptable and unregulated bore-well technologies; its governance has become important as people have increasingly turned to groundwater as a cleaner, cheaper, and more abundant source of freshwater. Box 2 summarizes key groundwater policies in Bangalore, noting some of their shortcomings.

The Bangkok case study illuminates several key pointers for urban governance in Bangalore (and urban India in general). In Bangkok, when the crisis caught national attention,

- there was enough data available to identify critical zones, and
- political will at the national level to implement legislation, and
- administrative capacity locally to enforce it

In India however, there exists a coarse network of groundwater monitoring across the country, of approximately 1 well per 200 km^2, where the Central Ground Water Board (CGWB) monitors groundwater levels four times annually in January, April/Map, August, November. Monitoring density does vary spatially from around 1/ 80km^2 to 1/500km^2. Sparse monitoring can only lead to coarse groundwater assessments; this resolution of monitoring is vastly insufficient for densely populated, complex Indian cityscapes. In Bangalore, across some 700 to 800 km^2, there are only a handful of long-term continuous groundwater monitoring stations. A comprehensive, fine resolution groundwater map does not exist.

In order to fill this gap, the Bangalore Urban Metabolism Project (BUMP, http://bangalore.urbanmetabolism.asia/) has been measuring groundwater levels in 150 locations on a monthly basis since December 2015. As of July 2015, approximately 2000 measurements have been taken[3]. The figures below show the value of this kind of information. Based on these measurements, interpolated groundwater levels in December 2015 and April 2016 are shown on page 9. These show the drawdown (fall) of water levels through the dry period, and also show that overall, outer periphery areas which have experienced the largest population growth, are also where groundwater levels are lower, and where drawdown is higher.

This kind of information lays the foundation for scientific, quantitative groundwater assessment, *without which the legitimacy of governance rule-making and management action is severely compromised*.

[3] Bangalore Urban Metabolism Project, 2017. URL: http://bangalore.urbanmetabolism.asia/2016/10/28/groundwater-measurements-ongoing-video/

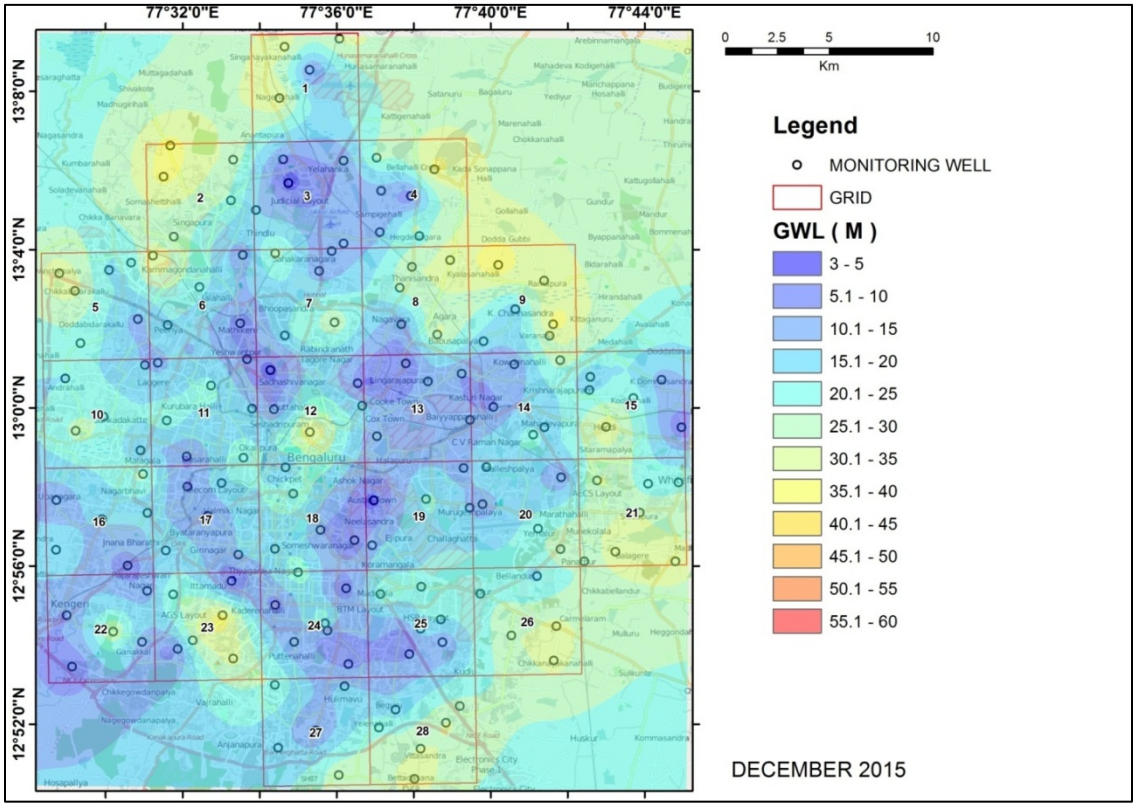
Box 2 Groundwater Policy Reforms in Bangalore, India

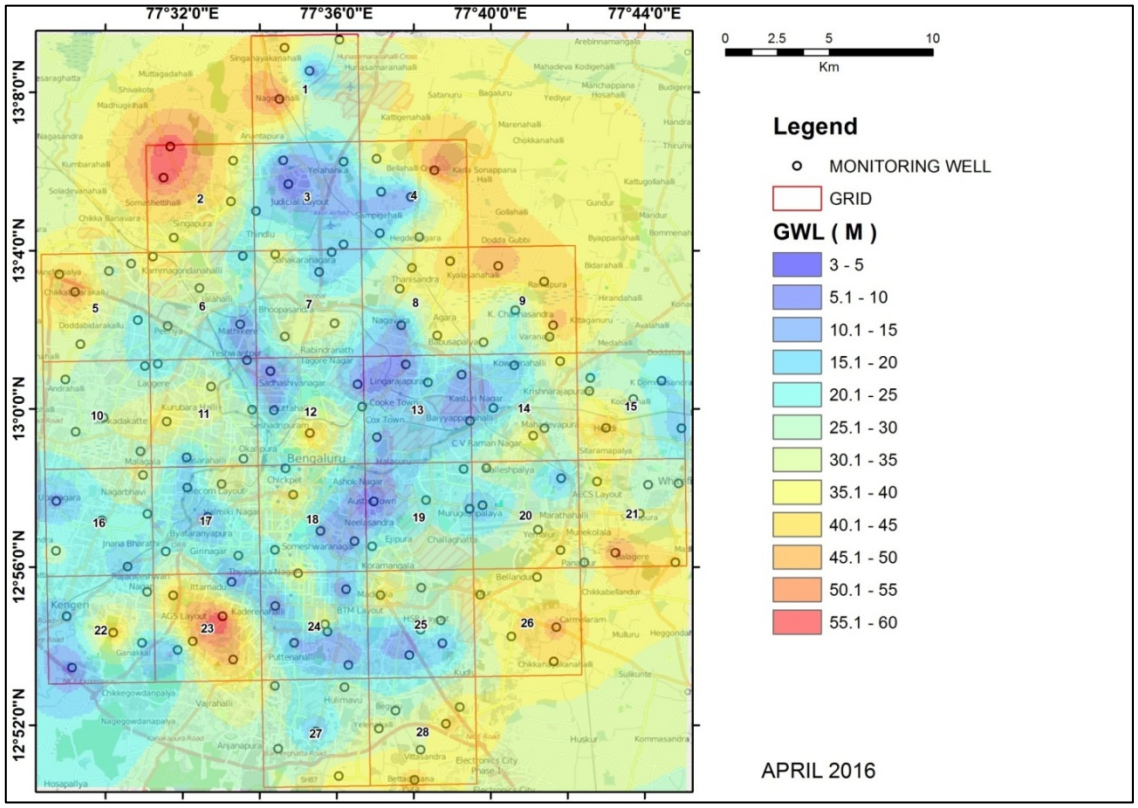
Karnataka Groundwater (Regulation for Protection of Drinking Water) Act, 1999 [19]:

- Mandates sufficient well spacing in order to protect public sources of drinking water.
    - Prohibits the extraction of water within a distance of 500 meters from a public drinking water source without obtaining permission from the appropriate authority.
- In times of water scarcity, the appropriate authority may declare an area to be a water scarce area for a duration specified by the order, but not exceeding one year at a time. Declaring an area as water scarce allows the appropriate authority to prohibit the extraction of water for any purpose when the extraction (well) is within 500 meters of the public drinking water source.
- The appropriate authority may declare a watershed as over exploited. This allows the appropriate authority to prohibit the sinking of wells in over exploited watersheds.
- If the appropriate authority determines that any existing well in an over exploited watershed is harming a public drinking water source, it may prohibit the extraction of water from such a well during the period from February through July of every year.
- The issue with this law is that historically there has been little to no evidence of enforcement. There were no offenders booked under this law as of 2013, and from its inception until 2009, there were no application for permits under the law nor any fines or penalties imposed in Bangalore [9].

Karnataka Ground Water (Regulations and Control of Development and Management) Act, 2011:

- The Act regulates groundwater access in an attempt to control groundwater exploitation through a permit based system. There have been three aspects to this system [9]:
    a. Well owners were required to register their wells before March 2013;
    b. Drilling companies were required to register themselves and their machinery prior to June, 2013;
    c. Anyone attempting to dig or drill a new borewell was required to obtain prior permission [9].
- Implementation and enforcement authority was vested with the Bangalore Water Supply and Sewerage Board (BWSSB) although it was initially supposed to have been vested in Bangalore's State Department of Mines and Geology. BWSSB has limited experience and capacity to deal with groundwater management [9].
- The 2011 Act only applies to new wells, and it does not apply to the deepening of existing wells, a widespread practice [9].
- An indirect objective of the Act is to collect data on groundwater conditions, existing structures, and resource use [9].
- The first objective of the Act, which required a comprehensive registration of wells by March, 2013, has been extended 3 times, and of the estimated 175,000 connections (and 500,000 wells) only some 66,000 well-owners have registered as of December 2013 [9,21].
- It is not apparent that sanctions, including fixed fines were significant enough for deterrence nor whether they have been adjusted for inflation. Additional electricity sanctions are outside the mandate of the BWSSB and thus non-enforceable [9].
- An indirect objective of the Act, collecting data about groundwater conditions and resource use, has been unsuccessful due to discrepancies in procedural provisions and a lack of institutional capacity [9].





Interpolated groundwater levels, based on point measurements, show the summer drawdown of the water table

Conclusions

In this paper, we have described the role of information in governance and management, with a focus on urban groundwater in India. Four key insights are consequently emphasized:

1. Yes, information supports legitimacy. However, the kind of information we have talked about here is not enough. On the biophysical side, we still need to know much more about the hydrogeology e.g. aquifer mapping at neighborhood to ward scale; and we also need to know much more about the demand side. Recent efforts like Urban Waters on participatory aquifer mapping[4], and a comprehensive water demand survey we are currently analyzing shine a light on the kinds of information that need to be generated.

2. The governance framework in Figure 1 points to the fact that data alone, without a strong institutional mechanism for embedding it within science-policy interfacing, will be meaningless. Data alone is not enough to inform evidence-based policy making. One example is the Public Interest in Energy Research (PIER) program in California. A small tax on the energy bill funded this program for several years. It helped the (virtual) California Climate Change Centre produce peer-reviewed research on climate change science, impacts on many sectors and adaptation strategies. Funds were allocated on a competitive basis to all research firms - academia, consulting and non-profits alike. Scientific rigor was maintained through the peer-review process and results were published in journals like Climatic Change. The outputs of the PIER program continue to play a major role in shaping California's forward thinking and proactive climate policies.

3. Participatory approaches are possible and necessary at almost every stage depicted in Figure 1. The examples of groundwater level mapping and aquifer mapping show how biophysical information at local level can be generated in a participatory manner. Similarly, participatory water budgeting and management actions at local level have been advocated. And empirical evidence suggests that participatory (financial) budgeting is also possible [13]. Participatory budgeting is a way for stakeholders from different socioeconomic backgrounds to interact together and decide how to equitably distribute resources and generate fees for enhanced capacity [13]. Equitable fees serve two interrelated long term goals: (i) they limit water use by those able to afford the fees; and (ii) they generate revenue for enforcing regulations necessary to limit the water use of those unable to afford such fees. They also generate revenue for creating new management institutions or sustaining existent ones, and solving knowledge gaps. Decentralized participation, in particular, has been demonstrated to increase equitable investment in poorer communities[13]. Stakeholder diversity and inclusive participation are key components because it is the interaction between people from different socio-economic backgrounds which actually facilitates equitable decisions. Within existing institutions, capacity can be built by dispersing work amongst institutions of

[4] Urban Waters 2017: URL: http://bengaluru.urbanwaters.in/participatory-aquifer-mapping-catalysing-a-social-response-to-manage-groundwater-494

like kind and by creating public value by increased stakeholder engagement.

4. Legitimacy needs the provision of adequate service levels. An example demonstrates this. Accounts from inhabitants of the peripheries of Bangalore explain that they didn't understand why they should comply with the first stipulation of the 2011 Act, which requires well registration, when their well had already gone dry [14]. Management agencies are in a good position to collect these types of ethnographic information. It is hard to imagine that groundwater pumping can be constrained without a substitute source made available, as we saw in the case of Bangkok. Smart (read common-sense) choices like conservation, lake rehabilitation, rainwater harvesting, reuse and recycling of treated waste water will be necessary, but may not be enough if the city keeps growing at its current pace. Looking to additional water from the Cauvery or diverting other rivers are both extremely difficult choices to consider. Land-use control – the elephant in the room - then becomes center stage. Bangalore may well become the poster child for the limits to growth in modern India. Will this happen through deliberative planning, or through business-as-usual stumbling along?

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