"Water When You Need It" – Examining Water Service Delivery With an Urban Planning Perspective

By

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Abstract

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Over 1 billion people in developing countries have no access to safe drinking water, and many more have only intermittent access. Approximately 97 million of the two billion live in India[1], which is also the world's second most populous country. With its increasing urban share of the population, just over 70 percent of Indian urban households obtain water through piped access (via individual or communal taps).[2] Piped access however does not assure reliable water; most piped water service is intermittent, or the water pressure is irregular, or the water is of questionable quality.[2] Using India as a case, this paper examines water service delivery in developing regions as a "wicked planning problem".[3] Addressing the problem is not necessarily a linear and a rational process rather it faces challenges related to unknown or inadequate information and the uncertainty associated with delivering water service at a rapid pace and on a large scale.

The approach toward delivering water service in the developed regions has been mostly technocratic with a focus on centralized piped systems providing continuous pressurized water through individual piped connections. Implementation of this approach today in the developing regions however faces the unique challenges associated with the large scale, rapid pace, and the heterogeneous form of urban development. This has serious temporal and financial implications. Using a representative case study of a growing city of Hubli-Dharwad in India, the study questions whether one type of water service achieved by one singular approach of a centralized piped system is the only way to deliver water in rapidly urbanizing and heterogeneous regions. The case study examines two water service delivery approaches at the local municipal level. With a broader perspective, this study finds approaches that can provide "water when you need it" by using different water sources; various physical modes of water service deliveries; and that are initiated and implemented through different institutional arrangements. Typically where large water service delivery is addressed as a technocratic problem with a physical lens, the planning perspective in this study extends to both the physical and nonphysical aspects. The study delves into how the broader approach can affect the planning and design of the outcome of a water

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[1] World Health Organization (WHO)/UNICEF, 2012, "Progress on Drinking Water and Sanitation 2012 Update."
[2] National Sample Survey Office (NSSO). 2013. Key Indicators of Drinking Water, Sanitation, Hygiene and Housing Condition in India. NSSO 69th Round July 2011- June 2012. Ministry of Statistics and Programme Implementation.
[3] Rittel and Webber, (1973), "Dilemmas in a General Theory of Planning* Policy Sciences 4 (1973), 155-169.

service and the approaches toward it. The study therefore has strong implications to large-scale water and other infrastructure provision in growing urban regions.

Dedicated to

Those who live without access to adequate water or other basic amenities

Acknowledgments

Oh, what a wicked planning problem this has been! I would not have been able to take on the challenge of pursuing the PhD path and this dissertation, if it were not for the invaluable support and wishes from many individuals.

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Table of Contents

Glossary and List of Acronyms

Terms/ Acronyms	Definitions
24/7 or 24/7 water service (Water When You Need It)	Water available 24 hours of water a day, 7 days a week in the quantity and quality and when needed for the purpose (Water When You Need It)
24/7 pressurized piped service or 24/7 pressurized piped water service	Water supplied continuously to deliver 24/7 water service through centralized infrastructure and pressurized pipes
ASCI	Administrative State College of India
BIS	Bureau of Indian Standards
Centre or Center	Central Government of India
CWC	Central Water Commission
Demonstration project (see also pilot project)	Project implemented to demonstrate that 24/7 pressurized piped water service can be achieved
Demonstration zone (pilot area)	Select portions of the city where the demonstration project is implemented.
Dwelling	Any type of housing (may include hutments, bungalows, apartment buildings)
GOI (see also Center or centre)	Government of India
GoK	Government of Karnataka
GSR	Gravity-fed Storage Reservoir
HDUDA	Hubli-Dharwad Urban Development Agency
HDMC	Hubli-Dharwad Municipal Corporation
Illegal housing or colonies	Housing or colonies built outside the legal boundaries
Informal settlements or development	Settlements or development outside the formal government system
IWRM	Integrated Water Resource Management
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
kl	Kiloliter
km	Kilometer
KUIDFC	Karnataka Urban Infrastructure Development Corporation
KUWASIP	Karnataka Urban Water Supply Improvement Project
KUWSDB	Karnataka Urban Water Supply & Drainage Board
KWB	Karnataka Water Board
LPCD	Liters Per Capita Per Day
Local provider or local water provider	Local municipality or utility that is the primary water service (mostly piped water) provider in a jurisdiction such as a city.
MoUD	Ministry of Urban Development
MWR	Ministry of Water Resources
MWRRA	Ministry of Water Resources Regulatory Authority
NRW	Non-Revenue Water
Pilot project	see demonstration project
Pilot area	see demonstration zone
Public Institution or entity	A government body
PPP	Public Private Partnership, which is a broad arrangement between public and private entities.
Private Institution or entity	A privately held business corporation that operates for profit
Provider	Actor or organization involved in the delivery of water to users.
PPP	Public-Private-Partnership. This dissertation uses a broadest interpretation of PPP as a contractual agreement between a public and a private organization where public or state organizations sign a contract or an agreement with one or more private organizations for building, operating,

Terms/ Acronyms	Definitions
	maintaining, or managing any particular aspect of infrastructure service delivery.
PSP	Private Sector Participation
Reservoir	Storage structure (earthen structure or concrete tank)
Rs.	Rupees (Indian currency)
Service	The service experienced by a user
Tenure (Census, 2011)	A housing unit is "owned" if the owner or co-owner lives in the unit, even if it is mortgaged or not fully paid for. A cooperative or condominium unit is "owned" only if the owner or co-owner lives in it. All other occupied units are classified as "rented," including units rented for cash rent and those occupied without payment of cash rent.
UAW	Unaccounted for Water
UDD	Urban Development Department
ULB	Urban Local Body
Unauthorized layouts	Parcels of land used for purposes or occupied with no authorization from the government. See also informal housing or colonies.
Unplanned developments	Development such as housing or other building structures that are not approved by a local government body or are approved but lack basic infrastructure services.
Urbanization	
Water delivery	The activity of delivering water from a water supply source to the user.
Water service	The service experienced/received by a user
Water service provider (see also provider)	A government body that is delivering or is responsible for delivering water to users.
Water transmission main pipeline	Large pipelines that are used to convey water from the natural source to a main reservoir, which then serves as the hydraulic source for a city's distribution network.
WHO	World Health Organisation

Chapter 1 Introduction

Without water there can be no existing, expanded, or new sustainable communities. Planners have a responsibility to help communities everywhere think about the supply and quality of water they will need, both now and in the future, and how best to meet those needs. Engineers design infrastructure that moves water from place to place or allows it to be reclaimed and reused. Planners help set the policies that determine how common water supplies are allocated; whether the flow of water to certain locations, at specific times, for particular uses, will be guaranteed; whether measures are imposed to conserve water; whether prohibitions are enforced to ensure appropriate water quality; and in some cases what the price of water will be.

- Page and Susskind, 2007, p.141-142

Despite Page and Susskind's exhortation, urban water service delivery is rarely addressed in the scholarly literature on urban planning. Various facets of urban water service delivery are independently researched within other fields: engineering focuses on the hydraulic design of water facilities and the treatment processes involved; environmental science looks at the natural and anthropogenic activities that affect water quality; public health targets the health impacts from lack of water access or poor water quality; economics considers the questions about pricing and finance; and political science focuses on the questions raised about organizational capacity to deliver water services in the political contexts and the implications of a public or a private entity delivering water. In the field of planning, however, urban water service delivery process remains a topic covered only rarely – for example, the Journal of the American Planning Association has published only four articles on water[4] in the past decade.

This dissertation contributes to the scholarly literature in planning by focusing on the water service delivery problem, showing how it relates to urban development processes, and examining ways forward. The dissertation also contributes to the study of urban water infrastructure by showing that physical infrastructure is insufficient to assure service, and must be coupled with effective institutional mechanisms, of which effective organizations and their management are a subset. This dissertation investigates water service delivery from an urban planning perspective. Planning brings the knowledge and insights of the different fields together and allows for the study to have a broad framework while considering an important public policy goal, that of delivering reliable water service.

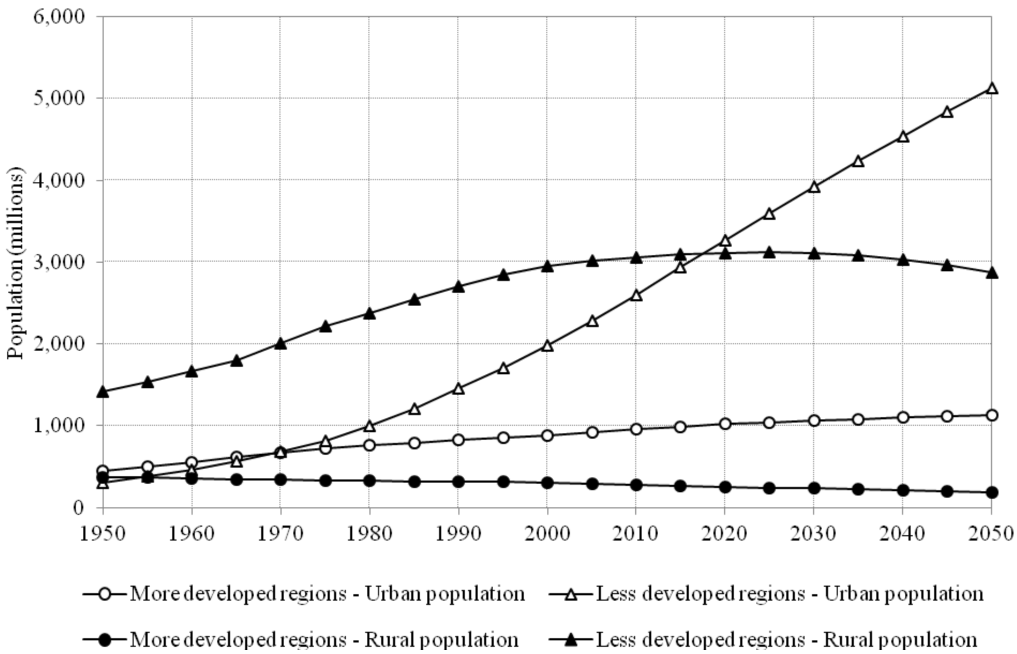
This chapter serves as an introduction to this new outlook by presenting an overview of the dissertation topic, outlining the research question and approach, the research methodology, and laying out a chapter-wise map of what the dissertation entails.

[4] A search with key words: "urban water service supply" and "water service supply" for a duration between 2004 and 2014 generated articles related to groundwater modeling, water use and urban heat island effect, and growth and water supply.

1.1 This Dissertation: A Brief Context and the Topic

Water is a human need, essential for life. However, millions still lack security with regard to this basic necessity in terms of water quantity, quality, and affordability. Water access is a problem worldwide, in wealthy countries as well as in less wealthy ones, and in cities and towns as well as in rural areas.[5] This dissertation focuses on delivering water in the burgeoning urban regions of the developing world. Urbanization is occurring rapidly in many less developed countries. It is expected that more than 50 percent of the world population will be urban by 2050, and that most future urban growth will occur in less developed countries (Figure 1-1; United Nations, 2012).

Figure 1-1 The Trend in Global Urban Growth

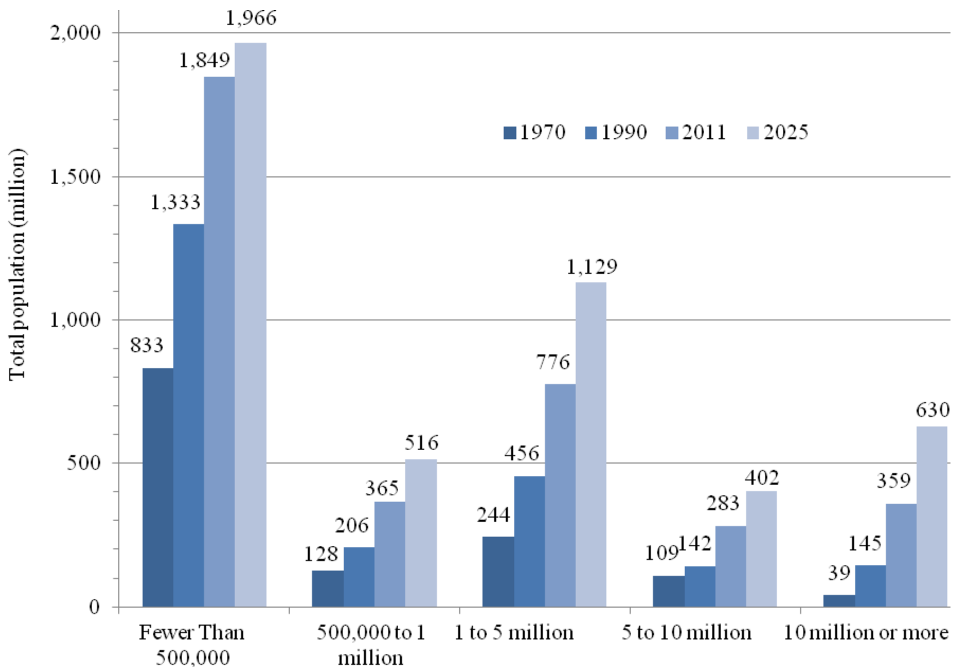


Source: United Nations, 2012

While megacities and regions[6] are a highly visible part of this phenomenon, much of the growth is occurring in relatively smaller cities and towns of population between 1 and 5 million (Figure 1-2). In the developing world, these small- and medium-sized cities often feature poor infrastructure in the form of unpaved roads, inadequate sanitation, poor telephone and internet connectivity, and unpredictable power supply, as well as low human resource capacity and limited financial resources. Water service, the focus of this dissertation, is often uncertain, and water delivery erratic in these cities.

[5] Wealthy countries such as the U.S. and the U.K., and less wealthy countries such as lower middle-income countries including India.
[6] Population of 20 million or more.

Figure 1-2 Total Population in Millions by City Size Class (1970, 1990, 2011, and 2025)



Source: United Nations, 2012

India is the locus of this work. India is the second most populous country in the world, with a 2011 population of 1.21 billion (Census of India, 2011). With a gross domestic product of ~$2 trillion, India is classified as a lower middle-income country by the World Bank (The World Bank, 2014)[7]. An annual growth rate recorded at 5.5% during 1981-2001 was followed by further acceleration in the GDP growth to 7.7% during 2001-2011 (HPEC, 2011). The economy has been undergoing rapid growth and along with it has come rapid and large-scale urbanization. Despite the growing economy, however, many Indians have not enjoyed a corresponding increase in the quality of life and infrastructure service. Water service is one of the several basic infrastructure services that is lacking or is inadequate, which is neither a new phenomenon nor a neglected one, yet remains looming at a massive scale.

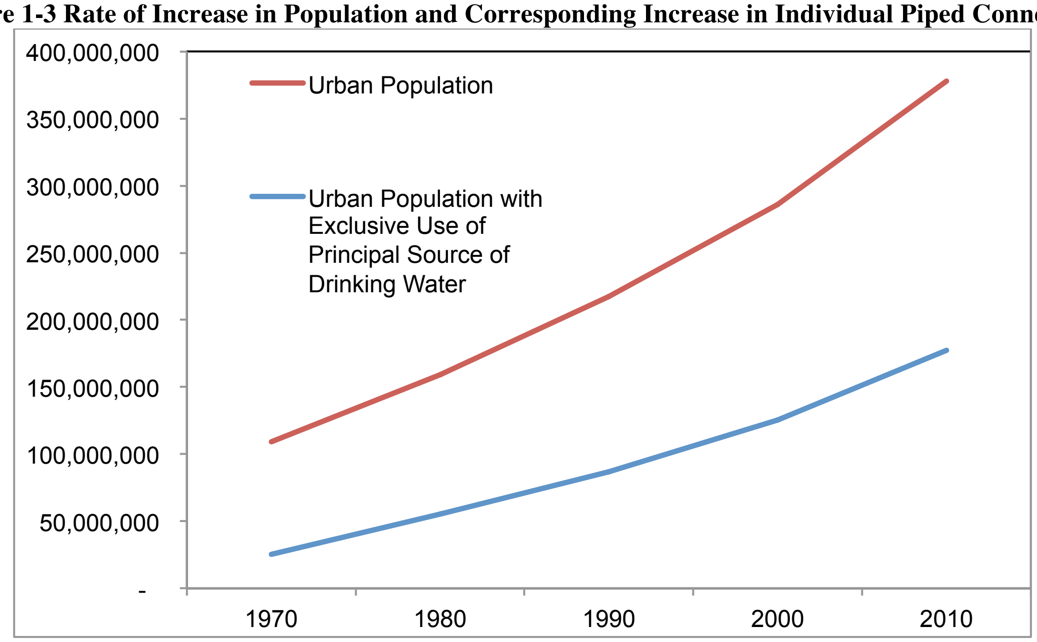
Post-independence in 1947, water supply was added to the Indian national agenda during the first five-year planning period (1951-1956), and investments have been made since then toward the water supply sector as part of subsequent five-year plans. There had been no water service standard or policy goal established for providing access to safe water as a basic urban service[8] until 2002, when the government accorded primacy to drinking water in the National Water Policy (GOI, 2002). However, it was as recent as March 2012 that the Centre for the first time recognized 24 hours of continuous piped access to drinking water, 7 days a week (24/7 service) as a "service level benchmark" with 100 percent coverage (GOI, 2012b).

[7] The World Bank lists India's 2013 population at 1.252 billion (The World Bank, 2014).

[8] Although the Constitution of India does not explicitly mention water as a human right, Article 21 entitled *protection of life and personal liberty* states that, "no person shall be deprived of his life or personal liberty except according to procedure established by law". The Supreme Court has expanded this notion of 'right to life' substantially while deciding on various public interest litigations (Hoque, 2012, p.3).

The Government of India has established service level benchmarks of continuously supplying water to all of the population 24 hours a day, 7 days a week (24/7) using the physical delivery approach of centralized pressurized piped networks (GOI, 2012b). In the National Water Policy (MWR, 2012), the government further has signaled a preference for private sector involvement[9] as part of the institutional approach of water service delivery. Currently only over 50% of urban Indian households have piped water access "within their dwelling or yard or premises" and over 20% have access to a "public tap or stand pipe" (GOI, 2011). The piped systems have been originally designed to continuously deliver pressurized water, however these systems now carry water only up to a few hours every day.[10] Thus, most have only intermittent piped water service provided mostly by a local utility or municipality (HPEC, 2011). While the goal of supplying 24/7 pressurized piped water service seems enticing, the rate at which piped pressurized water is being extended to unserved areas and developments suggests that full implementation could take many decades (see Figure 1-3). The prescribed water service objective, while mimicking what is provided in more developed nations, has failed to sustain over time and is a long way from being implemented in all of Indian cities.

Figure 1-3 Rate of Increase in Population and Corresponding Increase in Individual Piped Connections



Note: The chart is based on best available data to show the correlation between the urban population and access to individualized piped water.
The blue line in the figure shows the total urban households that have access to individualized drinking water taps indicated in the Census as "exclusive use of principal source of drinking water".
Source: Compiled from Census data, Office of Registrar, NSSO Reports, 2010, 2012, 2014

The "prescribed solutions" (as I call them) of continuously supplying 24/7 pressurized piped service through centralized infrastructure and an expansion of private sector participation,

[9] Chapters 2 and 3 delve further into the involvement of the government (public) and private organizations in water service delivery.
[10] The reasons for the poor service may vary in different contexts from having natural water resource constraints, aging physical infrastructure with frequent breakdowns, to poor operation and maintenance due to institutional capacity limitation (GOI, 2002; MoUD, 2009).

indicate the government's approach to the water problem as a relatively linear engineering challenge, which they propose to overcome by installing new centralized pipeline networks that continuously supply water from distant surface water sources to users through individualized piped connections (GOI, 2012); and as a problem that is blocked principally by a lack of local capacity (HPEC, 2011), which they propose to overcome by engaging private enterprises (MWR, 2012). The prescribed solutions thus reflect a uniform, singular approach (one service of continuously pressurized piped water through individual connections, one physical delivery approach of centralized piped infrastructure and one water source, and one institutional approach of a particular public-private-partnership) to solve the water problem. This dissertation challenges a narrow perspective with a homogeneous policy intervention for urban water service delivery by the central government and argues instead for a broader, more context-specific approach.

I demonstrate that water service delivery is a planning problem and a far more complex problem at that – indeed, that there are multiple views of the problem – involving not only engineering and institutional capacity, but also politics, finance, social equity, organizational design, and more. This dissertation draws upon the theoretical insights that planning theory offers on complex, "wicked" problems whose very definition is contested (Rittel and Webber, 1973). Water service delivery, the dissertation argues, is such a problem – a "wicked" planning problem. I argue that instead of a uniform, singular approach to the water delivery problem, taking a broader approach to consider multiple ways, such as a more context-specific and community-responsive set of strategies and institutional mechanisms would provide all the users with water when they need it – an improvement over the current poor service – at a faster pace, and most likely be more cost effective. There are multiple options that can be used to address the problem and precedents that can be drawn upon to find ways forward. A case study of water service delivery in a local urban context provides evidence for the argument and illustrates the options. I use the case of a growing city (pop. 1 million). The case illustrates the challenges cities face in considering:

- What the water service objective is that is to be delivered;
- What and how technical solutions (physical infrastructure) can be used to physically deliver water and achieve the water service objective; and
- What and how institutional aspects (in terms of organizations and institutional mechanisms) can achieve the water service objective.

1.2 Research Approach

The slew of different fields of research that tackle water service delivery manifest different views of the problem. Many recommendations have been put forward by the various experts, yet the problem of poor water service still persists, and on a large scale. This study examines urban water service delivery through a planning lens first, by engaging planning theory concepts to enable a deeper look at the water service delivery process and second, by proposing a new way to approach the problem by recognizing and responding to the challenges which form barriers to efficient and equitable water service delivery. The approach not only acknowledges but directly deals with the challenges in the entire delivery process, expands the considerations to what water service means, and leads to an outlook that can systematically address the challenges to deliver the service and maintain the service over time as the urban growth occurs.

The water service delivery process involves different institutions and their arrangements. The organizations related to water service studied here are the water service providers such as the local municipal corporation and its public works department or water utilities, and water / municipal boards as well as local urban development and permitting departments that approve new developments. Water resource agencies[11] are key to the identification and development of water sources, but are only considered tangentially in this study, which focuses on getting the extracted water to the user. Going beyond such organizations, the dissertation finds the linkages – or their lack thereof – between water service providers and urban development departments (public organizations and private developers) at the local level. This is an important institutional linkage but is rarely examined and dealt with in the water infrastructure service delivery and planning process. Spatial distribution and the location of users affect delivery of water because the physical infrastructure systems are built to target a specific spatial user configuration. However, if the growing urban demand is located such that it makes water service delivery both time consuming and costly and the resulting service poor, there is a disconnect between urban development and water service provision. I see this disconnect as both a cause and a result of the lack of a cognizance of the complexities on the ground and the limited flow of this understanding toward planning and policymaking.

1.2.1 Research Question

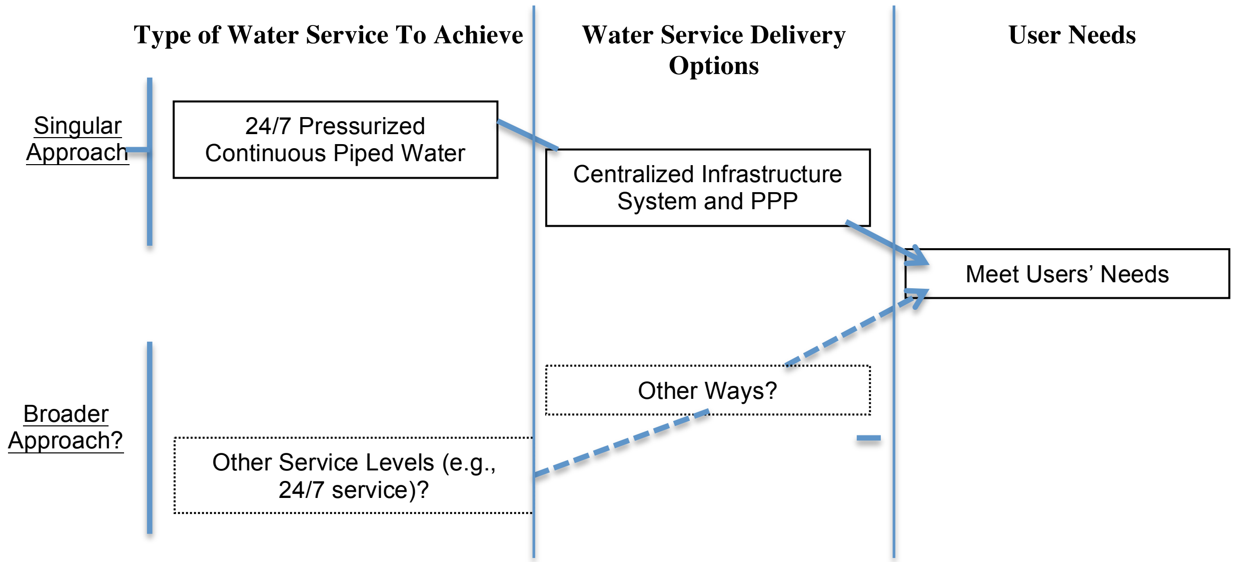
I frame the problem of water service delivery as a "wicked problem" – a concept introduced by Rittel and Webber (1973) to describe problems that are contested, open-ended, dynamic, and linked to other problems in complex ways. Recognizing the water service delivery problem as a "wicked" planning problem allows me to directly confront the multitudes of physical and institutional challenges and their interlinkages in water service delivery, and to acknowledge that there is not likely to be a single, permanent answer to the problem, which are not explicitly addressed in the literature.

I hypothesize that a broader perspective can lead us to other ways that can provide service levels that meet users' needs and offer physical delivery approaches that are faster and likely cheaper and institutional approaches that can ensure service delivery now, and over time (Figure 1-4). Figure 1-4 below shows how 24/7 pressurized piped water is only one type of water service delivered by one physical delivery approach (supplying water continuously through a centralized distribution system) through only one institutional approach (public-private-partnership or PPP). There could be other models of water service and its delivery that can meet users' needs. For example, clean water could be provided reliably to more people in a shorter time frame by using a combination of systems such as the local municipality recruiting local water vendors in delivering clean water or making treatment technology options available at point of use (e.g., water filters). Institutional mechanisms such as monitoring and enforcement can ensure that reliable water service is indeed delivered. Providing access to adequate supplies of clean water to all more quickly will have health and welfare benefits (Fewtrell et al., 2007). It may be that over time it would be practicable to replace vendor systems with piped in-house tap systems, hence these other mechanisms may also be considered transitional strategies. These mechanisms can fit

[11] I use the term water resource agencies for organizations that are directly involved in governing or allocating natural water resource quantity and quality and remain typically at a distance from the urban user.

to the local context rather than uniform centralized piped connections to existing individual houses, and planning for them as such can also empower and build up local governments to have a better ability to address challenges including equity than a single solution.

Figure 1-4 Approaches to Deliver Water Service to Meet Users' Needs



In approaching water service delivery as a wicked planning problem, I use the very essence of its complexities and interlinkages with broad planning considerations below:

- "Water When You Need It" as a Service Objective: I define the water service objective not in terms of the technology used but with a focus on meeting users' needs – "water when you need it". Rather than presuming one particular physical delivery approach that defines the service, providing water when it is needed means delivering water to the user such that the user has water available in the quantity and quality when needed for the purpose of use, regardless of the delivery mechanism.

- Achieving the Service Objective For All Users, Now: It is important to achieve the service objective not just for a section of a population but all of the users; the focus here being current and future users – i.e., the scale of the growth in the urban population and its distribution. Here, the feasibility of achieving the service objective becomes important, emphasizing the time and cost components. I see these components as institutional aspects, where different institutional mechanisms can ensure that the service is delivered as intended while accounting for equity concerns (e.g., providing water at affordable rates).

- Ensuring Sustained Service: Delivering water means going beyond achieving the service objective now, to making sure that the water service is sustained for all users in the future. For example, for a water utility, this would require attention to the entire service area and to population growth and its distribution, with a focus on the institutional aspects and how they impact service delivery.

What plays a central role in these challenges is the *water service objective* that I call, "water when you need it". By defining the objective in this way, I show that having water when you need it does not require that water be supplied continuously and delivered through pressurized pipes provided by a central agency from a single source. Other mechanisms for delivery and for storage of water can and do offer a wider menu or options or alternatives. While pressurized pipes may be an appealing standard they are not the only way to have water when you need it, 24/7, i.e., 24/7 water service does not have to mean continuously supplied or 24/7 pressurized piped water.

1.2.2 Case Study

Given the contemporary nature of the topic, this dissertation uses a single, representative case study to execute an empirical enquiry and investigate the phenomenon of water service delivery in depth and within its real-life and relevant context of urbanization. The case study for this research is located in the twin cities of Hubli-Dharwad in southwest India where the government has executed a demonstration or a pilot project to implement 24/7 pressurized piped water service for 10% of the city population. The project has been in operation for more than five years and thus offers multiple years of operation to study.[12]

I selected Hubli-Dharwad as a case because it offers water service delivery conditions representative of the growing and urbanizing regions in India that demand infrastructure services. Hubli-Dharwad has a population of over 1 million (Census of India, 2012) and is the second largest urbanized center in the state of Karnataka with a governing area of 202 square kilometers. Cities of this size collectively account for over 50 percent of the estimated national capital expenditures (HPEC, 2011). As shown in Table 1-1, Hubli-Dharwad falls under the City Class 1C (population up to 1 million) and is approaching Class 1B (population between 1 and 5 million) that represent the urban areas that are experiencing the greatest growth and commanding the largest estimated capital expenditures for urban infrastructure services (HPEC, 2011).

Table 1-1 Capital Expenditure Estimates by City Size Class

<table>
<tr><th>City Size Class</th><th>Population Size</th><th>Total (Rs. Crore at 2009-2010 prices)</th><th colspan="2">Relative Share (%)</th><th>Population - 2031 Projected (Million)</th><th colspan="2">Relative Share (%)</th></tr>
<tr><td>IA</td><td>> 5 million</td><td>860,136</td><td colspan="2">27.8</td><td>127</td><td colspan="2">21.2</td></tr>
<tr><td>IB</td><td>1 to 5 million</td><td>690,463</td><td>22.3</td><td rowspan="2">50.8</td><td>128</td><td>21.4</td><td rowspan="2">50.2</td></tr>
<tr><td>IC</td><td>100,000 – 1,000,000</td><td>883,346</td><td>28.5</td><td>172</td><td>28.8</td></tr>
<tr><td>II</td><td>50,000 – 100,000</td><td>174,072</td><td colspan="2">5.6</td><td>53</td><td colspan="2">8.9</td></tr>
<tr><td>III</td><td>20,000 – 50,000</td><td>280,541</td><td colspan="2">9.1</td><td>67</td><td colspan="2">11.2</td></tr>
<tr><td>IV+</td><td><20,000</td><td>209,583</td><td colspan="2">6.8</td><td>51</td><td colspan="2">8.5</td></tr>
<tr><td>Total</td><td></td><td>3,098,141</td><td colspan="2">100.0</td><td>598</td><td colspan="2">100.0</td></tr>
</table>

Note: The shaded rows represent the cities with the largest share of population growth and estimated future capital infrastructure investments. Hubli-Dharwad falls in this category.
Rs. 1 crore = $ 0.16 million; Rs. 100,000 crore = $16.3 billion
Source: HPEC, 2011

[12] Although there are other such demonstration projects implemented or being implemented, the project in Hubli-Dharwad is the one that offers multiple years of experience of operating 24/7 pressurized piped service to study, which is not offered by other projects.

The case was selected based on a review of project characteristics in the context of urbanization and the institutional reforms in India; discussions with experts in the field; and preliminary site visits. I identified Hubli-Dharwad as a promising case study because it was the only one that offered me multiple years of operation of 24/7 pressurized piped water service to study where I could examine how the water service has been sustained over the few years that the pilot project has been operational and not just at one point of time. While the State government has implemented 24/7 pressurized piped water service in a portion of Hubli-Dharwad, the government does not deliver 24/7 pressurized piped water service to the remaining portions of the city; instead it makes use of different water delivery approaches – both physical and institutional – an evaluation of this variety of approaches forms a key part of this dissertation. Thus, the case offers at least two water service delivery processes; one of continuously supplying 24/7 pressurized piped water, and second of providing other types of (non-24/7 pressurized piped) water service in the same city. This research overlapped with ongoing studies by other researchers of users in the demonstration zones in Hubli-Dharwad (where the pilot project was implemented) and representative areas in the remaining portions of the cities. The studies (Kumpel and Nelson, 2013; Burt and Ray, 2014; Ercumen et al., 2014) involved "user side" research on the quality of the water supplied through the piped system and that received by the users, household water use practices, and correlating factors between water service and health. The studies complement this dissertation, which presents "water provider"[13]-side research and examination of institutions and the entire urban water delivery process.

1.3 Research Methods

This dissertation draws upon multiple sources of evidence, and uses convergence and triangulation of the data to develop findings. The study is a culmination of institutional, financial, and policy analyses through literature review; field observation; in-person semi-structured interviews; data analysis, and writing.

1.3.1 Literature Review

The study began with a review of available literature on 24/7 pressurized piped water service in the form of a service objective and included the practices used to deliver water and achieve that objective. I extended this research to the history on 24/7 pressurized piped water open to all geographic regions. Literature researched and reviewed included available technical reports, academic journals, and documents in India associated with the 24/7 pressurized piped water service.

Additional sources of information included available reports on the pilot projects in India, mainly prepared by the Administrative State College of India,[14] the World Bank, United Nations, UNICEF, World Health Organisation, and other local and international organizations; and documents prepared by the government agencies at the national, state, and local levels; in addition to peer-reviewed literature. Additional literature included government reports on

[13] In this case, public organizations such as municipalities involved as primary water providers in a city.
[14] Established in 1956, the College trains corporate managers, administrators, entrepreneurs and academicians; provides research and consultancy services; and offers over 200 training programs every year in management development (http://asci.org.in/Introducation.aspx).

projects funded under the Jawaharlal Nehru Urban Renewal Mission (JNNURM), the 2012-2017 Five-Year Plan and the Working Group Reports on various urban governance and infrastructure investments, and organizational set up based on responsibilities related to water provision, water supply, and other infrastructure systems. The literature also covered the pilot project in Hubli-Dharwad and other cities in India centering around 24/7 pressurized piped water service, and operations of non-24/7 pressurized piped water service delivery.

I conducted archival search of newspaper articles on projects, infrastructure service delivery in the last 5-6 years for the most recent information related to 24/7 pressurized piped water service, broader water service delivery i.e., from the water supply source to delivering the service, and related to the larger urban infrastructure service delivery process and implementation in India. I also reviewed documents available at public agency offices and related to private sector operations. The literature review expanded into areas of different water delivery mechanisms including centralized and decentralized modes and various institutional approaches involving different combinations of public and private organizations.

In terms of the current institutional reforms and urban water service practices, I closely reviewed all the available information on demonstration projects in India implemented by the government including domestic and international databases, reports, and documents. Due to ongoing changes in the status and new projects and cities included in the list for pilot projects, I had to continually check candidate websites and databases and newspapers for new updates. I reviewed, where available, the descriptive characteristics of the projects such as their location, their coverage in terms of city size or population size, the organizations that implemented them, and the duration of project implementation.

I assessed any available costs, time duration, performance indicators and standards for delivering water and studied the role of the different organizations such as the State government, local municipal corporations, vendors, or the community and institutional mechanisms that affect the operation and delivery of the water service. I reviewed policies and the structure and goals of organizations making the policies, along with governance-related documents on water provision and urban development.

Further research involved identifying and documenting the operations and management practices that are needed to keep the water systems running effectively and to provide and maintain the water service. I conducted research and review of central, state, regional, and local organizations' policies related to water supply, natural water resource management, water service, and urban planning and development. Based on the information gathered, I interviewed individuals working in or who have worked in urban development and water and other infrastructure services, discussed further below.

1.3.2 Field Visits and Interviews

In addition to literature review, this research is based on fieldwork and interviews. I traveled to India, both to do field work and interviews in the case study city and other cities, and to participate in other key meetings on water service delivery. I made two trips to Hubli-Dharwad for conducting interviews and participant observation related to the existing mechanisms of water delivery. I identified individuals to interview based on the information gathered from the literature review, my personal and electronic information networks in India, and a snowball technique.

With the deductive nature of the method, visiting India and interviewing water engineers, planners, and other experts triangulated and built on the information obtained from my literature review. The information gathered included the challenges associated with centralized physical infrastructure and other delivery mechanisms and their performance in terms of variables such as time and budget (planned versus spent); the area or number of users covered; and the extent to which the delivery mechanism can be replicated in other locations or expanded to an entire city. As part of this process, I studied the role of the institutions involved, for example, the nature of the institution (public, private, or other); the responsibilities and costs shared for example between a private contractor and the municipal corporation for the water service they provide). This work also included conducting interviews and collecting data on how the water is physically delivered and what institutional mechanisms are used by the local water providers in the process.

I conducted structured and non-structured in-person interviews, and telephonic interviews as necessary, with 35 individuals who included local, state, regional staff, engineers who were/are involved in water service delivery or any parts of water delivery – water allocation, operation and maintenance of physical infrastructure, experts and practitioners in the field of water service and institutions (30), including broader infrastructure service, planning and policy, and urban development and policy (5). My interview guide is provided in Appendix A. In Hubli-Dharwad, I conducted structured and non-structured interviews with staff and officers at Hubli-Dharwad Municipal Corporation (HDMC), Hubli-Dharwad Urban Development Agency (HDUDA), Karnataka Urban Water Supply & Drainage Board (KUWSDB), Karnataka Water Board (or KWB, a sub-unit of KUWSDB created to operate local water service delivery in Hubli-Dharwad), and Karnataka Urban Infrastructure Development Corporation (KUIDFC). Interviewees included the Executive Engineer and Financial Comptroller at HDMC, the Assistant Executive Engineers at the Central Zone of HDMC in Hubli (currently operated by KWB), former and current employees at Veolia, Inc. including its local operations manager in Hubli-Dharwad.

I participated in events such the Indian Water Works Association annual conference in 2012 and (as a discussant at) the Regional Workshop on Resource and Energy Efficiency in 2013. The workshop was supported by the Urban Development Department and Directorate of Municipal Administration, and Government of Goa as the local partner state. The workshop was a part of various activities supported by the JNNURM - Comprehensive Capacity Building Programme, Ministry of Urban Development, and Government of India. From contacts made during these events, I identified additional persons to interview.

While in Hubli-Dharwad, I carried out field observations of user conditions in terms of dwellings; general land use; the urban development context and landscape; transportation and roadway conditions; within and outside the demonstration zones or pilot areas.

I also conducted interviews outside Hubli-Dharwad to understand the urban water service delivery process undertaken by other organizations such as Brihanmumbai Municipal Corporation (BMC- Engineering and Planning Divisions), Pimpri-Chinchwad Municipal

Corporation (PMC), along with state level organizations such as Maharashtra Jeevan Pradhikaran and the Maharashtra Water Resources Regulatory Authority (MWRRA) – the only water regulatory authority in India. Independent and academic experts in water provision were also interviewed at State Irrigation Department; Indian Institute of Technology, and non-government organizations. Through these interviews, I gathered information on the challenges in implementing different water service delivery mechanisms and how the challenges were addressed and by whom.

1.4 What This Dissertation Does Not Include

This research focuses on the problem of delivering water to India's urban metropolises, which include the already built up areas as well as the rapidly expanding urban peripheries. Some important aspects of, and related to, water service delivery are acknowledged here as important but are not discussed in this dissertation.

First, the water service problem is not just an urban problem but occurs in rural areas as well, not just in India but worldwide. India in particular faces severe problems with water service and water quality in its rural areas, but the examination of these problems is beyond the scope of this study. Likewise India and indeed much of the world faces a major crisis in water supply source, one that may exacerbate with climate change. In India, a limited or even shrinking supply of water, burdened in many areas by severe pollution, means that securing water supply and treating it sufficiently to make it suitable for consumption is an issue that must be given serious attention. While these issues are acknowledged, addressing them is beyond the scope of the dissertation,[15] which focuses on the urban service delivery portion of the water supply chain.

Third, within the urban realm, this study is focused on domestic users i.e., urban households. The study acknowledges that urban users also involve business, commercial, industrial and other users, which are mentioned where applicable but do not form the subject of this study.

Fourth, in focusing on delivery of water, the dissertation includes the water needs of users as a factor in the water service delivery process. Considerable research is currently ongoing or recently complete (Kumpel and Nelson, 2013; Burt and Ray, 2014; Ercumen et al., 2014) such as water service received by individual households, their willingness-to-pay and costs related to the water service, or how it affects health. This dissertation does not focus on such specific user conditions, rather draws upon this work to the extent that they affect or play a part in the water delivery strategies.

Lastly, it is widely acknowledged that water supply and wastewater treatment and disposal or water recycling are intertwined problems, but this dissertation focuses on the water side only and defers studies of wastewater and disposal issues to other research. Within the planning context, the water delivery problem is situated and is part of a larger context of different infrastructure services. This dissertation refers to the challenges associated with other infrastructure services but does not conduct a detailed study on them.

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[15] The water supply source issue is acknowledged and described more so to provide a context as a critical consideration in the urban water service delivery process.

1.5 Organization

This dissertation is organized into seven chapters as follows:

Chapter 1 introduces the topic of the dissertation and the research question, describes the research approach of using single case study analysis and methodology, and presents the organization of the work. The chapter sets up the central hypothesis of how water service can be delivered to all users in a city now and over time.

Chapter 2 provides an overview of urban water service delivery by presenting a topical background at a global level on what water service entails, its provision and maintenance, and the institutional debates on the topic. The chapter provides a context by discussing different water service situations and norms in different regions of the world.

Chapter 3 describes the current water service situation in India by examining what factors into the urban water delivery process. The chapter discusses the water supply and the water demand sides and the different variables on both the sides that affect water delivery such as water availability at the supply source and the rapid growth and the scale of the urban development with the heterogeneity of the demand. The chapter examines the physical infrastructure and the institutional aspects especially the policies and the "solutions" prescribed by the central government to address the poor water service situation. With the "singular" approach of one service (continuously pressurized piped water service) through one physical delivery approach (centralized piped infrastructure) and one institutional approach (expanding the role of private corporations) at the central level, the chapter presents a description of how the local municipalities deliver water service at the local level, and that they have a long way to go to achieve the prescribed water service objective. The chapter brings out the complexities and interconnectedness of the different aspects of urban water service delivery and highlights the difference between the central-level policies versus the local-level implementation of those policies.

Chapter 4 critically assesses the problem of urban water service delivery in India. In this chapter, I argue that the water service delivery problem has been misdiagnosed by the government and that the problem is a planning problem, specifically a "wicked planning problem" (Rittel and Webber, 1973). The chapter reviews approaches and strategies that could address a wicked planning problem. In practice, the chapter calls out the oversimplification represented by the prescribed solutions set forth by national policymakers and presumed approaches to address the problem of water service delivery. This chapter also proposes a rediagnosing of the problem so that it can be addressed more robustly once it is recognized as a wicked planning problem. Framing the problem as achieving the water service objective of "water when you need it" opens a broader perspective leading to a wider range of possibilities for resolving the problem. This framework is carried forward and shapes the analysis in the subsequent chapters.

Chapter 5 provides the case study for the dissertation; it studies whether a broader perspective leads to different ways of providing reliable water and investigates two water delivery processes ongoing in the twin-cities of Hubli-Dharwad in India. The chapter describes the changes that occurred in the State of Karnataka in the context of the urban water reforms and government interventions to improve water service. I find that besides the singular approach practiced in the demonstration zones in the city, a "hybrid approach" – as I call it – is in play in the remaining portions of the city that covers a majority of the population.

The case study showcases how the roles of a government body and a private company complement each other and can improve water service. It is the mechanisms in the form of different layers, features, and practices that can be used as a collection of tools to ensure water service delivery rather than zeroing largely on the entities being public and private to ensure water service delivery. The discussion shows how the range of tools available to government and in PPPs facilitates the current hybrid approach for water delivery in reaching a large section of the population and reaches more people faster than an approach that concentrates only on a certain type of delivery approach.

Chapter 6 recognizes water service delivery as a wicked planning problem and asserts the findings from Chapter 5 that a broader approach with considerations to scale, time, and budget does open up new ways of delivering water. The hybrid approach discussed in Chapter 5 uses different water supply sources, physical facilities and processes, and institutional mechanisms, which are seldom recognized as important components but offer powerful tools to plan and design drastic improvements in the water service, *now*. In this chapter, I argue that an improved version or an "enhanced hybrid approach" made up of a combination of water sources, technical solutions, and institutional aspects opens up the possibility of planning for and delivering improved water service to all, faster and considers costs as a factor. The chapter provides a discussion of the water service objective "water when you need it", which can be achieved by the enhanced hybrid approach. I find that the users and the user conditions otherwise considered passive receivers of water service can be actively involved in the design of a more effective water delivery process. The approach also accounts for the demographics as in low-income and higher-income population as well as informal and formal development and importantly, the temporal factor of delivering water now and in the future. The chapter identifies a need for a conducive environment for the enhanced hybrid approach; one way to create it would be have strong policy impetus (that is currently enjoyed by the singular approach) with financial and political support for broader set of considerations that could be adapted to the local context faster (such as the enhanced hybrid approach). The impetus can provide parallel focus and dedicate resources to the enhanced hybrid approach similar to the singular approach.

Chapter 7 is the concluding chapter of the dissertation. It summarizes the main contributions of the previous chapters, i.e., the redefinition of the water service delivery problem as a wicked planning problem and taking a broader approach to open up to multiple ways of water delivery such as the enhanced hybrid approach consisting of a combination of diverse technical or physical solutions and institutional tools. The chapter provides pointers for future research that has significant planning and policy implications for rapidly urbanizing regions of the world, particularly in the emerging economies. It identifies a key research question raised by the findings: How to incorporate sensitivity to the local context into the national governmental planning and policy design.

Chapter 2 Urban Water Service and Delivering It: Background

This background chapter on urban water service delivery first describes the water service experienced by urban users across different regions and then describes the delivery of the water service. As part of the delivery process, the chapter discusses how water is commonly delivered using physical infrastructure facilities (i.e., the physical delivery process) and describes who is typically involved in water delivery focusing on institutional arrangements in water delivery, particularly between public and private organizations (i.e., the institutional aspects). The chapter finally describes water service goals in the form of some water service standards that show large variability in the perspectives internationally of what water service should be.

The intent of the chapter is not to provide a comprehensive review, rather it provides topical background on water service delivery. This chapter is developed based on a review of relevant literature spanning engineering, planning, political science, and public policy. The literature research for this chapter includes a recently available comprehensive review of urban water delivery in developing countries by Herrera and Post (2014), which in particular provides useful insights on institutional changes. The chapter is also based on information gathered from interviews with water service providers, practitioners, and experts and field observations. This chapter provides a brief overview of water supply and demand sides in terms of how they factor into the delivery process, but focuses mainly on the connection between the two sides that of delivering water from the supply source to the user.

2.1 Water Service

This section discusses water service as experienced by the users. Here, I examine service in terms of three physical dimensions: access, water availability, and water quality; and a fourth dimension: price. Service to a user is affected in all of these four dimensions.

2.1.1 Access

Historically, humans have obtained water by extracting it from lakes, rivers, creeks, and springs, by capturing and storing rain and snow melt, and by digging wells. Even today, accessing water directly at a natural water supply source is widely practiced by users (WHO&UNICEF, 2014). With modern technology and networked systems, tap water has now become a common access point for water to users around the world. In this case, access is in the form of individual piped water connection to a household. In some regions of the world, tap water may be available as a communal or public tap in a neighborhood of one or more apartment buildings that do not have individual connections. Users that do not have piped access or a natural water source near by, rely on facilities such as water tankers operated by the local municipality or private vendors. Many a times, users purchase water at retail stores in the form of bottled water or water cans. Table 2-1 summarizes the different water access points.

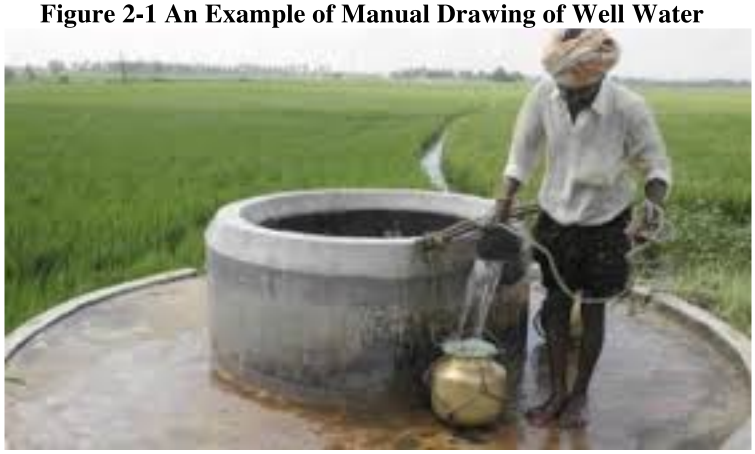
Table 2-1 Water Access Points For Users

Types of Access Points			
Natural Supply Source	Hydraulic Supply Source		Other Access Points
Water Supply Source	Water Tap	Tankers	Retail Stores
Examples or Types of the Aforementioned Access Points			
River, Stream, Lake, Well, etc.	• Individual Tap • Public Tap • Communal Hand Pump	Those operated by: • Local Municipality • Private Vendor	Purchase Bottled Water or Water Cans

2.1.2 Availability

Having a water access point does not mean water is readily available to the user. For example, in case of a groundwater well, water may be pumped and piped to the user(s), or a user may have to manually draw water from the well. . The water available to the user then would depend on the water table of the groundwater and the means of drawing it, for example the user has to rely upon an external source of power – mechanical, animal, or human. Figure 2-1 shows an example of water manually drawn from a well.

Figure 2-1 An Example of Manual Drawing of Well Water

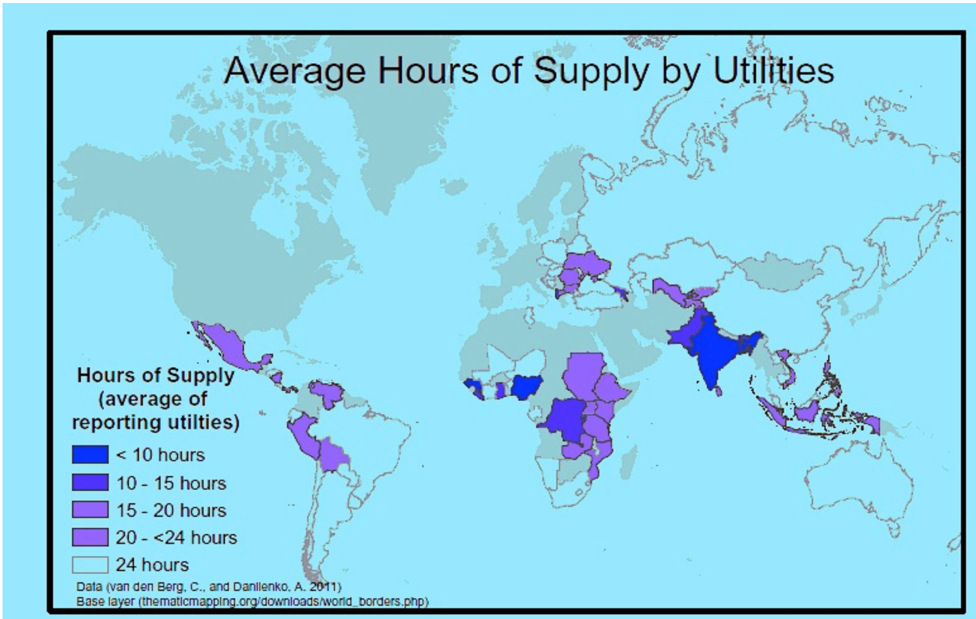


Source: Indiawaterportal.org

If a tanker delivers water, the availability of the water would depend on the quantity of the water transported by the tanker. It would also depend on the time when the tanker would deliver the water for the users. Thus, water availability is also a function of time and duration that water is available for.

In countries such as the U.S. and the U.K., drinking water is supplied on a continuous basis and is available through individual piped connections to each household. However, it is not the same in many other parts of the world. Even in the case of a piped connection that is intended to deliver water continuously to a household, water may be available only intermittently and on an arbitrary schedule if the supply is inadequate or if the infrastructure to deliver the water fails frequently. Figure 2-2 shows the average number of hours water is available daily in different countries indicating the widespread intermittency of piped water availability.

Figure 2-2 Average Hours of Water Service Reported in the International Benchmarking Network for Water and Sanitation



Data mapped by Kumpel E. from van den Berg and Danilenko, 2011. The map shows data for countries covered by the International Benchmarking Network for Water and Sanitation. Areas in grey were not included in the authors' dataset.

2.1.3 Water Quality

Having water available from a source or an access point does not mean it is available in the quality for which a user needs it. Water directly used from a stream may have high particulate matter or other pollutants, which may render it not fit to drink (although it still may be suitable for other uses such as house cleaning). Most centralized water systems rely on a series of steps to render raw water drinkable. These include protection of the water supply source from contamination, and treatment of water such as clarification to remove particles in the water (often through settlement or skimming), filtration to remove additional particles, and purification, often using chemical treatment such as chlorination (Frobisher, 1974). Unfortunately, these steps are not always taken or available or recontamination occurs during the delivery process, and as a result, water reaching the users may often be of uncertain quality. Dubious water quality is a problem worldwide and is a threat to public health (Fewtrell et al., 2007). Water quality varies widely for the different types of water access points and supply sources shown in Table 2-1.

2.1.4 Price

The fourth dimension of water service is price, which affects the type and quality of the water service a user experiences. In other words, if the price for the service is unaffordable by a user, the user may suffer from poor water service (i.e., remain without access and/or have poor water availability and/or water quality). Urban users typically pay a fee for piped water similar to many of the infrastructure services such as electricity, heating fuels, and telephone. However, low-income households with lower ability to pay may find the price unaffordable and face the possibility of service disconnection and thus loss of formal access.[16] In developed nations such as the U.S., access for low-income households is enabled through lifeline pricing policies that are often mandated by law (16 U.S. Code Section 2624). However, such policies or their enforcement do not exist in all places.

High, unaffordable tariffs can preclude a user with piped access from receiving reliable water availability and water quality. Price to the user then is not only in the form of a fee for the piped connection, but also in the form of mechanisms the user has to adopt to cope with the unreliable water service and the costs associated with the mechanism. If water is not available readily at the tap, users typically cope by storing water when it is available for use in times when it is not, or obtaining water from additional sources (e.g., buying bottled water or water from a private water tanker). If water available at the tap is not fit for consumption, users often cope by using home filtration systems and by boiling water used for drinking and cooking (Chatterji, 1997) or obtaining water from additional sources (e.g., buying bottled drinking water, which is extensively practiced even in developed countries). Through these coping mechanisms then, the users incur a price in addition to the tariff charged for the piped water service. However, such additional costs may not be affordable for all, thus precluding such households from the basic water service necessary.

2.2 Urban Water Service Delivery: The Physical Infrastructure

Water service for a user varies with the physical infrastructure used to deliver the water. In particular for an urban user, water service is a function (but not only) of piped infrastructure systems. This section discusses a common physical water delivery process, i.e., how piped water is delivered by a water provider, say a local utility or a municipality.

2.2.1 Centralized Piped Water Infrastructure

Systems for transporting water have been in place for thousands of years. Drains and pipes have been found that date to 3000 BC in Mesopotamia and ancient aqueducts still appear across the landscape in Rome (Nemet-Nejat K., 1998). Water has been hauled and transported in cans and wastewater disposed of in sluices and canals, and in pipes made of clay, stone, wood, bamboo, lead, copper, brass, iron, and plastic. As communities grew, networked systems became an efficient way of delivering water from distant water sources into cities to a large number of people. In recent times, centralized piped systems have become the most common facilities to distribute water from distant natural water sources to a large population, especially in the world's urbanized regions.

Today, water service delivery is viewed, mainly from an engineering perspective. A "world-class city standard" (The World Bank, 2005; Indian Express, 2012) that has been frequently cited by international financial organizations such as the World Bank and the Asian Development Bank

[16] Outside the formal domain, theft of services such as power and water is common in urban areas in developing regions especially in the informal settlements.

and in consulting reports by McKinsey Global Institute typically consists of centrally managed water extraction from a natural source, a storage and treatment system coupled with a piped network carrying pressurized water on a continuous basis to all users through individual connections. Such systems manifest the traditional engineering approach of delivering water practiced for years in certain contexts. The following discussion on the centralized infrastructure system focuses on the implications related to the treatment and transportation of bulk water and its distribution within a city.

Bulk Water Supply: Treatment and Transportation

Surface water bodies such as rivers are a common source for urban water supply where dams and reservoirs are built to store and then transport the water through bulk water pipelines (Figure 2-3) or aqueducts into a city.

Figure 2-3 Examples of Centralized Water Infrastructure Facilities

Hetch Hetchy Dam (Water Supply Source) Located ~182 miles from San Francisco

Source: San Francisco Public Utilities Commission, 2014

Los Angeles Aqueduct (Transporting Water) ~ 100 miles to Los Angeles

Source: Circleofblue.org

Such large facilities forming a part of essentially the same traditional approach have been common over the years in the western regions of the world, and now geographically shifting toward Asia and South America. Doyle and Havlick (2009) in their review of water infrastructure and its environmental effects report an accumulation of river infrastructure to staggering numbers and scales.

> *There are >48,000 large dams (>15 meters tall) worldwide, which are capable of retaining about 15% of the global water runoff, and perhaps as many as 800,000 known impoundments worldwide. In the United States, there are ~78,000 dams (>3 meters tall) and as many as 3 to 8 million detention reservoirs and small man-made impoundment ponds….Globally, the rate of dam construction has remained relatively constant, although dam construction has shifted from western Europe and North America toward Asia, and South America… Both dams and levees experienced a substantial construction boom in the twentieth century; the age of most dams in the world is now >35 years, and >85% of U.S. dams will be >50 years old by 2020. Because of their age, an estimated $36 billion is needed to bring U.S. dams into safe working conditions and to remove those no longer needed.*
>
> *- Doyle and Havlick, 2009, p.355*

In addition to safety and environmental implications it is costly (in terms of money, time, and human resource capacity) to construct and maintain the facilities, sufficiently.

Even if the facilities may be built with sophisticated technology, the surface water source itself such as a lake or a river may be at the mercy of natural changes such as precipitation and snowmelt. Besides a centralized fresh surface water source, there can be different water supply sources. For example, a nationwide water use report for the United States by the U.S. Geologic Survey documents both freshwater (surface and groundwater) and saline water for different uses of water, urban domestic use being one of them (Kenny et al., 2005). Changes in technology and economic conditions have affected industrial and thermoelectric power water uses and spurred interest in water reuse and reclamation. More recently, other supply sources are being harvested by state and local water providers in the U.S. and Europe such as treating sewage water to advanced levels and using it as recycled water for landscape irrigation or industrial use, which offsets municipal domestic water use.

Water drawn from the supply source is treated at a central facility (e.g., a water treatment plant) and transported to storage facilities that connect to the citywide piped distribution network. The centralized extraction and treatment is intended for water to be of the highest (drinking) quality for each user. In many centralized systems, water quality is (and is intended to be) uniform for all uses irrespective of the varying water quality needs for the varied uses of water within the households. For example, the water used to flush toilets or irrigate landscapes is the same as that used for drinking. The piped infrastructure overcomes the obstacle of distance between the source and the user, and can also reach a large number of users at the same time. However, whether the water drawn and transported into a city reaches the urban households as intended is also a function of the distribution system in the city.

Water Distribution System

A centralized distribution network delivers the bulk water transported into the city to urban households and other users through piped connections. A citywide distribution system includes storage, pumping, and other facilities and a mostly underground piped network through the city typically laid in grids or radial patterns along transportation corridors, roadways or major drainage channels. However, building of well-engineered facilities, even assuming adequate water supply – a questionable assumption in many countries, especially with climate change concerns – does not guarantee the delivery of clean or continuous water. Failures can occur because the infrastructure systems do not always function well. Problems with water quality can occur at several points, from contamination of the supply, to inadequate filtration or purification, to recontamination during transport due to the use of open aqueducts and reservoirs or leaking pipes or pumps. Pipe bursts or pump breakdowns can result in low or no water pressure. Oversubscription also can reduce water pressure and availability to individual users. Thus, an initially well-built infrastructure system can over time start failing to provide reliable water service if all elements of the delivery system are not given the necessary attention on a regular basis.

In addition, the piped service may not reach all users. In rapidly growing communities, the infrastructure system needs to expand rapidly to deliver service to meet the increasing demand as new developments are built as infill and added at the periphery. It becomes imperative to build (or rebuild) the infrastructure where the demand lies or is anticipated and to ensure that the infrastructure system is more dynamic than static in order to keep up with the changes in the demand.

When an urban distribution system is built in advance of significant urban development, the system may be up and operating for the users as they move in. As a result, there is minimal if any, community disruption. This is typical of what occurs in developed countries such as the U.S. (although rebuilding systems can require excavation of streets). However, the situation is far more complex if the users and the development are already present and the water infrastructure system is not, which is the case in large urban areas in the developing world. Further, if other basic services such as roadways and sewerage are nonexistent or poor, challenges in implementation become severe. Often times there is limited or no information on the location of existing utility lines, which may be ruptured during construction of new lines. At times there are no roads along which to lay the water pipelines. In such cases the construction or reconstruction of a pipeline system can be extremely costly, complex, and time-consuming as there can be challenges in obtaining the right-of-way for installation. The complications are exacerbated not only by the large scale of the existing urban development but also by the rapid pace at which growth and change occur.

For the many urban dwellers in developing countries with no access to safe drinking water, and the many more who have only intermittent access, getting pressurized piped water continuously at an individual household level (a norm in developed countries) may mean a long wait. Even in areas that have been served with pressurized piped water, problems are cropping up, as rapid urbanization is exceeding the capacities of the legacy piped network systems, and diminishing the functioning of such systems. If urban planning and water delivery processes are coordinated, infill development may be denied access to the system if there is no capacity remaining; if it is allowed, the overtaxed system may suffer from reduced water pressure. If demand exceeds the available water supply in the system, providers sometimes resort to delivering water for only few hours a day (water rationing), thus making the water service intermittent (Andey and Kelkar, 2009).

Once a water system is built, the provider has the responsibility of operating and maintaining the system and delivering the service in a sustained manner; this includes establishing and perpetuating the conditions that can keep the physical infrastructure functioning reliably. Ideally, that means the physical infrastructure needs to function with limited or no breakdowns (CalFed, 2003). In areas with a stable user base, operation and maintenance (O&M) are often based on a useful infrastructure life schedule. Under dynamic conditions, however, focusing only on O&M may not be effective. With a continually growing population and greater per capita demand, increasing development and redevelopment, and changing urban land uses, the physical demands on the infrastructure system increase and change with time. The infrastructure system may wear out or become undersized far faster than originally planned. A network also may be under-maintained, as available funds are directed toward other infrastructure services or focused on expansions to meet new demand; the deteriorating water lines may suffer from leaks and breaks, resulting in water losses and allowing contaminants to enter the pipes, affecting the quality of water reaching the users. Therefore there is a parallel need for increased monitoring and for dynamic, demand-responsive maintenance and upgrading activities, along with new investments.

A key issue in building and maintaining infrastructure systems is their costs in terms of money, time, and human resource capacity. A failure to invest in an adequate level for system monitoring, testing and preventive maintenance as well as repair and upgrades of the infrastructure is a major problem for many infrastructure systems (not just water-related systems) around the world. The costs may be private for the individual, as in the case of a household with a well, pump, storage tank, water treatment system, and septic system for handling wastewater, or costs may be incurred by the society as a whole, as is the case with water and sewer systems that are built and operated by government, where the costs may be paid for through general taxes. In smaller communal systems, the entire community may share the costs. For larger public systems in a city, the costs may be borne by some combination of general fund contributions, intergovernmental grants or funds transfers, and user fees or tariffs (Fox, 1994).

Regardless of how costs are allocated, the high costs of water infrastructure can be a problem even in rich countries. In the U.S., for example, many localities are faced with the need to replace aging water and sewer systems, which are beginning to fail; they see the high costs of replacement as a major political and financial problem (Levin, 2002; ACSE, 2013). While charging users is the most common way forward, this can raise serious issues about affordability for low-income households. Many jurisdictions have established subsidies or "lifeline rates" to help such households upgrade their water systems and obtain the necessary water service. While the problem exists in developed countries like the U.S., it is far more pervasive in developing countries with many low-income households. For these households, the cost of installing even a single tap can be a barrier to access to water. There are often striking intra-urban disparities in water access. Those living in low-income, extralegal settlements tend to have lower levels of access to an improved water supply (WHO & UNICEF, 2014). Programs to extend water services to low-income communities are common, but in many countries their coverage is only partial. In particular, in extralegal communities, there can be legal and political impediments to water delivery. Providing and maintaining the water service thus extends beyond engineering into other realms, including finance, pricing, equity, public versus private water provision, and more.

2.3 Urban Water Service Delivery: The Institutional Aspects

Physically delivering the water service, ensuring that the service is delivered, and maintaining the service to all of the users over time is up to the provider, i.e., the one who delivers water. The water service experienced by the users worldwide has a very wide range (Section 2.1) and so do certain standards of water service by which a water provider or a utility delivers or has to deliver. These standards are established by various organizations and vary with the different contexts. This section tackles the institutional aspects of water service delivery by one, discussing the role of the public and private organizations in water delivery through the continuing debate on their involvement, and two, the service standards that various organizations have set or follow.

2.3.1 Role of Public and Private Organizations: The Continuing Debate

Both public and private entities have been involved in water as well as other infrastructure service delivery. However, few debates about public service delivery have become as polarized as the question of private sector (or corporate) participation in the water sector (Davis, 2005, p.146). The debate can be viewed through various perceptions of water, which influence the belief of who should deliver water, including whether it should be free or available at a price; and through some historical transitions between public and private provision of water.

Water: Some Perceptions and Attributes

Many view water as a *merit good* – a term introduced by the economist Richard Musgrave (1957).

> *A merit good is one which the society judges all its members should have access to, and which is expected to be under-produced by the market because its consumption generates positive externalities, such as health and protection from fire, whose values are not reflected in its price.*
> *- Davis, 2005, p.152*

Many believe that water is a service deemed so meritorious, in terms of health or overall quality of life, that all should receive it regardless of their ability to pay (Fox, 1994). Besides being perceived as a merit good, water is considered by many to be a public service, something that should be provided by government directly, financed by government or perhaps mandated through regulation.

> *There is a fundamental mismatch in the objectives of the private sector (business, profit) and water infrastructure (provision of water).*
> *- Interview with Researcher and Policy Analysis in Water*

An opposing perspective – very different from that of the conceptions of water as a merit good – argues that water (and transportation, and many other publicly provided goods and services) are in fact economic goods that could be provided by the private sector with gains in efficiency. The interest in private provision of so-called public services can be connected to the "shift away from statist and towards neoliberal (free market) policies in the North from the late 1970s" (Budds and McGranahan, 2003, p.91).

> *While statist ideology holds that society's needs and problems are best addressed by the state through the political process, the neoliberal doctrine believes that social functions and economic development should be undertaken by business within free markets, with the state playing a facilitating and regulatory role without direct engagement.*
> *- Budds and McGranahan, 2003, p.91*

Besides the different perceptions of water, its physical features affect its availability for the users especially distant (urban) users, which also bear upon who provides it. Features of water such as its mobility and different forms of it occurrence, say flowing river, lake, or snow affect its uses and benefits that can be drawn from it. Spatial distribution and variability in natural water availability make some areas richer in water than others – thus spatial and temporal matching of supply with demand is a major challenge for most large centralized water systems (Hanemann, 2005). The large capital investments with long-range planning necessary for such systems lead to natural monopoly where the largest supplier in an industry, often the first supplier in a market, has an overwhelming cost advantage over other actual and potential competitors (natural monopoly). The natural monopoly in water has been that of the government. Providers of urban infrastructure as a public good have historically belonged to the public sector (Gramlich, 2001).

Some Historical Transitions In Public and Private Involvement

A public infrastructure system does not necessarily have to be publicly provided; public agencies can contract with private enterprises for construction and operation. In addition, public utilities can be corporatized, i.e., set up to operate with an independent board of directors and streamlined labor and procurement practices designed to increase efficiencies. Nonetheless, in many nations, providers of urban infrastructure have historically belonged to public organizations or the government (Gramlich, 1994).

Scholars have offered a variety of explanations for the transition to, and then persistence of, public management of water infrastructure (Crocker and Masten, 2002; Ogle, 1999; Troesken, 1999). Likely reasons include the merit-good aspects of water services as well as its role in public health and economic development.

> *Government has also historically involved itself in water service delivery because of the merit-good nature of the sector.*
> *- Davis, 2005, p.152*

Another likely reason may be the level of coordination and control the infrastructure development demands.

…the construction and operation of large-scale surface water storage and distribution systems require a high degree of co-ordination and social control.
- Hanemann, 2006, p.75

Water infrastructure systems are similar in this respect to public roadways, sanitation systems, and storm drains, which have been used by public at large and also have historically been public systems for the most part, i.e., public monies (taxes). According to a recent comprehensive review of urban water service reforms in the developing countries by Herrera and Post (2014, p.622), "prior to the reform wave in the 1980s and 1990s, developing countries have commonly managed water and sanitation systems through national bureaucracies", which increased service coverage albeit not consistently:

While many countries managed their water systems locally prior to World War II (often due to constitutional mandates), many national governments centralized water management alongside other services during the post-war period. This centralized model of infrastructure management yielded impressive rates of service access by the 1960s and 1970s in Latin America, Asia, and the Middle East, thanks in part to countries' trade surpluses and access to international finance during the first decades after WWII, which were used to finance expansion efforts. For example, 57% of urban households in Bolivia and 60% of urban households in Jordan had household connections by 1962. In Africa, however, national bureaucracies were formed later, and while many post-independence bureaucracies did invest in expanding services, economic crisis undermined the ability of national bureaucracies to expand services enough to redress inequalities in access dating from the colonial era.
- Herrera and Post, 2014, p.622

"National bureaucracies and state-owned enterprises however often prioritized new infrastructure, including new household connections, at the expense of system maintenance" (Herrera and Post, 2014, p.622). Without adequate maintenance, the 1994 World Development Report by the World Bank claimed that water losses grew to 2 to 3 times the rate observed in developed countries (World Bank, 1994, p. 27).

Neoliberal ideas had a profound influence on international development and policy debates in the water sector in the 1990s (Budds and McGranahan, 2003; Goldman, 2007), which bears upon today. Neoliberalist policies sought to maximize the role of the corporate sector in determining the political and economic priorities of the state (Goldman, 2007). Kessides (1993; p.30) stated that "…delegating management and investment functions to the private sector would insulate providers from short-termist political pressures even more effectively than delegation to corporatized utilities because managers would need to respond to shareholder (or other owners') interests rather than oversight boards staffed by political appointees".

Government-centered versus private enterprise-focused positions have been fiercely contested in many countries. Given the debate about whether water should be treated as a merit good or as any other economic good with profit as an objective, it is not surprising that many public agencies, including those in the developing countries, have faced difficulties establishing a clear policy on water pricing as well as on the respective roles of the public and private sectors in water delivery. In developing countries, Herrera and Post (2014, p.622) found that "it was politically difficult for the governments to increase the rates charged to consumers in line with inflation".

> *…within political systems dominated by patronage politics, state agencies often failed to enforce payment of these increasingly low, official charges. As tariff revenues became increasingly insufficient to cover expenses, national agencies increasingly funded system costs out of national coffers rather than user fees. This model of infrastructure finance became difficult to sustain when governments' access to finance decreased in the wake of the 1980s debt crisis, which resulted in a sudden lending freeze to developing countries. This combination of factors led in many cases to a vicious cycle of underperformance that Savedoff and Spiller (1999) termed a "low level equilibrium," characterized by low tariffs, low consumer expectations regarding service quality, and low consumer willingness to pay -- which in turn detracted from funds that might have been reinvested in water systems.*
> *- Herrera and Post, 2014, p.622-623*

By the end of the 1980s, water supply systems in most cities of the developing world were facing growing problems of quality, reliability, and coverage (Marin, 2009, p.18). Burgeoning urban populations required massive investments in expansion, which few public utilities had the means to carry out, and water rationing was becoming the norm (Marin, 2009, p.18).

> *Political interference and clientelism had led to excessive staffing and low morale, which translated into inefficiency and poor service quality. Governments, both local and national, had found it politically convenient to let inflation erode tariffs to levels well below costs… Because investment resources came more from central government budget transfers than from tariff revenues, customer service was hardly a priority.*
> *- Marin, 2009, p.18*

Mounting pressures on infrastructure in the 1990s have been attributed both to long-term infrastructure deficiencies and the unfavorable fiscal context, which reduced the ability to maneuver on spending. Another problem was inadequate responsiveness to local concerns and inappropriate provision for local conditions (The World Bank, 1994, p.6,125). One line of action, prescribed to reduce demand for additional infrastructure capacity and alleviate some of the pressure on the public purse, was to seek greater efficiency in the provision of infrastructure goods and services. Ideally efficient infrastructure management should maximize the benefits to society and minimize the costs that arise from the construction and use of that infrastructure, including the costs that users impose on others and on the environment (OECD, 1993, p.9), however that does not consistently manifest in practice.

The untenable situation in the early 1990s pointed to the malfunctioning existing state monopolies, which led to breaking of the status quo by replacing the public management of water utilities with private management (Marin, 2009). The shortage of public sector investment resources needed in order to expand and upgrade existing water networks was particularly evident in low- and middle-income countries (Nickson & Franceys, 2003). There have been calls for greater cost-reflectivity of tariffs (Franceys and Gerlach, 2008) that can help with the financial needs for service delivery. Cases such as water delivery in South Africa showed improvement in service coverage, quality, and cost recovery from delegating water service delivery responsibilities to the private sector (Blanc and Ghesquieres, 2006). At the same time however, Blanc and Ghesquieres (2006, p.21) point out that no new PPP water contract has been signed in South Africa since 2001 attributing to different factors such as greater scrutiny of the corporate operations of services essential as water and the new process of decentralization with small, newly formed municipalities that do not know how to go about contracting with the private sector.

The shift to the private provision that occurred during the 1990s was much more rapid and widespread than had been anticipated at the start of the decade. Annual investment in private infrastructure projects grew on average by over 30% a year from 1990 to 1997, increasing from $18 billion to $128 billion (Harris, 2003). Evidence of the growing prevalence of private corporations in water service delivery is seen in the World Bank's Private Sector Participation in Infrastructure database. Here, privatization refers to private enterprises investing in any form and aspect of water service delivery. A global outlook report (PPIAF, 2012) on privatization contracts in all low- and middle-income countries reports that private activity in water infrastructure has more than doubled over the last decade (523 new projects since 2001 versus 232 in 1991-2000). Over the last 10 years, the global water market has been atomized with more than 275 sponsors for 513 water projects. Private corporations, Veolia and Suez have implemented most (over 46%) projects (PPIAF, 2012). These flows peaked in 1997 and have fallen more or less steadily ever since (Harris, 2003, p1-12). The reasons for the decline include unanticipated problems on the ground and unforeseen failure of private sector service delivery (Clarke and Wallston, 2002: p.21-22; Lora and Panniza, 2002: p.12,14-15,24; Bayliss et al., 2011: p.43; The World Bank, 1994: p.43).

Water service delivery is now moving toward other different arrangements between the private and public sector. While service providers with private sector participation came to serve only 5% of the world's population and investors have shown far more interest in middle-income than low-income countries (Budds & McGranahan, 2003), the privatization trend has not stopped. Authoritarian regimes such as China—which possesses the largest number of projects in Asia—continue to attract investors, and giant countries such as India and Russia have just begun to roll out national infrastructure policies emphasizing private sector participation (Herrera and Post, 2014, p.628).

In terms of the actual performance of an arrangement between private enterprise and a public organization in a local context, there are studies that observe adverse effects. One such adverse effect from private provision is unaffordable water tariffs (Dagdiviren and Robertson, 2008; Bayliss, 2008; McDonald, 2002), which keep poor or marginalized households from getting the service. While it is incumbent upon the public sector to address such social concerns of extending service to the poor, the private sector, by contrast, is primarily motivated by economic profits and has few little or no incentive to serve the poor (Davis, 1995).

The Role of Public and Private Organizations: A Range of Involvement

From an extensive review of discussion papers and policy reform documents published by international financial institutions, Herrera and Post (2014) outline a range of models involving varying levels of delegation to private corporations, and, by implication, "insulation from political pressures".

While some contracts only delegated short-term responsibility for the management of commercial aspects of service provision (management contracts), more substantial shifts occurred under concession contracts (long-term contracts for both management and investment in state-owned systems) and divestitures (sales of equity in public utilities that own network infrastructure to private investors).
- Herrera and Post, 2014, p.628

The PPIAF global outlook (2012) reports that 105 water utility projects were implemented under concession contracts in the last ten years, and 61 projects implemented under management contracts. Over time, a spectrum of roles of the public and private sectors has developed across the world varying in the levels of ownership and control of the capital assets or infrastructure. The spectrum has an entirely public ownership at one end and an entirely private ownership at the other end (Table 2-2).

Table 2-2 A Spectrum of Public and Private Sector Roles in Terms of Investments in Physical Water Assets and Delivery

Name of Arrangement or Contract	Brief Description	Range of Involvement of Public and Private Entities
Service Contracts	Short-term agreements where a private contractor takes responsibility for a specific task such as installing pipeline segments.	SMALLER ROLE OF PUBLIC ENTITY
Management Contract	The government transfers certain operation and maintenance responsibilities to a private company but retains responsibility for investment and expansion. Payment is either fixed or performance-related.	↓
Lease and affermage contracts	Similar to management contracts, but the private operator takes responsibility for all operation and maintenance functions, including billing and revenue collection. In both cases, the operator collects the tariff revenue but, under an affermage, the contractor is paid an agreed-upon affermage fee for each unit of water produced and distributed; whereas under a lease, the operator pays a lease fee to the public sector and retains the remainder.	↓
Concession contracts	The private contractor manages the entire utility and is required to invest in the maintenance and expansion of the system at its own commercial risk. Concessions have longer terms, to allow the operator to recoup its investment and, at the end of the contract, the assets either are transferred back to the state or a further concession is granted. The role of the government is predominantly regulatory.	↓
Divestiture	The government transfers the water business, including the infrastructure, to the private company on a permanent basis through the sale of some or all of the shares in the company.	LARGER ROLE OF PRIVATE ENTITY

Note: This table is based on literature review specifically Budds and McGranahan (2003) and Davis (2005).

There are different forms of private sector participation (or PSP; Table 2-1), which have been also called public-private partnerships (PPP), probably to imply the aspect of partnering of public and private entities than focusing on the role of the private entity. The term “privatization” is also widely used but can refer to (at least) two rather different things. It is sometimes used as a generic term to refer to increasing private sector involvement, but also specifically to the model of divestiture (see Table 2-1). My interviews with government organizations and independent experts for this study suggest that privatization is interpreted to include both complete ownership and transfer of capital assets to a private enterprise, as well as different levels of participation of the private enterprise in the different water service delivery components such as water treatment, storage, and building infrastructure as well as O&M of the system. “Public–private partnership” is a common term but it also has multiple meanings. In the water and sanitation sector, it tends to be used to refer to contractual arrangements in which private companies assume greater responsibility and/or risk, especially through concession contracts (Budds and McGranahan, 2003).

2.3.2 Water Service Standards

Delivering water service that meets the users’ needs is one important service goal for an infrastructure system and a water provider. In the broader infrastructure planning arena, establishing service standards is an implicit necessary goal (Kaiser et.al., 1995). Service standards provide normative measures of desirable service levels that can be used to gauge the adequacy of existing facilities. The desired service levels can vary with community values, which in turn can determine the standards.

On the one hand, the norm in developed countries and also the legacy of centralized infrastructure is having access to continuous pressurized water through individualized piped connections. On the other hand, in the larger global context one broad standard is that of having access to safe drinking water. For example, UNICEF and the World Health Organisation (WHO) define “access to drinking water” as access to a source located less than 1 kilometer away from its place of use and that it is possible to reliably obtain at least 20 liters per member of a household per day. “Safe drinking water” is water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on drinking water quality. Over two billion people in developing countries lack access to safe drinking water by these standards: they do not use improved drinking water sources such as a household connection, public standpipe, borehole, protected dug well, and protected spring or rainwater (UNICEF, & WHO, 2012). Many also must travel long distances to fetch water. It is worth noting that the 20-liter standard may be enough water for drinking but not necessarily enough to take care of other hygiene needs; WHO advises that 50 liters per capita is the minimum needed to maintain hygiene.

In September 2000, building upon a decade of major United Nations conferences and summits, world leaders came together to adopt the United Nations Millennium Declaration committing their nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound targets - with a deadline of 2015 - that have become known as the Millennium Development Goals (MDG). MDG 7 calls for halving the proportion of the population without sustainable access to safe drinking water and basic sanitation between 1990 and 2015.

The attractive simplicity of the MDG target, which is based on categorizing the world's households into “haves” and “have-nots”, contrasts with the diversity in the levels of access and quality of service found on the ground (Bartram and Cairncross, 2010). For example, on the one hand, based on my field observations in India, households may have inconsistent service, i.e., not have ready access, availability or water quality at the same time. They may have access to safe water but not in sufficient quantity for their daily needs, necessitating burdensome actions to secure additional water or the use of unsafe water to meet part of the household needs, or they may have access to an adequate quantity of water that is billed by the provider as safe but whose quality is questionable. On the other hand, as a point of comparison, the U.S. Geologic Survey estimates that the average American, who receives continuously pressurized piped water, uses 80 to 100 gallons of water or 300 to 380 liters per day (Kenny at al., 2009).

Most countries specify universal access to certain infrastructure utilities, including telecommunications, electricity, and piped water and sewerage, as a public policy goal. Specific laws and objectives differ by country and by industry, but the general goal is to ensure access for all people at affordable prices (Clarke and Wallsten, 2002, p.4). Drinking water (with sanitation) has historically been perceived as relatively low in priority, compared with other social sectors, at both donor and developing country levels (UN, 2010, p.13).[17]

A water service objective thus can vary widely (i.e., 24/7 pressurized piped water is not available continuously for everyone, everywhere) and thus could then be identified based on an understanding of the local water service conditions. The service objective would then also inform the devising of the physical local water delivery system to cater to the users’ water needs. This is different from setting a water service objective say for a region, which is based on a standard developed in a completely different context in another region. Although the objective by itself may be desirable by many, achieving it may have different trajectories of challenges and benefits in different contexts with temporal implications, which can be a consideration while setting a standard.

2.4 Tackling The Water Service Problem

The most recent WHO report (WHO/UNICEF 2012) indicates substantial progress toward achieving the MDG especially in Asia, Latin America, and North Africa with 90 percent improvement in the water service coverage. While coverage of improved water supply sources is 90% or more in Latin America and the Caribbean, Northern Africa and large parts of Asia, it is only 61 per cent in sub-Saharan Africa. Approximately half of those who gained access to drinking water include 522 million people in India. Coverage in the developing world overall stands at 86 per cent, but it is only 63 per cent in countries designated as ‘least developed’. Similar disparities are found within countries – between the rich and poor and between those living in rural and urban areas (WHO/UNICEF, 2012; p.4).

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[17] Drinking water (with sanitation) has historically been perceived as relatively low in priority, compared with other social sectors, at both donor and developing country levels. Sanitation and hygiene education is especially difficult to place as a priority area due to the lack of clear identification of institutional roles and responsibilities for sanitation, the merging of sanitation with drinking water services and the perception in some countries that sanitation is mainly a household issue (UN, 2010, p.13).

Although most subregions and countries in the Asia-Pacific region are likely to achieve the MDG for water supply, they are left to grapple with the fact that 4 to 8 per cent of the population remain persistently deprived of access in most subregions, except East and North-East Asia. This suggests that even after an overall improvement in service extension, a "last-mile" effort is necessary to ensure universal access to basic urban services (UNHabitat, 2010). In addition, in some countries access to urban water supply has declined. Targeted initiatives are therefore needed to ensure that safe water is supplied to all urban residents (UNHabitat, 2010). Gaps still remain such as safety of drinking water supplies in the long term and need for methods to measure the actual sustainability of water and sanitation facilities on the ground (WHO& UNICEF, 2012). Devising ways to sustain access to safe drinking water over time continues to be a necessity.

2.4.1 The Need for A New Outlook

Traditional approaches to delivering water service have focused on how to design, fund, and build, and operate and maintain water supply systems. As noted previously, these systems typically include engineered systems for water extraction, filtration, storage, transport, and local delivery – pumping stations, dams and reservoirs, chlorination plants, aqueducts, water mains, water treatment facilities, and local piped connections. For urban areas, these systems are usually built on a large scale and are centralized.

The centralized systems have brought great benefits to water users by improving the reliability of service, reducing water-related diseases associated with poor water quality, and buffering the impacts of extreme hydrologic events such as floods and droughts (Centre for Science and Environment, 2011; Gleick, 2003). They have also however brought great costs, ranging from ecological and environmental degradation, social disruption associated with infrastructure construction, to growing financial demands. In addition, in many developing countries, it is proving difficult to make these systems deliver water in a timely manner to all urban users.

Gleick (2003, p.277) proposes an alternative approach, dubbed the "soft" path that relies on centralized infrastructure but complements it with investment in decentralized facilities, efficient technologies, and human capital. This approach strives to improve the overall productivity of water use rather than seek endless sources of new supply. It delivers diverse water services matched to the users' needs and works with water users at local and community scales (Gleick, 2003). This approach can be observed in various ways on the ground such as in the different forms of water delivery technologies such as water transportation mechanisms and treatment (Parker et al., 2006; ADB, 2011) or different community-based institutional arrangements (Das, 2010; Ruiz-Mier and Ginneken, 2006). Yet, these approaches may not be coordinated with the larger urban development that continues to increase, plus efficient replication of such approaches remains limited with questions still looming on delivering water fast to a large scale of the urban population.

While technological innovation may play a key role in reinvention of urban water systems, it is only part of what is necessary. On the basis of past and present changes in urban water systems, Kiparksy et al. (2013) argue that institutional innovation is of similar importance to technological innovation in urban water reinvention. To solve current urban water infrastructure challenges, these researchers argue that technology-focused researchers need to recognize the intertwined nature of technologies and institutions, and the social systems that control change (Kirpasky et al., 2013).

Another perspective with a similar water delivery goal but entirely different from centralized infrastructure is that of decentralized systems (Nelson, 2008). Nelson argues that decentralized water technologies and designs such as water-efficient appliances, rooftop rain gardens, and onsite wastewater treatment and resource recovery are the key to enhancing the performance of aging centralized water and sewer systems, and to assuring adequate water supplies and healthy ecosystems into the future. Decentralized technologies are still at the margins of engineering practice, and construction of big-pipe water, stormwater, and wastewater infrastructure continues (Nelson, 2008, p.11). Further, Nelson also talks about institutions. Part of the unrealized potential for decentralized alternatives can be explained by the continued segregation of advocates, entrepreneurs, and professionals into the three separate spheres of water supply, stormwater, and wastewater, and by their primary focus on the individual technologies or "appliances" rather than their cumulative impact. This "siloing," as Nelson calls it, thwarts the emergence of the major benefits and values of the decentralized approach because it is only when all of the water sources, uses, and movements are thought about in an integrated fashion in a watershed, and when the trio of technologies is jointly-designed at the site or neighborhood scale, that a dramatic synergy of value-creation begins to occur (Nelson, 2008, p.11).

The emergence of such new approaches to providing water service indicates that traditionally engineered, centralized systems or aping standards from entirely different contexts are not the only way to proceed, or may not even be the best way, especially considering the scale of the urban population that remains unserved and the time factor for implementation. Also, water delivery systems are then more than engineered systems, whose performance is affected by the institutional set up, and needs parallel attention.

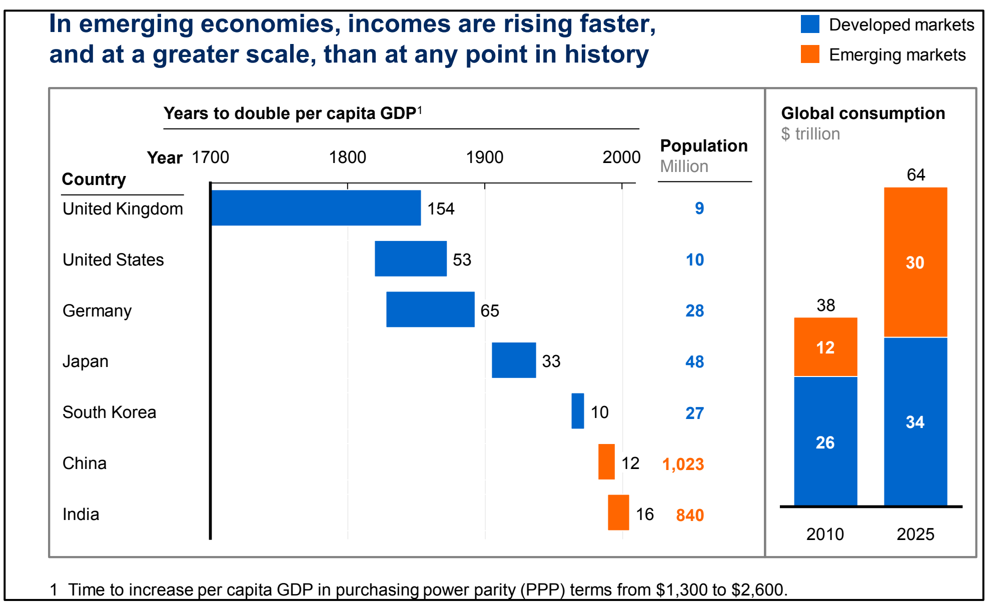
Chapter 3 Urban Water Service in India: A Function of The Water Delivery Process

3.1 Introduction and Chapter Organization

This dissertation focuses on India as a case of an emerging economy that despite its economic growth is suffering from the lack of basic infrastructure services, water being one of them. Out of the two billion people in developing countries that have no access to safe drinking water, approximately 97 million live in India (UNICEF&WHO, 2012).

With an area of 3.29 million square kilometers and a population of approximately 1.2 billion (The World Bank, 2012; Census of India, 2012), India occupies about 2% of the world's land mass and has about 17% of the world's total population. Besides its large population, which has an annual growth rate of 1.34 percent (The World Bank, 2012), India has been experiencing rapid economic development. India's gross domestic product (GDP)[18] per capita was 3,800 U.S. Dollars ($) in 2011, climbing to $3,900 in 2012 and $4,000 in 2013 (2013 dollars; Central Intelligence Agency, 2014). Figure 3-1 below shows the accelerated rate of increasing growth in the emerging economies of India and China on a comparative scale with the developed economies.

Figure 3-1 Rate of Growth in India – A Comparative Scale



Source: Data compiled and mapped by McKinsey Global Institute, 2014

[18] In this context, the GDP is used only as one measure of the economic growth. One of the common criticisms of GDP is that it averages out the impacts by income and social classes.

The rapid economic development in India however does not mean better quality of life for all, which is evident in the lack of adequate infrastructure services as basic as water. This chapter draws attention to the quality of urban water service as a function of the water delivery process and also a function of the approach to the delivery process in India.

Figure 3-2 below maps out the organization of this chapter. I examine how urban water service delivery is affected by some variables first, on the water supply source side (Section 3.2) and second, on the water demand or user side (Section 3.3). As shown in the figure below, the chapter then studies the urban water service delivery process (Section 3.4) by breaking it into institutional aspects and physical infrastructure, especially through the prevalent approach of piped water; and then presenting the economic aspects that cut across both. This section provides a relevant institutional background for urban water service delivery in India, in particular its policies, and the organizations involved in the policymaking and implementation, and then assesses how the policies manifest at the local level, i.e., the water supplied by the public provider (mostly the local municipality or a utility) as against the water service experienced by the user. The last section of the chapter provides an assessment of the water service and the approach to deliver it.

Figure 3-2 A Schematic of Water Service Delivery In This Dissertation and Topical Organization Of This Chapter

Water Supply Source: Some of Its Influences on Urban Water Delivery **Section 3.2** (Examples: surface water such as stream, river, lake, or groundwater)	**Urban Water Service Delivery** **Section 3.4** →	**User / Water Demand: Some of Its Influences on Urban Water Delivery** **Section 3.3**
• Availability of freshwater • Water transportation from source to a city • Water availability at the source • Beyond physical availability: Having "access" to water	Institutional Aspects • Primary public organizations and their functions • Standards and Policies: Setting (the central-level arm) and implementing (the local-level arm) Prevalent Standard: Piped Water Service • Providing, operating and maintaining the service o Water supplied versus service intended and experienced by user Scale of What Goes into Delivering the Intended (But Not Delivered) Piped Service • Cost of water production and delivery • Cost to the user	• Scale and pace of urban growth: Growing population and urban centers (distribution of demand) • Heterogeneous development
	Section 3.5 An Assessment of Water Service and the Approach to Deliver It Beyond Piped Water Service? The Approach to Delivery The National/ Local Divide of Policy Design and Implementation	

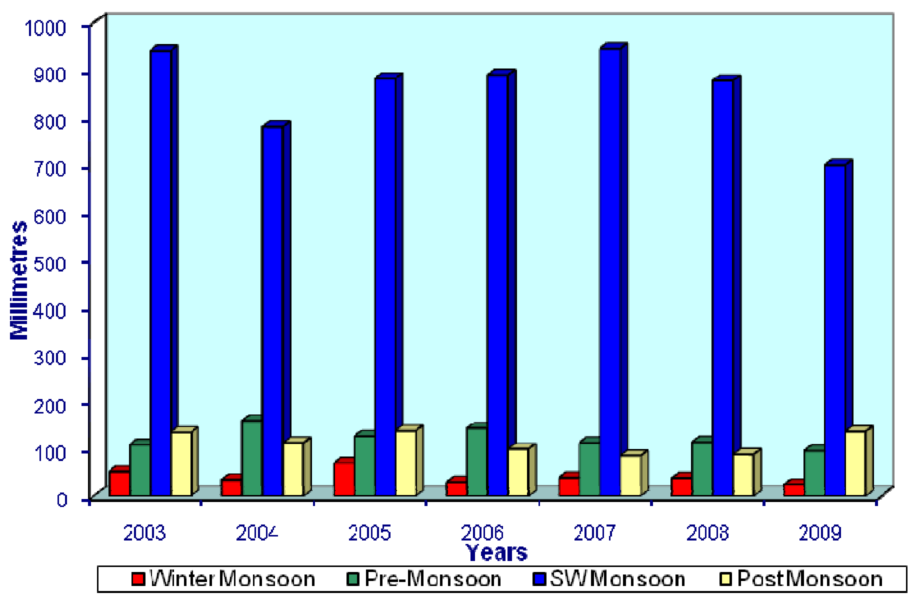
This chapter is developed based on a review of relevant literature spanning engineering, planning, and political science, as well as data and government reports at local, state, and national levels. The chapter is also based on information gathered from interviews with water providers, other practitioners and experts in conjunction with field observations. The discussion of the local utilities and local water service operations in particular draws upon two utility performance survey reports prepared by the Government of India (GOI) and Asian Development Bank (ADB) in 2007 and the Centre for Environment Planning and Technology (CEPT) University in 2011.

3.2 Water Supply Source: Some of Its Influences on Urban Water Delivery

3.2.1 Availability of Freshwater

Freshwater in India is available mostly through seasonal precipitation and surface water, including snowmelt. Groundwater aquifers, some of which depend on precipitation for recharge, also are tapped (Amarsinghe et al., 2005). The seasonal variations in the naturally available water resources make water storage an important, sometimes costly step in urban water service delivery. This is because most of the rainfall occurs in a relatively short monsoon period of three to four months. Figure 3-3 shows the temporal variability in precipitation through the years 2003-2009 (CWC, 2010).

Figure 3-3 Seasonal Rainfall in India



Source: CWC, 2010

The following quote reflects the direct seasonal effects on piped water service for urban dwellers:

Households in these cities [part of a 7-city survey] also face wide seasonal fluctuations in municipal tap water supply. More than 85% of the households in these cities say that shortage in water supply becomes acute during summer.
- Shaban, 2008, p.13

In this context, relying only on one water supply source to deliver water to all the dwellers in a city poses high risk in terms of at least two aspects: one, the location of the source and its distance from the urban users, and two, the physical availability of usable water at the source.

3.2.2 Water Transportation from Source to A City

Historically a technocratic perspective has prevailed in the form of the traditional approach of building centralized infrastructure systems in India. These systems deliver water from a natural water source (e.g., through capture of rain or extraction from river), through a network of various facilities and engineered processes to treat, produce, pump, store, and eventually distribute water to the user.

Centralized water infrastructure with pipeline distribution networks is a common mechanism for municipalities to deliver water. Such systems mostly utilize a surface water body, even though distant, as a water supply source. The concept of using surface water, however much distant from the user, is institutionalized in Section 11.2 of the redrafted 2012 National Water Policy[19], which states that, "urban domestic water supplies should preferably be from surface water" with no rationale or flexibility to adapt to the local conditions provided.

A 71-city survey on water and sanitation in India by the Centre for Science and Environment (CSE, 2012) shows that traditionally water sources had been local within the city. However, to meet growing water demands, with subsequent searches for freshwater, especially for surface water sources, and the ability of centralized infrastructure systems to connect far-off sources with urban demand, increasingly distant water sources were harnessed and used to deliver water to urban dwellers. The survey found that it is common to have water transported over long distances (in kilometers or km) from a natural surface source for delivery into many cities (shown in Table 3-1). The "subsequent sources" mentioned in the table (in the fourth column) are the sources transitioned away from mostly the local sources and pursued by government organizations.

[19] Section 12.3 of the first draft of the National Water Policy (2012).

Table 3-1 Natural Water Sources Used by Cities

City	Traditional source	Distance from city	Subsequent source	Distance from city	Current/Future source	Distance from city
Agra	River Yamuna	Within the city	River Yamuna	Within the city	Mathura-Vrindavan water supply scheme	400 km
Rajkot	Barrages on river Aji	11 km	Bhadar dam (River Bhadar)	65 km	River Narmada water from Malia canal	400 km
Delhi	Stepwells	Within the city	Tehri dam (River Ganga)	Over 300 km	Renuka dam	325 km
Chennai	Redhills and Poondi lakes	50-70 km	Veeranam lake	235 km		
Jodhpur	Stepwells and lakes	Within the city	Indira Gandhi Canal	205 km		
Aurangabad	Shallow wells	Within the city	Nath Sagar dam	42 km	Nandur Madhmeshwar dam (River Godavari)	185 km
Dewas	Stepwells	Within the city	River Shipra	12 km	River Narmada	168 km
Bhilwara	Meja dam	11 km	Groundwater from bed of river Banas	9 km	Bisalpur dam (River Chambal)	138 km
Tumkur	Maidala tank	Within the city	Bugudanahalli reservoir	8 km	Hebbaka tank Hemavati dam	133 km
Mathura	Groundwater (shallow wells)	Within the city	Groundwater and River Yamuna	Nearby	Upper Ganga Canal	130 km
Mumbai	Prior to 1870, shallow wells	Within the city	Bhatsa, Tansa, Upper Vaitarna, Tulsi, Vihar lakes	100-110 km	Middle Vaitarna	120 km
Hyderabad	River Musi and Hussain Sagar lake	Within the city	Osman Sagar lake Himayat Sagar lake	15 km 9.6 km	Manjira, Singur IV & Nagarjuna Sagar dams	59-80 km 116 km
Solapur	Hipparaga lake	Nearby city	River Bhima and Ujani dam	27 km 110 km		
Bengaluru	River Arkavathi	25 km	River Cauvery	100 km & 1,000 m below city		
Jhansi	Shallow, open wells	Within the city	Matatila dam on river Betwa	45 km	Rajghat dam on river Betwa	95 km
Surat	Borewells and ranney wells	Within the city	River Tapi (Ukai dam)	90 km	River Tapi	5 km
Gurgaon	Groundwater (shallow wells)	Within the city	Groundwater and Yamuna canal	69 km	Yamuna canal (through pipeline)	70 km
Indore	Yashwant Sagar dam and Bilawali tank	8-12 km	River Narmada	70 km		
Bhopal	Upper and Lower lakes	Within the city	Kolar dam	44 km	River Narmada	67 km
Kozhikode	The Poonurpuzha river	Within the city	River Chaliyar	20 km	Peruvannamuzhi reservoir	55 km & 500 m above MSL

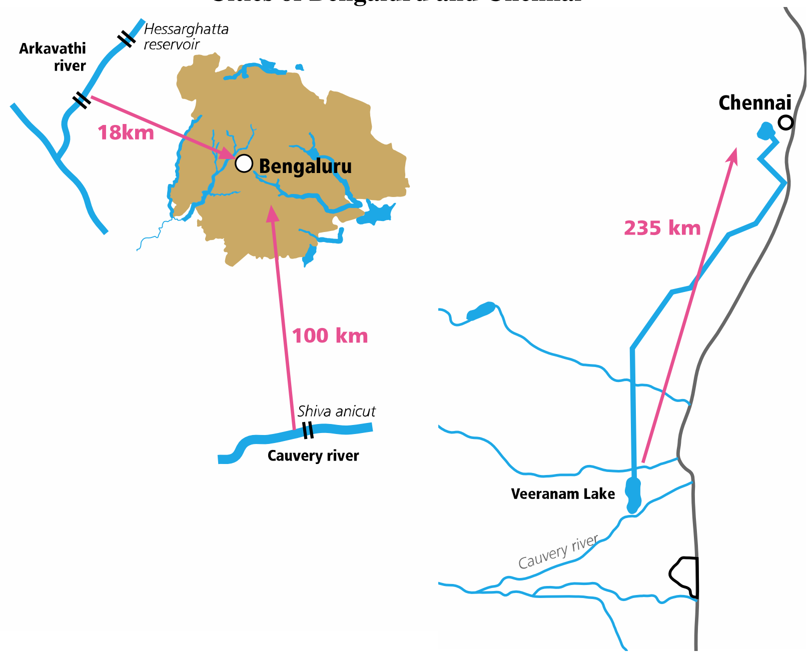
City	Traditional source	Distance from city	Subsequent source	Distance from city	Current/Future source	Distance from city
Thane	Shallow open wells	Within the city	Bhatsa dam,	58 km	Temghar dam	26 km
Hubli-Dharwad	Shallow wells	Within the city	Neera Sagar lake and Malaprabha reservoir	30 km & 55 km	Malaprabha reservoir	30/55 km
Udaipur	Stepwells and lakes	Within the city	Jaisamand lake	50 km	Mansi, Wakal and Dewas dams	42-45 km
Baramati	Left bank canal from river Neera	Near city	Ujani dam (River Bhima)	50 km		
Thiruvanantha--puram	Aruvikkara dam across river Karamana	16 km	Peppara dam (River Karamana)	45 km		
Nagpur	River Kannan Gorewada lake	20 km 10 km	Pench dam	45 km		
Bhubaneswar	Rivers Kuakhai and Daya	2-3 km	River Mahanadi	30 km	Mundali dam	40 km
Dhanbad	Shallow open wells	Within the city	Topchanchi lake River Damodar	20 km 22 km	Maithan dam across river Barakar	35 km
Gwalior	Shallow open wells	Within the city	Tighara dam	27 km		
Srinagar	Shallow wells and Dal lake	Within the city	River Doodhganga Harvan Tarn	15 km 21 km	Sindh *nullah* (tributary of river Jhelum)	25 km
Ujjain	River Kshipra	Within the city	River Gambir	22 km		
Dehradun	Open wells and springs	Within the city	Groundwater, springs and canals	8-10 km	Dam on river Song	20 km
Ranchi	Shallow wells	Within the city	Kanke and Rukka dams and Dhurwa reservoir	7-20 km		
Aizawl	Springs and rooftop rainwater	Within the city	Tlawng river	18 km & 1,000 m below		
Jaipur	Ramgarh lake	27 km	Groundwater	Within the city	Bisalpur dam	12 km
Pune	Open wells and shallow borewells	Within the city	Khadakwasla dam	12 km		
Mussoorie	Spring water from Jinsi and Bhilaru	6-7 km down the valley	Spring water from Jinsi and Bhilaru	6-7 km down the valley	Hardy Falls	10-12 km
Uttarkashi	River Assi Ganga	8 km	Kohri Ghad	11 km	Basunga spring	5 km
Kanpur	River Ganga (shallow wells)	Within the city	River Ganga (shallow wells)	Within the city	Luv-Kush Barrage (River Ganga)	10 km
Hazaribagh	Hazaribagh lake	3 km	Chharwa dam	8 km		
Srikakulam	Shallow open wells	Within the city	River Nagavali	5 km		

km = kilometer. 1 kilometer = 0.62 miles
Source: CSE, 2012

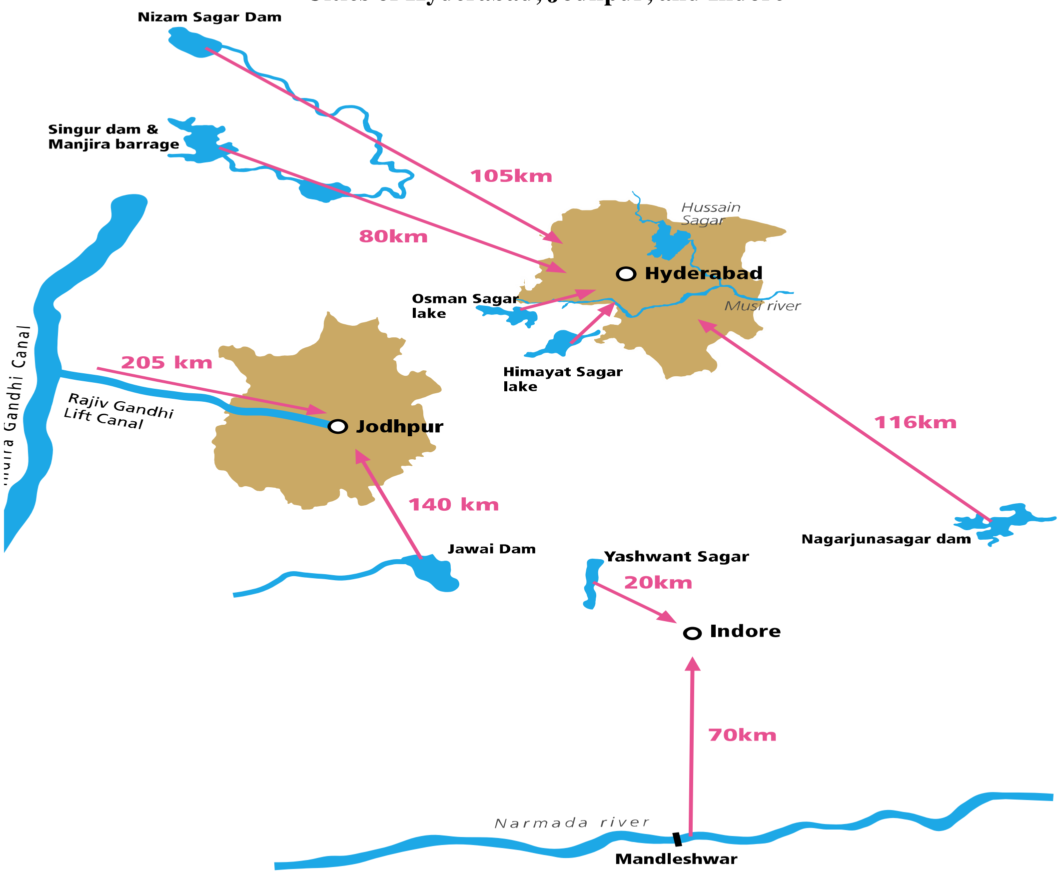
Figure 3-4 below shows schematics of some examples of cities from the 71-city survey that tap into distant water sources for their urban water deliveries.

Figure 3-4 Water Sources Located Farther Away from Cities: Schematic of Some Examples

Cities of Bengaluru and Chennai



Cities of Hyderabad, Jodhpur, and Indore



Although the National Water Policy indicates a preference for surface water, it also states the following (Section 11.3):

> *Where alternate supplies are available, a source with better reliability and quality needs to be assigned to domestic water supply. Exchange of sources between uses, giving preference to domestic water supply should be possible. Also, reuse of urban water effluents from kitchens and bathrooms, after primary treatment, in flush toilets should be encouraged.*

Yet, implementation of water infrastructure systems seems to favor distant surface water resources with absence of similar parallel impetus by the state and local governments on other systems with different water sources.

In the case of distant water sources, with the long distances covered by water pipelines, the infrastructure system can become subject to higher risks of water losses from breakdowns as well as from thefts or illegal connections from the piped network (GOI, 2012). Such risks make the system more vulnerable affecting the quality of water service delivered e.g., all of the water supplied through the infrastructure may not reach all of the users due to losses en route (see Section 3.4.2 below). With centralized pressurized piped systems as the primary focus, the question is not only about building them but it is also about the opportunity cost of not diversifying the risks and not pursuing other local water supply sources and ways to deliver water with the same thrust.

3.2.3 Water Availability at the Source

Water supplies are vulnerable to various natural and anthropogenic influences, from the effects of drought to pollution from industry or farming. With climate change, water stress in India is increasing, whether it is drying up of surface water due to increasing temperatures or lowering of groundwater due to excessive withdrawals (UNICEF, 2012). Thus even when a source has been earmarked for human consumption, the availability of usable water at the source cannot be guaranteed. Further, even if the water is available at the source, in the case of large capital-intensive infrastructure network, delivering the water service to the urban dwellers heavily depends upon the performance of the facilities such as dams and reservoirs, and their continual functioning as intended, which can weaken over time due to say, sediment build up resulting in reduced capacity (Doyle and Havlick, 2009).

Water stress is also evident in the quality of water available due to pollution from industrial and farming activities. These impacts can be serious enough to render the water unusable (evident in the quotes below), unless it is treated specifically for the purpose of use at the point-of-use.

> *Growing pollution of water sources, especially through industrial effluents, is affecting the availability of safe water besides causing environmental and health hazards. In many parts of the country, large stretches of rivers are both heavily polluted and devoid of flows to support aquatic ecology, cultural needs and aesthetics.*
> *- Section 1.2 (ix), National Water Policy*

> *Inadequate sanitation and lack of sewage treatment are polluting the water sources.*
> *- Section 1.2 (xii), National Water Policy*

Treating water, especially polluted water, to drinking water standards at a centralized treatment facility adds to the cost of production; however the value of the production and treatment can be lost if the water is allowed to be polluted again during its delivery and needs to be treated again by the users.[20] Hence, the availability of water at the source affects the water supplied to the users not only in terms of its physical location with respect to the user but also in terms of water quantity and quality.

3.2.4 Beyond Physical Water Availability: Having "Access" To Water

Availability of water for delivering the service to urban dwellers goes beyond its physical availability at the supply source. The use of a natural source of water supply can be governed by rights to utilize the source, which is possible by accessing it. The term *access* is often used (de Janvry and Sadoulet, 2001) to include property rights to water, which can be accomplished through owning land adjacent to or over the water source or by other means such as contracts or laws. In the latter sense, access to a water source is a sociological concept (Ribot and Peluso, 2003) where access is not only about a physical connection but is also reflected in the power embodied in and exercised through various mechanisms, processes, and social relations that affect people's ability to benefit from the source. This formulation includes a wider range of social relationships that constrain or enable benefits from resource use. For example, it can include traditional (informal) practices as well as formal (legal) ones. Some people and institutions control resource access while others must maintain their access through those who have control. Different people and institutions hold and draw on different "bundles of powers" located and constituted within "webs of powers" made up of these strands (Ribot and Peluso, 2003, p.2). This "nonphysical" aspect of access to the source can affect the use of water at the supply source.

An example of this nonphysical aspect of access is when allocation of certain quantities of water for different uses, e.g., domestic, industrial, and agriculture sectors, can drive water access for those users. Under the Constitution of India, water supply is a State responsibility, meaning water supply planning, allocation, and investments in water supply infrastructure fall under the individual State jurisdiction. Typically a State executive body such as the State water irrigation department makes the water allocation. Here, the power dynamics at the local level including presence of a specific industry, as well as the executive decisions made by the State organization can bear upon the water allocated to that industry and thus, also affect the physical availability of water for other sectors. This is evident in the following statement:

> *The growth of cities and industries is inevitable and this growth will have massive implications on the use of water and discharge of waste. In the industrialised world, water use is primarily in the industrial and urban sectors and the demand from these sectors is also bound to grow in India. This necessitates a 're-allocation' of water from agriculture to industrial/urban use. Unless this is managed in an equitable manner, it is likely to lead to conflict with traditional users in rural areas, especially farmers. Such tensions are already in evidence in certain parts of the country. Indian cities and industries will have to reinvent their water trajectory to both secure the water they need and do so in a way that minimises the scope for conflict.*

[20] See the water quality discussion as part of water service experienced by the users later in this chapter in Section 3.4.3.

- Twelfth Five-Year Plan (2012-2017), Government of India, 2012

While water supply is a State responsibility, the policies affecting use of a water supply source, its delivery and use are developed by the central government. The central Ministry of Water Resources, in its initial draft of the National Water Policy (MWR, 2012), stated the following about the water supply source and how it should be used for different purposes.

Water, over and above the pre-emptive need for safe drinking water and sanitation, should be treated as an economic good so as to promote its conservation and efficient use.
- Section 1.3 (vi) of the first Draft of National Water Policy released

Following a backlash in the media and by the public on the focus of using water as an economic good after basic uses of drinking and sanitation slighting users such as subsistence farmers (Dharmadhikary, 2012; InfoExchange, 2012; The Economic Times, 2013), Section 1.3 (vi) of the National Water Policy was revised to reflect sensitivity to other high-priority water needs:

Water, after meeting the pre-emptive needs for safe drinking water, sanitation and high priority allocation for other domestic needs (including needs of animals), achieving food security, supporting sustenance agriculture and minimum eco-system needs, may be treated as economic good so as to promote its conservation and efficient use.
- Section 1.3 (vi) of the revised Draft of National Water Policy

Dharmadhikary (2012) points that there is no explicit list of prioritization amongst various water uses in the Draft Policy 2012. Water needed for basic livelihood support for the poor and for food security has been treated as an economic good. The implications of this are hidden in Section 7 (below) that deals with pricing of water (Dharmadhikary, 2012).

For the pre-emptive and high priority uses of water for sustaining life and ecosystem for ensuring food security and supporting livelihood for the poor, the principle of differential pricing may have to be retained. Over and above these uses, water should increasingly be subjected to allocation and pricing on economic principles.
- Section 7.1 of Draft National Water Policy

The quote indicates that pre-allocation and pre-determined uses of water can affect water availability for different urban uses. Availability of water at the water supply source is therefore not only physical in nature; but it also comprises of complex social aspects.

3.3 Water Demand: Some of Its Influences on Urban Water Delivery

The National Water Policy (2012) acknowledges that water demand in India is increasing rapidly due to growing population, rapid urbanization, industrialization, and economic development. One example of the increase in water demand is the increase in the water requirements projected for various sectors shown in Table 3-2. The table shows a significant increase in drinking water requirements. The table also indicates that urban water demand – a part of the drinking water – is not only one part, but also a relatively smaller part, of the total water demand, pointing to the need for a broader perspective.

Table 3-2 Water Requirements for Various Sectors Cited from Two Sources

	Water Demand in cubic kilometers (or billion cubic meters)					
	Standing Sub-Committee of Ministry of Water Resources			National Commission on Integrated Water Resources Development		
Year	**2010**	**2025**	**2050**	**2010**	**2025**	**2050**
Irrigation	688	910	1072	557	611	807
Drinking Water	56	73	102	43	62	111
Industry	12	23	63	37	67	81
Energy	5	15	130	19	33	70
Others	52	72	80	54	70	111
Total	**813**	**1,093**	**1,447**	**710**	**843**	**1,180**

Source: Central Pollution Control Board, 2009

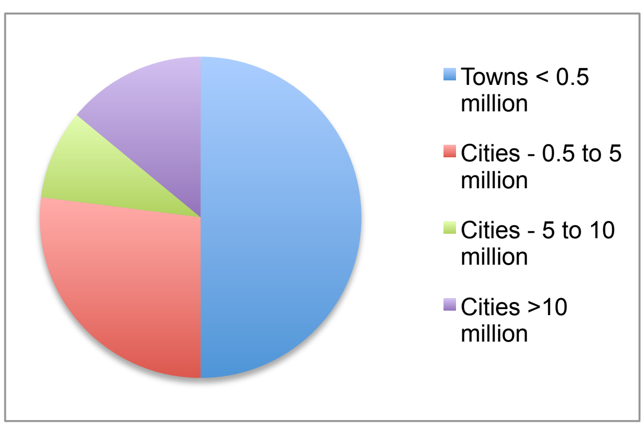
Note: It is worth nothing that there are two different numbers published as projected water requirements made by the central government (e.g., ~30% and ~44% increase in drinking water requirements in 2010-2015 and ~40% and ~80% increase in 2025-2050. The two different data points may point to the uncertainty in the water requirements and likely the planning process.

In addition to the quantitative estimates of drinking water requirements (shown in Table 3-2), a qualitative study of the water demand below reveals the different ways in which it can influence the urban water delivery process. Some of the ways are the forms in which urban growth is manifesting, e.g., the scale and pace of urban growth and the distribution of the urban demand conditions.

3.3.1 Scale and Pace of Urban Growth: Growing Population and Urban Centers

One attribute of urban water demand in India is that it is concentrated within specific urban population centers, for instance, the three largest metropolitan cities with population of 10 million or more – Mumbai, Delhi, and Calcutta – that together account for 14% of the Indian urban population. About 9% of the urban population live in cities ranging from 5 to 10 million in size and 27% live in areas with population of 0.5 to 5 million (HPEC, 2011; Figure 3-5). The bulk of urban Indians —181 million or 50% of the urban population — reside in smaller "towns" with less than half a million population (The Times of India, 2010; shown in blue in the figure below).

Figure 3-5 Distribution of Urban Population in India



What is spectacular is that urbanization can be seen not only in the increase in the urban population, but also in the number of populous cities. The number of cities with populations greater than 1 million grew from 35 in 2001 to about 51 in 2011 (HPEC, 2011). More than a quarter of India's population lives in these cities (seen in red in Figure 3-5 above).

The rapid pace of urbanization in India on an international level is shown earlier in the chapter (Figure 3-1). At the national level, urban growth (Table 3-3) can be seen through the number of towns that has increased by over 53% in between 2001 and 2011 (GOI, 2013; Census, 2001; 2011). Further, the physical changes in the cities and the local administration are extraordinary. There are 242 new urban local bodies (ULBs) such as municipal corporations (increase of 6.4%) that operate the local urban services in between 2001 and 2011.

Table 3-3 Change in Towns and Urban Local Bodies (2001-2011)

	2001	2011	Change
Towns	5,161	7,935	+53%
Urban Local Bodies	3,799	4,041	+6.4%

Source: GOI, 2011, 2013; Census 2001, 2011.

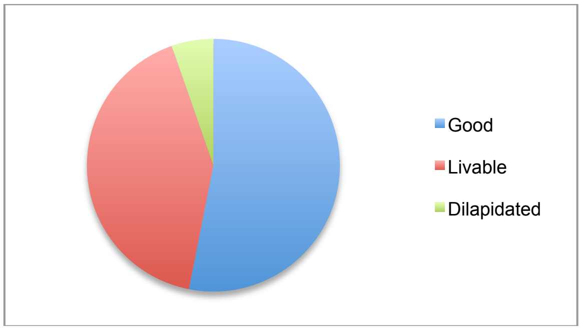
This increase and the fast pace of urban growth does not manifest only in the increase in water demand but also in how the water service is delivered within such a magnitude and pace of increase in the demand and its distribution. As we see in the following sections, the municipal corporations in existing cities, including large metropolitan cities such as Mumbai, supply water only intermittently for up to a few hours a day at varying schedules and not all the areas served by the piped network have individual piped connections (service discussed in detail in Section 3.4 below); how then newly formed ULBs would deliver 24/7 pressurized piped water now, on a continuous basis to all is yet to be seen.

3.3.2 Heterogeneous Development: A Look at Housing

Another manifestation of urbanization and the increasing urban water demand is in its multiple forms of development, some of which are far more difficult to serve than others in a timely manner. One of the different features that influence how water service is obtained by users or is available to them is the diversity in housing development; in particular it is about the ability and location of the varied housing structures to which water needs to be delivered and presence of other basic infrastructure services such as access streets or pathways. The feasibility of installing centralized networks with individual piped water connections for all households depends on the integrity and the size of the dwelling structure where a pipeline can be laid and a tap installed so that it would continuously deliver water.

At the national level, the Census of India (1971) attempts to cover several different aspects in its definition of a house, which is a "building or part of a building having a separate main entrance from the road or common courtyard or stair case etc. used or recognized as a separate unit; it may be inhabited or vacant; and may be used for a residential or non-residential purpose or both". The Census data shows the types of households based on their conditions – seemingly subjective – good, liveable, and dilapidated (Figure 3-6). The conditions indicate the levels of integrity of the structure.

Figure 3-6 Types of Households in India



Note: The official definitions of good, livable, and dilapidated were not described.

In addition, heterogeneity within the structural integrity of houses can be seen in how the central government defines various housing types as a function of their "permanence", defined primarily by the materials used in their construction (Box 1).

Box 1. Different Types of House Structures

- Permanent House: House with wall and roof made of permanent materials. Wall can be galvanized iron, metal, asbestos sheets, burnt bricks, stone or concrete. Roof can be made of tiles, slate, galvanized iron, metal, asbestos sheets, brick, stone or concrete.
- Semi-permanent House: Either wall or roof is made of permanent material (and the other having been made of temporary material).
- Temporary House: House with wall and roof made of temporary material such as grass, thatch, bamboo, plastic, polythene, mud, unburnt brick or wood.
- Serviceable Temporary: A house with walls made of mud, unburnt bricks or wood.
- Non-serviceable Temporary: A house with walls made of grass, thatch, bamboo, plastic or polythene.

Besides the individual structures, factors such as the distribution of such different dwelling structures in a community and presence of basic infrastructure services such as continuous or linear roads and drains, along which the water pipelines can be laid and also maintained over time, form a significant part of providing piped connections to households. Figures 3-7 and 3-8 below show examples of different housing structures, which show the diverse conditions in which they are located.

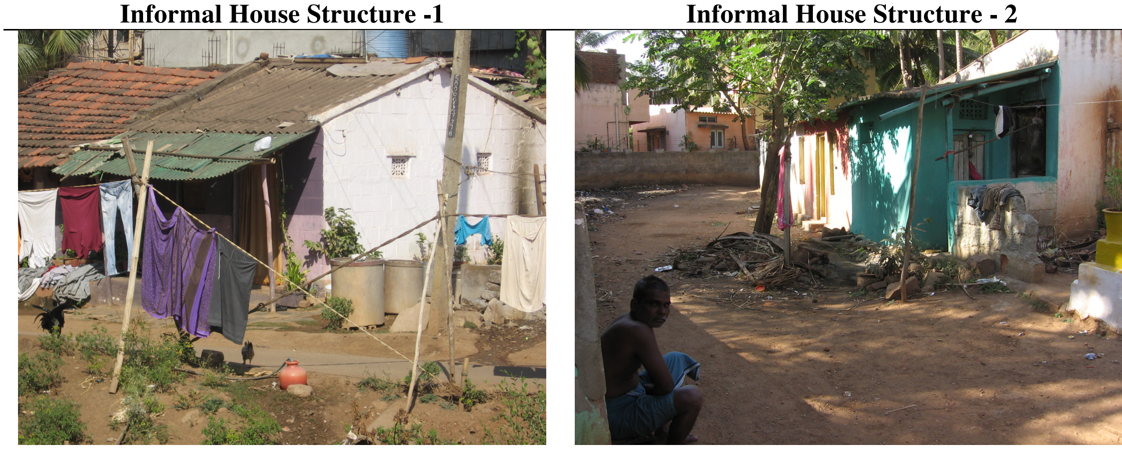
Figure 3-7 Examples of Single-Family Houses and Multi-Family Building

Single-Family House	**Multi-Family Apartment Building**	**Single-Family House**

Providing piped connections means installing taps to each household (in many cases, existing developments) and making pipeline connections between the households from a water main line in a city.

Figure 3-8 Additional Single-Family Housing Examples

Informal House Structure -1	**Informal House Structure - 2**

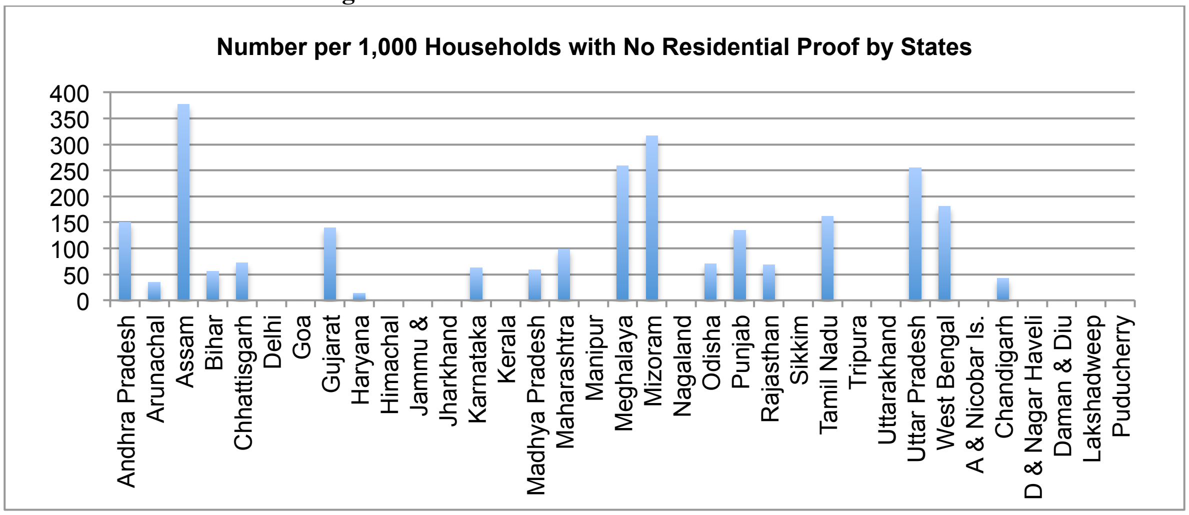


Depending on the local jurisdictional guidelines, providing a water connection may rely upon presence of formal structures or a legal proof to occupy the property. Figure 3-9 shows a distribution of dwelling units with no residential proof in Indian states; a maximum of up to 400 out of 1,000 dwelling units do not have residential proof or legal right to occupy the property. Delivering water in these circumstances, especially where tenure security is required[21] to provide

[21] Depending on the local and state regulations, a residential proof or a legal right to occupy the property may or may not be required to obtain an individual water connection for the household. There may be different mechanisms such as legally recognizing the property, or institutional mechanisms such as establishing an authority for providing basic infrastructure services such as the Slum Redevelopment Authority in Mumbai (Burra, 2005), which is now called Slum Rehabilitation Authority.

piped connections is then not only about building physical infrastructure but also having institutional mechanisms in place to provide formal water connections.

Figure 3-9 Households with No Residential Proof



Source: Ministry of Statistics, 2013

Further, even if the housing structures were legal i.e., approved by the local development agency, they may not be necessarily planned for, i.e., there is no advance planning for implementation of timely delivery of reliable infrastructure service as the developments are built. Many housing structures may not be legally approved, i.e., they may be extralegal, in which case their infrastructure needs are certainly not planned for. Yet, they do however need the infrastructure services. This widens the water demand situation from a dichotomy of planned versus unplanned and legal versus extralegal housing structures to serve through pressurized piped systems.

In addition, there is no one particular type of housing structure identifiable as part of planned or unplanned growth. Both approved developments and unplanned growth (Figures 3-7 and 3-8 above) include a mix of different building types, which may or many not have even other basic infrastructure facilities built, such as roadways. Large swaths of land are being developed for housing, commercial, and industrial use with inadequate or no access to basic urban infrastructure service including water supply, sewers, solid waste services, and roads (Ministry of Statistics, 2013). Some are relatively easily served by piped water; for others, where the legality of occupancy is in doubt and/or there is no clear right-of-way for utilities, it is far more difficult to envision ways to provide piped water to individual units. This is especially evident in slums defined by the Indian Census (2011) as "residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and design of such buildings, narrowness or faulty arrangement of street, lack of ventilation, light, or sanitation facilities or any combination of these factors which are detrimental to the safety and health." Figure 3-10 below shows some examples of slums.

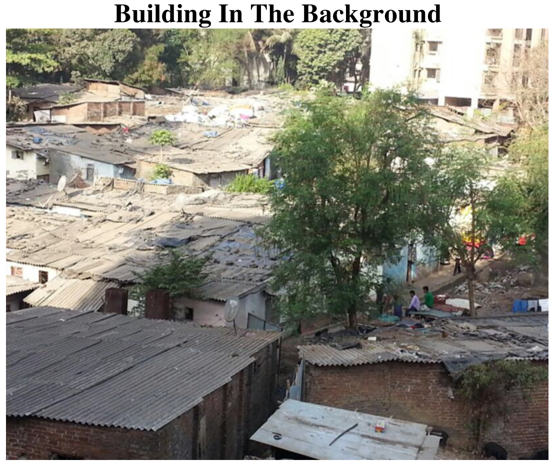
Figure 3-10 Examples of Slums

Slums With Multi-storeyed Buildings In The Background

Inside An Slum Settlement

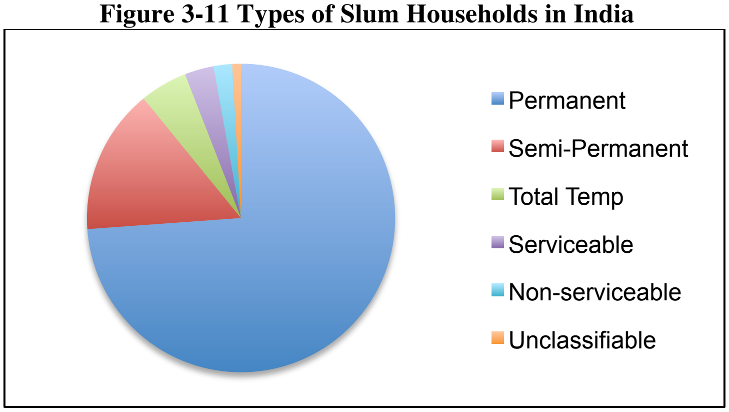
Top View of a Slum

Another Slum with a Multi-Family Apartment Building In The Background



The diversity in the slum households can be seen in the types of housing structures drawn by the Indian Census in Figure 3-11 below.

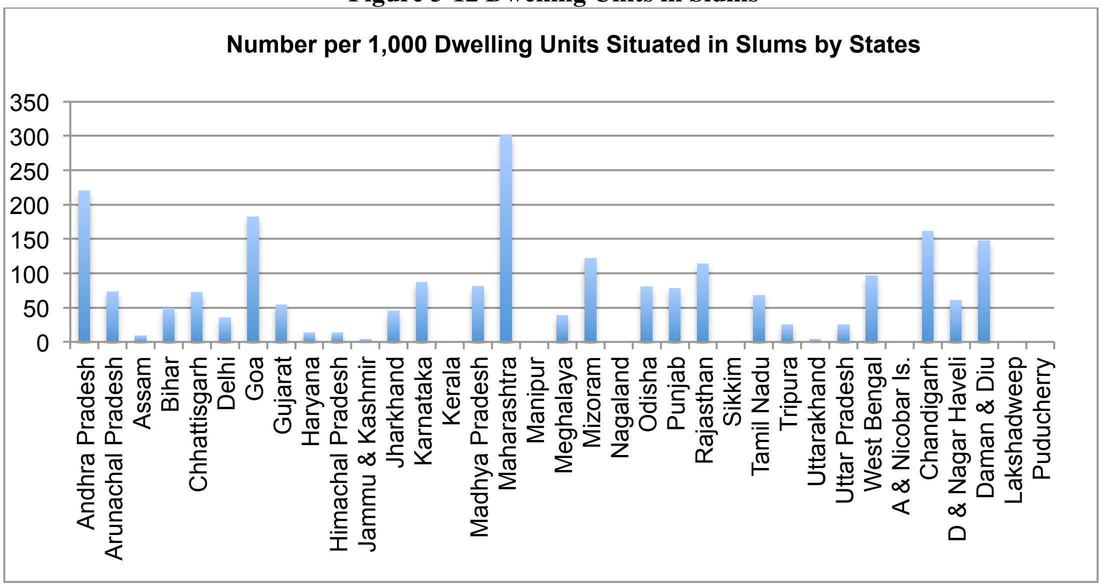
Figure 3-11 Types of Slum Households in India



Source: Census 2011

As Figure 3-12 below shows that almost all of the Indian states have dwelling units located in slums. As high as 30% of the dwelling units are considered slums, where the existing centralized citywide infrastructure networks encounter barriers of no clear right-of-way or lack of linear paths to reach the individual dwelling units within.

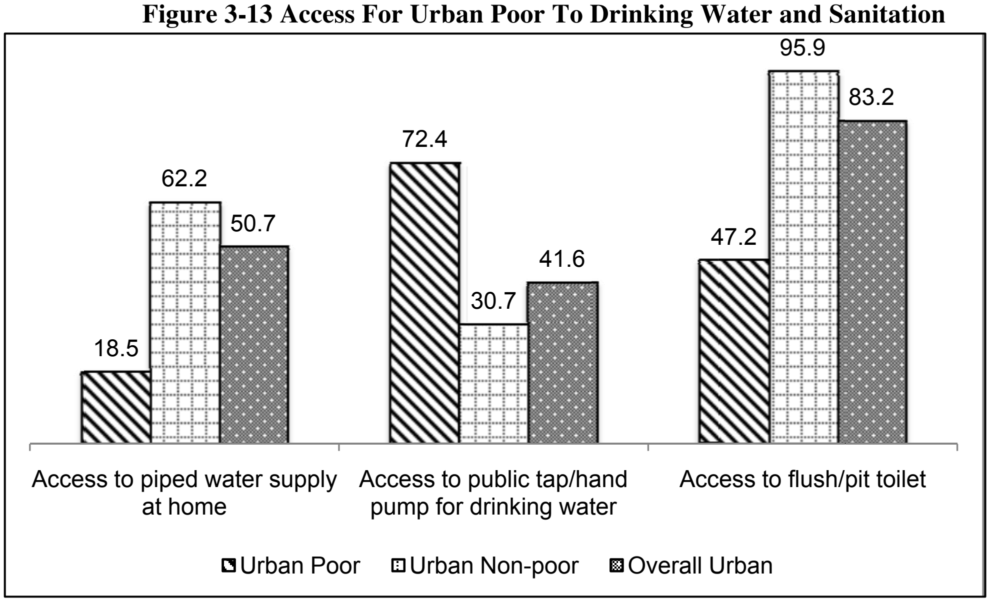
Figure 3-12 Dwelling Units in Slums



Source: Ministry of Statistics, 2013

Of the 1.2 billion-population in India, approximately 65.4 million live in slums (2011 Census). Besides the aforementioned challenges of delivering water, the prevalence of slums casts light on urban poverty, which is a critical factor under urban water service, evident in the disparity of service levels that the urban poor have access to (left-most hatched columns in the three-column stacks in Figure 3-13).

Figure 3-13 Access For Urban Poor To Drinking Water and Sanitation



Source: Planning Commission, 2011; Data available from 2005-2006

The Planning Commission (2011) reports that in 2004-05, 80.8 million people out of an estimated urban population of 309.5 million persons were below the poverty line i.e., their per month consumption was less than Rs. 538.6. There has been an increase in the proportion of the urban poor from 18.7% in 1973 to 26.8% in 2004-05. In addition, about 40 to 45 million persons are on the "borderline of poverty" (Planning Commission, 2011, p.3). These numbers constitute a significant proportion of the world's total urban poor estimated at 291.4 million (Planning Commission, 2011).

> *Most of the slum settlements lack water and sanitation systems … In many cases, entire townships have emerged in slum developments operating within the framework of an informal economy.*
> *- Report on Urban Infrastructure in India by the High-Powered Expert Committee (HPEC), 2011, p.18*

Rapid densification and urban growth, the heterogeneity of the urban development present in Indian cities, and the lack of basic infrastructure in many urban districts, add up to a highly complex environment and a factor in delivering water service, now.

3.4 Urban Water Service Delivery

This section is organized in three parts: one, the relevant institutional aspects of water service delivery, specifically the different functions carried out by government organizations at the central, state, and local levels including the water service standards and policies that are the focus of this dissertation; two, different examples that indicate the current status in different cities of the centralized piped water distribution service and its operation – the predominant water delivery mechanism espoused by the government and which forms of the focus of policymaking. In the context of the performance of the centralized pressurized piped water service operations, the third part of this section steps back and provides perspective on what the topics discussed so far by assessing what goes into delivering pressurized piped water as intended but is not delivered in terms of some costs incurred by the provider and users.

3.4.1 Institutional Aspects

The term "institution" refers broadly to socially constructed patterns of behavior as well as to organizations that embody such rules. Giddens (1984) states that, "institutions by definition are the more enduring features of social life". He notes that institutions encapsulate social orders and modes of discourse, and as such shape political economic and legal decisions. I use this conception of institutions to draw attention to the national level of government organizations that are involved in India's planning and policy on water service and the local-level implementation of these policies to deliver the water. Within this definition, I also consider institutional mechanisms such as setting policies and delegating responsibilities, which bear upon the performance of an organization, and of the quality of water service.

Primary Public Organizations and Their Functions Related to Urban Water Service Delivery

Table 3-4 shows the broad functions that are related to urban water service delivery from policymaking to those related to the physical components from the water source to maintaining the physical infrastructure and shows the government levels at which they are executed, i.e., the central, state, regional, and local levels.

Table 3-4 Organizations Responsible for Water Service Delivery Functions

Function	Name of Government Organization	Aspects Related to Water Service	Government Level
Set Guidelines and Policies, Service level benchmarks	Ministry of Urban Development (MoUD)	Urban Development, Water Service Goals	Central (National)
Technical Reviews under MoUD (e.g., Manual for Water Infrastructure)	Central Public Health & Environmental Engineering Organization (CPHEEO)	Water Infrastructure Systems	
Secretariat for Infrastructure (developing physical infrastructure, maximize public-private-partnerships)	Planning Commission	Type of Institutions Delivering Water (Public or Private or Other)	
Set Guidelines and Policies	Ministry of Water Resources	Water Resource (Bulk Supply)	
Set Standards	Bureau of Indian Standards	Water Service Standards (Service)	
Policies and Nodal Agency for Implementation	Ministry of Environment and Forests (MOEF)	Water Resource (Natural Water Resource)	
Technical Services/Monitoring, National-level Coordination on water and air pollution control	Central Groundwater Board	Groundwater	
Provide technical assistance on water and air pollution control	Central Pollution Control Board (CPCB)	Water Resource (Water Quality)	
Overall policy, planning, funding and coordination of programs of drinking water and sanitation in the country	Ministry of Drinking Water & Sanitation	Water Resource	
Harness surface water for irrigation and drinking water purposes, resolve interstate water disputes	Irrigation or Water Resource Department	Water Resource (Water Quantity)	State
Plan, regulate, control and facilitate development, create infrastructure	Urban Development Department	Urban Development	
Plan, design, construct, finance water Infrastructure for city deliveries,	State Water Departments (e.g., Water and Sanitation, Drainage Boards)	Water Infrastructure	
Statewide standards for air and water pollution control	State Pollution Control Board (SPCB)	Water Resource (Water Quality)	

Function	Name of Government Organization	Aspects Related to Water Service	Government Level
Prepare and approve Development Plans, Prepare & implement Development Plans (residential, commercial, etc.)	Regional Development Authority (in some areas)	Urban Development	Local
Operate and Maintain and Extensions of Physical Infrastructure	Municipal Corporation (Water or public works department)	Water Infrastructure System	
Issues new permits to approved developments	Municipal Corporation (planning department)	Urban Development	

Source: Individual departments and organizations may vary with states and local jurisdictions.

National-level policies, guidelines, technical guidance, and financial assistance and grants are established by central government organizations such as the Ministry of Urban Development (MoUD), the Planning Commission, the Bureau of Indian Standards, and the Ministry of Water Resources that are discussed below to provide a brief background for water service discussions later in the chapter.

The MoUD sets national-level guidelines and policies related to urban development and infrastructure service including water service level benchmarks, and provides technical and financial assistance to the States. MoUD also appoints committees such as the High-Powered Expert Committee to develop planning and policy documents (HPEC, 2011) on urban and infrastructure development in India. The MoUD, the Planning Commission, and the Urban Development Department (UDD) also establish urban development policies and guidelines.

The Central Public Health Environmental Engineering Organisation (CPHEEO) is the technical wing of the MoUD that develops standards and guidelines on water supply and sanitation to the States and local municipal corporations including technical guidebooks or manuals for building and maintaining the physical infrastructure systems. All of the expenditure incurred by the government is paid from the Consolidated Fund of India[22] (GOI, 2014), which is financed by the taxes that the central government levies such as income tax[23], customs duties, central excise, sales tax and service tax (CBGA, 2014). For water supply, the CPHEEO plays a vital role in processing the schemes posed for external funding agencies including the World Bank and Asian Development Bank and Bilateral and Multilateral funding agencies. It acts as an advisory body at central level to advise the concerned State agencies and ULBs in implementation, operation and maintenance (O&M) of urban water supply, sanitation and solid waste management projects and helps to adopt latest technologies in these sectors (CPHEEO, 2014).

The Ministry of Water Resources (MWR) lays down policy guidelines and programmes for the development and regulation of country's water resources. The National Water Policy established by the MWR in 2002 assigned the highest priority for drinking water supply needs followed by irrigation, hydropower, navigation and industrial and other uses.

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[22] Similarly, all loans raised by the Government by issue of Public notifications, treasury bills (internal debt) and loans obtained from foreign governments and international institutions (external debt) are credited into this fund (GOI, 2014).

[23] Tax on agricultural income is levied by State governments.

Under the Constitution of India, water supply is a State responsibility, meaning water supply planning, allocation, and investments in water supply infrastructure lies under the individual State jurisdiction. For example, several state-level organizations are responsible for different aspects of the natural water source such as a river or groundwater; the State Water Irrigation Department makes the water (quantity) allocation, whereas the State Pollution Control Boards regulate water quality. While not listed in the table, private contractors are often involved, for example in advising on policy or constructing major infrastructure.

States plan, design and execute water supply schemes (and sometimes operate them) through their State Public Health Engineering Departments and Water Boards (GOI, 2002). States are generally financed by land revenue, including the assessment and collection of revenue on land used, the maintenance of land records; taxes on agricultural incomes, consumption, sales or purchase of goods, tolls, and luxuries such as entertainment (CBGA, 2014).

While water supply infrastructure is planned and built by the States, in most cases, O&M of the infrastructure and the actual delivery of the service occur at the local city municipality level, which is the direct link – as the local water provider – of urban water service provision to the user. The local bodies are funded by tax on properties, the entry of goods for use/consumption within their jurisdictions (octroi), and on markets; and user charges for utilities such as water supply and drainage (CBGA, 2014).

As Table 3-4 above shows, a multitude of agencies at every level of government have a hand in water service delivery. The quote below shows the downside of having several agencies in delivering urban services such as water.

> *The multiplicity of agencies with overlapping jurisdictions and fragmented roles and responsibilities has been a major factor in the poor delivery of urban services.*
> *- High Powered Expert Committee (HPEC), 2011, p.62*

Amidst the slew of different government organizations, it is worth noting that there has been no regulatory authority in water service delivery in India until as recently as the last decade. In 2005, the Maharashtra Water Resources Regulatory Authority was established in the state of Maharashtra – the only state to have such an authority. The Authority however does not yet enter in the space of regulating water service operations of private and public utilities or water providers. One of its prime responsibilities is to develop technical criteria for the pricing structure for bulk water supply, which is allocated by the State water resources department (executive arm) for the different sectors or uses (e.g., industrial, agriculture, and domestic).

Service Standards

Setting the Standards: The Central-Level Arm

Much of the policy and standard setting occurs at the central government level or at the state level, whereas implementation of those policies and the standards intended by the Centre occurs at the local level. However, the standards are not uniform and seem to have varied with time. Table 3-5 shows some examples of standards by listing minimum water supply standards established by the central Bureau of Indian Standards (BIS), in the Five-Year Plans released by the Government of India, and the more recent service level benchmarks by the MoUD. The water requirements are presented in the form of liters per capita per day (LPCD) of water to be supplied.

Table 3-5 Water Supply Standards

Source	Minimum Water Supply (LPCD)	Purpose of Water Use
Bureau of Indian Standards, IS: 1172-1993	200	Domestic consumption in cities with full flushing systems
	280	Industrial and commercial towns with full-flushing system
The Ninth Five-Year Plan (1997-2002)	125	Cities with planned sewerage systems
	70	Cities without planned sewerage system
	40	For those collecting water from public stand-posts
Tenth Five-Year Plan (2002-07)	150	Metropolitan or megacities with planned sewerage system
	135	Non-metropolitan cities with planned sewerage system
Union Ministry of Works and Housing[24]	140	Household water use
Ministry of Urban Development (2012 Service level benchmarks)	135	No particular use; combined with eight other service level benchmarks

Adapted from Shaban, 2008.

The standards seem to make certain assumptions for different purposes of water use. What is key is the assumptions on the minimum quantity of water to be supplied seems to vary inconsistently for similar purposes such as the city size (whether the city is metropolitan city or a megacity) and have arbitrary criteria such as presence of sewerage or full-flushed system rather than water needs. For examples, the water use assumed for cities using public stand-posts is much lower than other cities that presumably have citywide individual piped connections. The standards also seem to implicitly assume presence of functioning piped infrastructure networks (which may not be the case as discussed in detail later in this chapter). The 135-LPCD standard however seems to be a common metric of service and continued to be used over time.

A breakdown of two of the standards; one established by the Union Ministry of Works and Housing[25] (140 LPCD) (WG, 1999) and the other by the BIS (135 LPCD) shows the assumptions for water use at a household level.

[24] The Ministry of Housing and Urban Poverty Alleviation is the apex authority of Government of India at the national level to formulate policies, sponsor and support program, coordinate the activities of various Central Ministries, State Governments and other nodal authorities and monitor the programs concerning all the issues of urban employment, poverty and housing in the country.

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Table 3-6 Standards for Urban Water Use

Purpose	Quantity in LPCD (Union Ministry of Works and Housing)	Quantity in LPCD (BIS)
Drinking water	5	5
Cooking	5	5
Bathing	55	55
Washing of utensils, clothes, and household	45	40
Flushing of toilet/sewer	30	30
Total (of above)	**140**	**135**

A quantity-based approach can also be seen at the international level. For reference, water needs and requirements are categorized very broadly as is evident from the categories established by the United Nations/World Health Organization (WHO) (Table 3-7).

Table 3-7 Categories of Water Access Based on Water Quantities Available

Category	Quantity of Water Available
1. No access	Below 5 LPCD
2. Basic access	Average ~ 20 LPCD
3. Intermediate access	Average ~ 50 LPCD
4. Optimal access	Average 100-200 LPCD

Source: UN&WHO, 2003; Howard and Bartram, 2003

For research purposes, with such varied levels of minimum water quantities that are used as standards or categories of service, an average or a best estimate of an average quantity of water required is used in studies depending on the goal of the study. For example, the Tata Institute of Social Sciences[26] in a report on water use in different Indian cities, states the following:

> *…various agencies recommend different quantities of requirement of water for domestic use, we have taken 100 LPCD consumption (an indication of availability, as consumption is determined by the availability) of water as benchmark for finding out water deficient households. It must be noted here that there is no strong basis for this 100 litres bench mark but it is some kind of average requirement one must get in order to live with minimum health and hygiene.*
> *- Shaban, 2008, p.6*

The discussion of the water service standard or the intended water service so far has been about supplying certain volumes of water, which is considered the best estimate of water supplied for different basic needs.

More recently, in 2012 the MoUD established specific service level benchmarks for water service. The benchmarks were established as part of an effort to emphasize "its [or the system's] performance related to the …access to quality service and on the prevalence and effectiveness of the systems to manage the water supply networks" (MoUD, 2012). The first two columns in Table 3-8 show the nine water service level benchmarks and the last column explains what the benchmark is an indicator of.

[26] A premier social science institute in Asia.

Table 3-8 Water Service Level Benchmarks

Indicator	Benchmarks	Indicator of What?
1. Coverage of water supply connections	100%	Service
2. Per capita supply of water	135 LPCD	Water quantity supplied
3. Extent of metering of water connections	100%	Water quantity metered
4. Extent of non-revenue water	<=15%	Quantity of water supplied that is not billed or is lost through the system
5. Continuity of water supply	24 hours	Time of water supplied
6. Efficiency in redressal of customer complaints	80%	Service
7. Quality of water supplied	100%	Quality of water supplied
8. Cost recovery in water supply services	100%	Management of operations
9. Efficiency in collection of water supply related charges	90%	Management of operations

As shown in Table 3-8, supplying 135 LPCD of water – the previously mentioned and current BIS water service standard – forms only one of the nine benchmarks. One other benchmark is to supply water continuously for 24 hours (MoUD, 2012). The service level benchmarks thus incorporate both volume-based as well as flow-based indicators. The water service standards continue to be determined and established by the Centre and the implementation of these standards continue to occur at the local levels. The new service level benchmarks involve continuous supply of piped water to all users with a minimum of 135 LPCD with no upper limit. Currently, however only the volume-based standard of supplying (a minimum of) 135 LPCD continues to be practiced by utilities (without the continuity in the supply) as we see in the next section.

My interviews with local engineers and planners as well as review of Government of India water policy documents do not indicate presence of direct involvement of local jurisdictions in the central-level decisions on major infrastructure or on nationwide urban growth policies or construction of large capital works.[27] An example is a glimpse at the process of standard-setting by the BIS. The BIS states that standards are formulated (see quote below) consistent with the International Organization for Standardization and after careful investigation and deliberations.

> *….The work of formulation of standards on any specific subject shall be undertaken when the Division Council concerned is satisfied as a result of its own deliberations or on investigation and consultation with concerned interests that the necessity for standardization has been established.*
> *…. standards are developed keeping in view national interests and after taking into account all significant view points through a process of consultation. Decisions in BIS technical committees are reached through consensus. As a policy, the standards formulation activity of BIS has been harmonized as far as possible with the relevant guidelines as laid down by the International*

[27] However, the local jurisdictions such as municipalities do set zoning regulations and are responsible for maintenance of the local infrastructure systems.

Organization for Standardization (ISO). BIS, being a signatory to the Code of Good Practice for the preparation, adoption and application of standards (Article 4 of WTO-TBT Agreement, Annex 3) has also accordingly aligned its standards formulation procedure.

- Bureau of Indian Standards (BIS), 2014, "How Indian Standards are Made?", Standard Formulation

Implementing the Standards: The Local Arm – Local Municipalities or Private Enterprises?

In the past two decades, local urban water service delivery has been influenced by two movements in determining *who* delivers water: decentralization and privatization or increased corporate involvement. Yet, as I find below, both movements point to the need for greater attention to the institutional mechanisms rather than only delegating responsibilities to local jurisdictions or private companies.

Decentralization

In his historical assessment and the planning roots in India, Banerjee (2003) finds that the idea that local government is closest to the people, widely held, e.g., in the U.S., has been absent from the Indian organizational framework until the recent two decades. This changed at least at the policy level in 1992. The Government of India, through the 74th Constitutional Amendment, proposed delegation of the responsibility and powers from the States to the ULBs such as municipal corporations. The 74th Amendment proposed to provide for…

(a) Constitution of three types of Municipalities:
(i) Nagar Panchayats for areas in transition from a rural area to urban area;
(ii) Municipal Councils for smaller urban areas;
(iii) Municipal Corporations for larger urban areas.
… and
(g) Devolution by the State Legislature of powers and responsibilities upon the municipalities with respect to preparation of plans for economic development and social justice, and for the implementation of development schemes as may be required to enable them to function as institutions of self-government.

In addition, the recent 2012 National Water Policy (Section 9.1) calls local governing bodies such as municipalities to be "involved in planning of water resource projects" albeit it does not provide specific direction on it.

The 74th Amendment stipulates that the ULBs are responsible for providing water and sanitation services. …In the operational sphere, it ***shall function professionally and autonomously*** *within the framework established by higher tiers of government through transparent policy and regulatory guidelines and compliance mechanisms.*
- MoUD, 2009, p.38

The phrases in bold in the quote above (emphasis added) highlight certain institutional aspects such as professional and autonomous operations of the ULB, which reflect the belief in improving the performance of institutions. However, the following quote shows a different picture:

> *The 74th Constitutional Amendment Act did not provide for a 'municipal finance list' in the Constitution to match the municipal functions listed, thereby signaling an 'incomplete devolution' package and leaving the issue of financial devolution to state governments.*
> *- HPEC, 2011, p.126*

The stipulation and proposition of decentralization needs to be accompanied by the delegation of responsibilities to the ULBs and the necessary accompanying authority as well as resources to deliver water in many cities. For example, large capital works have been still taken up by the State government with minimal participation of the local agencies except for operating the systems after they are built. Plus, at times, decentralization has not proceeded as intended; one striking case is the cities of Hubli-Dharwad in the State of Karnataka where the local municipal water operations have been transferred to the State water department (discussed further in Chapter 5).

Private Sector/Corporate Involvement

While the decentralization process is still in progress since the 74th Amendment was made in 1992, there has been a policy impetus on in involving private enterprises in the local operations, including forming public-private-partnerships (PPPs) in new water projects in India, where they would be "insulated from political interference".

> *… the autonomous, ring-fenced service provider will be **accountable to the ULB**, that is, politically accountable but **insulated from political interference** in operational matters*
> *- MoUD, 2009, p.38*

Expanding the role of private corporations in water service delivery has been one of the more contentious proposals as part of the MWR's Draft 2012 National Water Policy. The policy calls out the ineffective water management and emphasizes private sector participation for improvement. Some stark shifts in the new policy from the previous 2002 policy are the expanded role of the private sector in water delivery and treatment of water as an economic good over and above the preemptive uses of sustaining life and ecosystem:

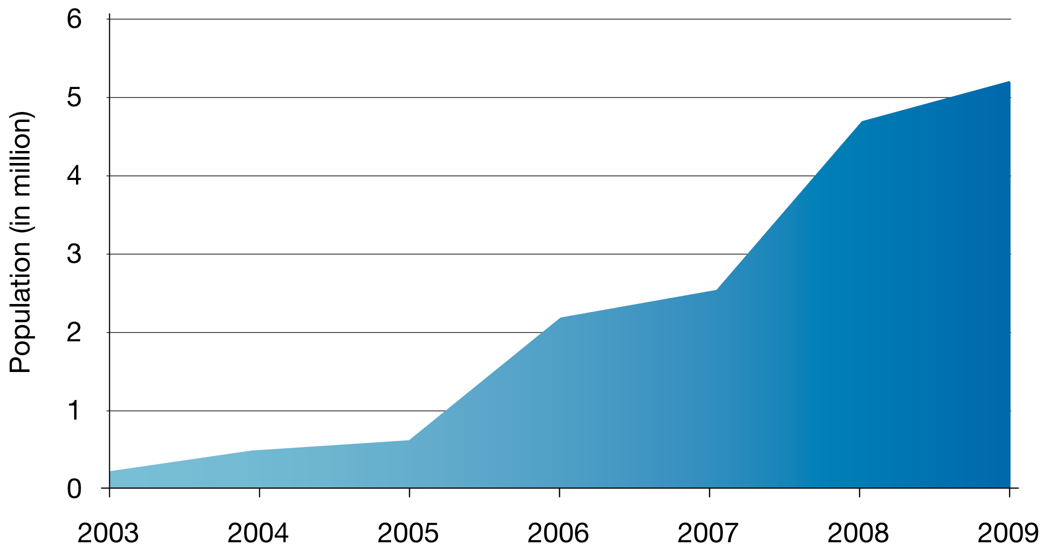
> *… water should increasingly be subjected to allocation and pricing on economic principles.*
> *- Section 7.1 Draft National Water Policy*

> *…The state has to be gradually shifted to that of a regulator of services and facilitator for strengthening the institutions responsible for planning, implementation and management of water resources. The water related services should be transferred to community and/or private sector with appropriate Public Private Partnership mode.*
> *- Section 13.4 Draft National Water Policy*

The local implementation and operation of water deliveries can be viewed through the increasing momentum in forming PPPs, albeit with limited critical evaluation or evidence of sustained performance.

In a review of PPPs in the Indian urban water supply sector since the 1990s, the Water and Sanitation Program at the World Bank found that there has been an increase in the number of PPP projects initiated or awarded since the 1990s (WSP, 2011). The PPP projects today have a reach of approximately five million urban population and the proportion of projects successfully awarded has also increased. Only four PPP projects were awarded through 2004. Since 2005, 13 projects have been awarded. Up to 2004, only 40 percent of the initiated projects were successfully awarded. Since 2005, this number has more than doubled (WSP, 2011; Figure 3-14).

Figure 3-14 Timeline of Population of Cities with Active PPP Projects



Source: WSP, 2011, p.27

However, in terms of the performance of the PPPs, the report (WSP, 2011) states the following:

> *It is too early to arrive at a conclusion about the success or failure of private sector participation in urban water in terms of outcomes. It is nevertheless possible to gain an improved understanding of factors which have contributed to the success or failure of contracts being awarded for water PPP projects.*
> *- The Water and Sanitation Program, 2011, p.43*

Studies on private-sector participation (Devkar et al., 2013; WSP, 2011; 2014) list some factors contributing to the success or failure of awarded contracts:

> *…in all the projects the consequences of not meeting the targets, or standards outlined in the contracts, are either too weak or too unrealistic. There is not adequate incentive to perform, and there is limited recourse for poor service performance. The service level objectives should not only influence the PPP choice and contract design but should be embedded in specific and meaningful contractual commitments*
> *- WSP, 2014, p.23*

But these factors, spelt out for a PPP, may also apply to the operations of a local municipality or utility. A recent study of five urban PPP projects (Devkar et al., 2013) in particular on the competency of ULBs in the context of decentralization and for urban PPPs in water delivery and sewerage project in India provides an insight in the larger governance process:

> *ULBs often sought assistance from external agencies to supplement competency gaps. These external agencies primarily supplemented competencies up until the selection of the private operator. ULBs relied more on in-house competencies in order to manage service management and project lifecycle needs. In particular, while ULBs have been focusing on asset creation in conjunction with the private sector, they have not given enough attention towards the process of service delivery over the course of the concession period. This is reflected in the fact that effort was made to bridge competency gaps in project development (either through in-house or outsourced means), but not in long-term project governance.*
>
> *- Devkar et al., 2013, p.140*

The local jurisdictions have new or greater responsibilities of meeting the growing, heterogeneous urban water demands amidst the decentralization as well as increased private sector involvement movements. The local water demands however remain far from being met by the piped water delivery systems.

3.4.2 Providing Piped Water Service

Local municipalities provide piped water through centralized infrastructure that they operate and maintain. In this section, we see that the piped connections do not have full coverage in India, plus that having piped connections do not necessarily mean adequate water service. Yet the traditional approach of delivering water through centralized piped networks continues to be perpetuated by the central policymakers. It is important then to understand the currently delivered piped water service through centralized distribution in cities in the light of the service level benchmarks. Centralized systems emerge as the predominant and actively pursued mechanism, albeit barely functioning, while other mechanisms practiced by the municipalities appear marginal, evident through their limited mention in the policy debates.

Piped Water: The Service Delivered Versus Intended, and Experienced By Users

A citywide pipeline network system connects with the users through water mains and tie-ins to piped connections for urban households and other uses.[28] The connection can be in the form of different water access points for users, which may or may not reach all urban users. With the heterogeneity in urban development and the scale and pace of urban growth, I investigate the piped water service in terms of the service attributes in the national service level benchmarks: service coverage (e.g., piped coverage and other water access points), water availability (e.g., quantity and duration it is available), and quality of water (e.g., it is treated or needs treatment by the household).

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[28] Interviews with municipal water engineers indicate that commercial, institutional, and industrial users such as hospitals and railways are connected to the water network directly through the city water mains.

Before examining the piped water service, I highlight the variations in the available data by giving some examples, which indicate the need for detailed and careful data collection prior to determining any particular approach to delivering water, especially that of full coverage of supplying pressurized water through centralized networks on a continuous basis.

The extent of the piped water distribution is determined at the local utility or municipality level; it is this local entity that operates and maintains the piped distribution system.[29] The data for piped coverage however varies with the source. I find that the estimates of water coverage is de facto provided by the percentage of households connected to the centralized infrastructure system through individual pipes and sometimes, including stand posts or communal taps. For example, a survey of 20 utilities in India conducted by the Government of India (GOI) and Asian Development Bank (ADB) (2007)[30] provides estimates of population served by house connections and by public taps in the surveyed cities, where the reported average coverage in years 2005-06 was 81.2% (ADB&GOI, 2007). As against this, the International Benchmarking Network (IBNET) database (2014) estimates piped coverage in India (before 2007) at 89% in 2005. These estimates are higher than the more recent national coverage reported at approximately 70% (Ministry of Statistics, 2011; also discussed below).

There are also differences in how the coverage is computed, which raise questions on the consistency of data used for setting policies. One way, the total coverage is calculated is by using the sum total of house connections and public taps (KUWSDB, 2013). Another way is by using the number of house connections and public taps multiplied by the corresponding average number of persons served by each type of connection (ADB&GOI, 2007, p.x). However, the ADB& GOI survey report also states that, "in a number of instances, the reliability of the average number of persons served became suspect when the resulting population served exceeded the total population in the area of responsibility". There is a lack of information on the actual number of people that the utilities serve. While the number of connections is known, the average number of persons that each type of connection serves remains suspect (ADB&GOI, 2007, p.x).

At the national level, the Ministry of Statistics (2011) estimates that approximately 52% of India's population (and 71% of its urban population) receives its drinking water through piped connections, which include both individual and public taps or standpipes (Table 3-9).

Table 3-9 Access Points for Drinking Water Used by Households

Drinking Water Source	Percent Households		
	Urban	Rural	Total
Improved Source*	95	84.5	87.9
Piped water into dwelling/yard/plot*	50.7	11.8	24.5
Public tap/standpipe*	20.3	16.1	17.5
Tube well or borehole	21.3	53.2	42.8
Protected spring	0.1	0.3	0.2
Protected dug well	1.8	2.8	2.5
Rainwater	0	0.2	0.1

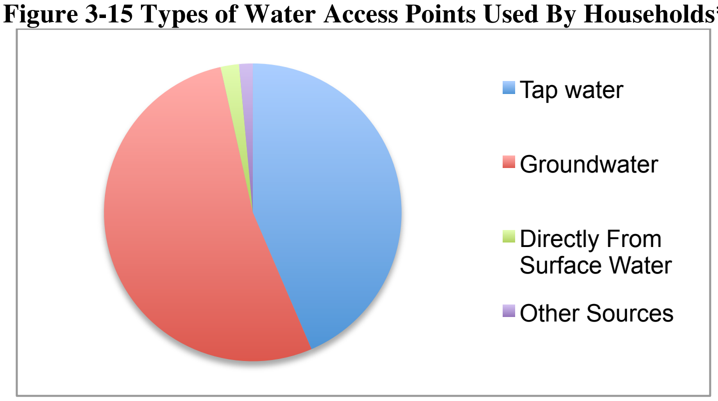
[29] Capital investments are made and large, centralized infrastructure systems are built by the States and handed over to the local municipalities for operation and maintenance, which includes extending water connections to new users, the responsibility of which may vary with the financial investments and the State and local jurisdictions.
[30] One of the early reviews of utility performance in India.

Drinking Water Source	Percent Households		
	Urban	Rural	Total
Bottled water improved source for cooking, hand-washing	0.8	0.1	0.3
Non-improved source	4.8	15.4	11.9
Unprotected dug well	2.9	12.4	9.3
Unprotected spring	0.1	0.8	0.6
Tanker truck/cart with small tank	0.9	0.3	0.5
Surface water	0.8	1.8	1.5
Bottled water, non-improved source for cooking, hand-washing	0.1	0	0
Other source	0.2	0.1	0.2
Total	**100**	**100**	**100**

* Includes water service through centralized piped infrastructure system. Piped water into dwelling/yard/plot and public tap/standpipe are provided as part of the municipal water supply through centralized infrastructure typically from a surface water source.
Source: Ministry of Statistics, 2011

In terms of granularity, the national-level data (Table 3-9) shows the different water access points, which serve as water sources for the households, which is not necessarily observed in the case of the local-level utility data. Another set of national-level data on water access is provided by the Indian Census. Figure 3-15 below shows a profile of the different types of water access points used by households in India, which are termed by the Indian Census as "water sources". However, in this case the categories of the sources do not provide clarity in the divisions. The actual source for tap water may be surface water provided by the municipality via the citywide pipeline network, or it may be groundwater provided to a community or a multi-family apartment building from a well located in the premises. Households obtaining water directly from surface water may be fetching or drawing water manually and not getting water delivered.

Figure 3-15 Types of Water Access Points Used By Households*



* The figure shows three broad categories that comprise of subcategories of water sources as follows: Tap water (from treated and untreated surface water sources), groundwater (from a hand pump, tubewell or a borewell), and directly from surface water (such as a spring, river or a canal, tank, pond, or a lake). "Other sources" are not defined.
Data is for both urban and rural households. Centralized systems delivering water through taps are more common in urban areas, although not absent but are rare in rural areas.
Source: Census of India Databook, 2012.

I was able to find more information on the water coverage and details on the other water service delivery mechanisms besides piped water service only when I categorically and specifically requested the local jurisdictions for the information for my research; this is discussed more for the case study in Chapter 5.

Water Access

Based on the national-level data, if we assume that just over 70 percent of Indian urban households (2011 est.) obtain piped water[31]; water is available to these households through taps that provide connections to centralized piped water distribution networks *designed to*, but which in reality do not provide round-the-clock pressurized water.

In neighborhoods with piped households, different types of communities have different levels of access, such as having individual water connections inside their homes, sharing taps with neighbors, or having access to outdoor communal taps. In addition, some communities depend on water delivered via tankers or trucks rather than through pipes (see Figure 3-16 below).

Figure 3-16 Piped Water Connections and Tanker as "Water Sources" for Households

A Communal Tap

Closer View of a Communal Tap

A Public Tap

Tanker Delivering Water

[31] The definitions in use tend to be static, so that once a community has been 'served' it is considered covered, regardless of the current conditions of the facilities or water table or the population growth that has occurred after the connections are installed.

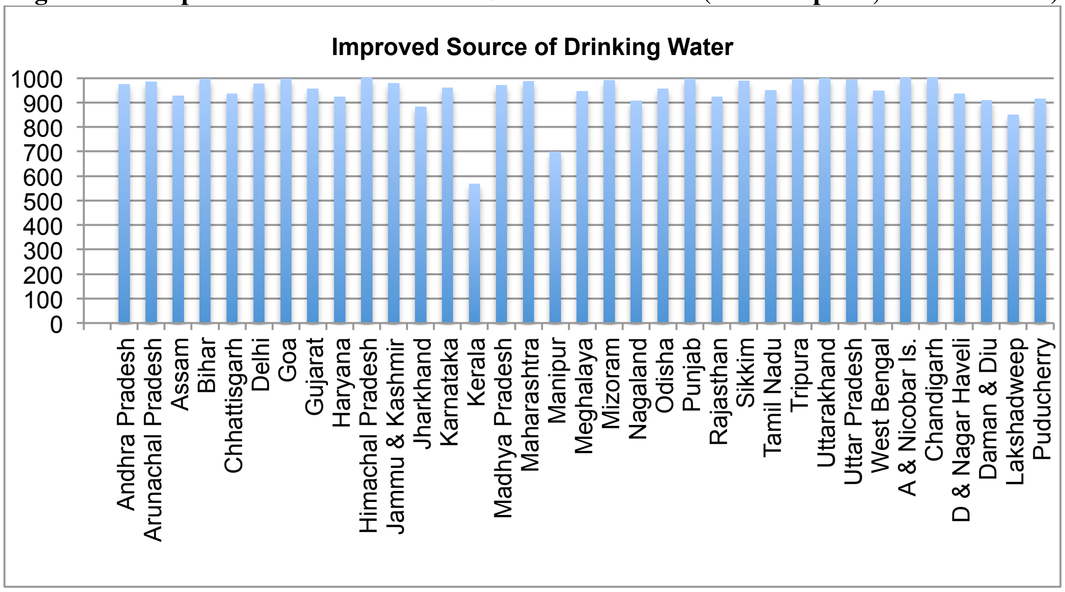
Users that do not have access to piped connections to municipal water supply form approximately 30% of India's urban populations. Users with no piped water service commonly obtain water delivered by tankers known to be mostly operated by (unregulated) private vendors at exorbitant prices (Zerah, 2000; Ranganathan et al., 2009; Davis, 2005) or they manually draw and fetch water from a groundwater well or have it connected to the house with a pipe. The well may be located within or outside their premises. Figures 3-15 and 3-16 above show examples of how households obtain water, i.e., their main "water sources".

What was noteworthy through field observations is that the type of water service, by way of the source or availability or the quality of water available and is delivered, does not have a particular pattern for a particular type of housing development. For example, an authorized apartment building may have private groundwater wells in the building premises serving as the primary water source, from which water is pumped to the individual units. A community of single-family homes, regardless of being authorized or unauthorized, may obtain water through private tankers and have no functional piped connections. It is however common to see communities farther from the city core receiving water by tankers mostly because the distribution network and piped connections have not been able to catch up with the development.

Having access to piped water connections or another water source does not necessarily guarantee water reliability – in terms of its availability or quality at the tap. Most municipality-supplied piped water service is intermittently available, the water pressure is irregular, or the water is of questionable quality (McKenzie and Ray, 2009). Similar to the households that have no piped water, households having access to poor piped water use modes, such as purchasing water from vendors as alternative or supplemental modes. These modes serve as a "back up" option for households when piped water fails; further such modes serve as options for local municipalities as well. Based on newspaper articles (Indian Express, 2011; 2012; 2014) and my interviews with local municipal engineers in different cities, alternative access points such as tanker deliveries to serve drinking water to the unserved are also used by municipalities, but mostly as back up options.

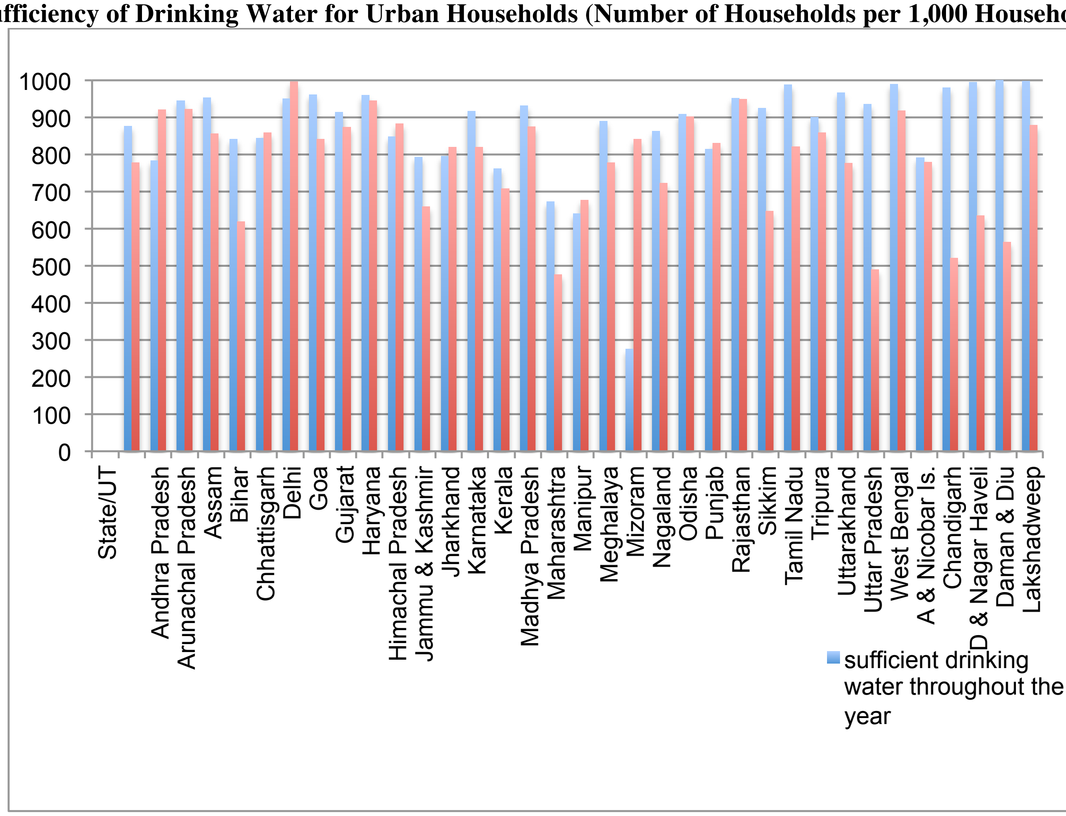
The charts below (in Figure 3-17) on national-level data indicate access to drinking water sources in different ways: an improved source such as 'bottled water', 'piped water into dwelling', 'piped water to yard/plot', 'public tap/standpipe', 'tube well/borehole', 'protected well', 'protected spring', and 'rainwater collection'; as well as having 'sufficient quantity of drinking water through the year'; and having drinking water facilities 'within premises' and 'outside premises within 0.2 kilometers' or 'between 0.2 and 0.5 kilometers'. The definition of "sufficient" drinking water was however not available.

Figure 3-17 Improved Water Sources for Urban Households (Number per 1,000 households)



Note: Improved source of drinking water include: 'bottled water', 'piped water into dwelling', 'piped water to yard/plot', 'public tap/standpipe', 'tube well/borehole', 'protected well', 'protected spring', and 'rainwater collection'.

Sufficiency of Drinking Water for Urban Households (Number of Households per 1,000 Households)



Note: The availability of drinking water from the principal source was taken as sufficient throughout the year if availability of drinking water was sufficient in each of the calendar months of the year.
Source: Ministry of Statistics, 2013

The second chart in Figure 3-16 above shows only "sufficiency" of drinking water to the households and number of households in 1,000 households across the Indian states. Under this parameter, the chart shows higher number of households per 1,000 households that have access to sufficient drinking water throughout the year (blue bars) than those having direct access to drinking water within premises (red bars). Direct access to drinking water within premises was higher only for three states: Andhra Pradesh, Delhi, and Mizoram. Access to drinking water within premises may include, but does not necessarily mean, having a piped connection inside the dwelling, therefore the chart indicates that sufficiency of drinking water throughout the year can also be achieved through sources other than pressurized piped water available on a continuous basis.

Water Availability: Quantity Supplied and Reported by Utilities Versus Delivered to and Reported by Users

The traditional approach of building centralized infrastructure with piped networks involves supplying pressurized piped water continuously (Andey and Kelkar, 2009). Even notwithstanding the continuity in the supply, a study of water utilities in 248 cities (first of its kind in India; CEPT, 2011) in the state of Maharashtra shows that the utilities supply an average of 100 LPCD, which is below the standard benchmark of 135 LPCD set by the Government of India – also the new service level benchmark (MoUD, 2012). The 100-LPCD standard is far above the 20 LPCD of water supply that the MDGs seek for all and the 50-LPCD standard that WHO claims will assure enough water for both consumption and hygiene (Howard and Bartram, 2003).

Another study – a nationwide 20-utility survey (ADB&GOI, 2007) reported the quantity of water supplied by the utilities. From the "user side", there was a Tata Institute of Social Sciences[32] study based on a 2,734-household-survey on water service in seven major cities in India (Shaban, 2008). The household survey shows far lower domestic water consumption levels by households than the quantity of water supplied as reported by the utilities (Table 3-10).

Table 3-10 Domestic Water Consumption (per household and per capita) in India

Cities	Water Consumption Per Household Per Day (Liters)	Water Consumption (LPCD)	Water Supplied (Source: ADB&GOI, 2007)*
Delhi	377.7	78	-
Mumbai	406.8	90.4	191
Kolkota	443.2	115.6	130
Hyderabad	391.8	96.2	-
Kanpur	383.7	77.1	-
Ahmedabad	410.9	95	171
Madurai	363.1	88.2	-

- = Not available
* Reported by the utility
Source: Shaban, 2008

Using all the three examples where data was available (Table 3-10), the 191 LPCD water supplied by the municipality in Mumbai is much higher than the water consumed (90.4 LPCD).

[32] A premier social science institute in Asia.

Water supplied in Kolkata (130 LPCD) is higher than the household-reported quantity of 115.6 LPCD. Similarly water supplied in Ahmedabad (171 LPCD) is much higher than the 95-LPCD consumption reported by households. This points to a discrepancy in the presumption that water supplied is equivalent to the water service experienced by the user, or that all of the water supplied is received by the user.

Here I present the water supplied by the provider versus the water consumed because investigating the methods of deriving the water consumption levels reveal that water consumption here is assumed to be the same as water supplied. The ADB&GOI study (2007; p.ix) calculates water consumption for the utilities as follows:

> Per capita consumption (LPCD) = [total annual domestic consumption (cubic meters) x 1,000/365] / [number of people served]

The accuracy of the water consumed however is questionable since the study also states that, "with less than 25% metering of service connections, assessing the actual amount consumed by users is difficult" (ADB&GOI, 2007). The water consumption therefore does not only assume that all of water supplied reaches the user (which is debunked by the preceding discussion and Table 3-10) but also that all the metered households have properly functioning meters, when the same survey reports non-working and out-of-service meters in some cities.

The water consumption estimates provided by the utilities alone may not provide the best representation of water usage, yet they continue to be used by national policymakers.

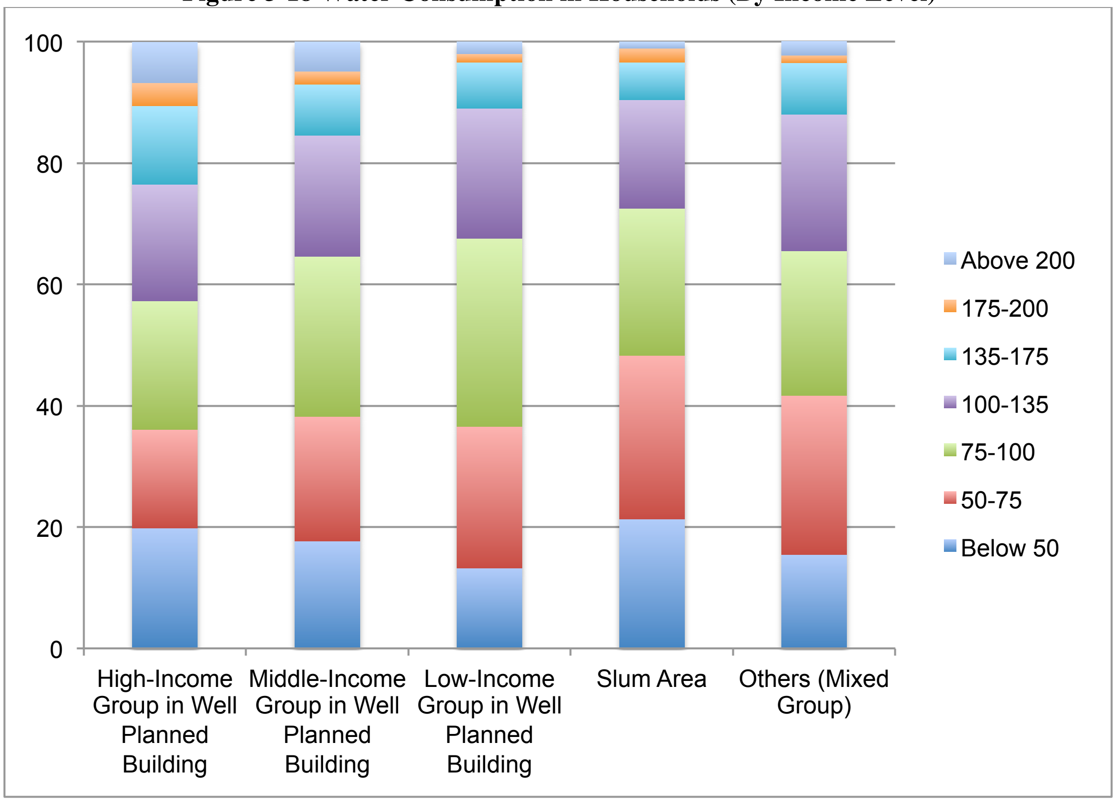
Also, the following statement from the utility survey report indicates that "water consumption" is lower in some cities, not necessarily due to lower quantities consumed by the users but due to water losses or constraints on the utility side.

> *"...The low-consumption areas… Indore and Chennai have source constraints. Amritsar and Bangalore have high levels of unaccounted for water (UFW)"*
>
> *- ADB&GOI, 2007, p.8*

Within the mixed viewpoints of water consumption, there is another layer of water supply and consumption levels – the levels reported by different income groups. A study in 7 cities in India (Shaban, 2008) finds that the water consumption among different areas within a city does not vary widely, as much as it varies with the different income groups. Just as the water consumption levels reported by the utilities (ADB&GOI, 2007; CEPT, 2011) represent the water supplied to the households, here the 7-city survey study of households (Shaban, 2008) shows that water consumption levels represent or are at least in direct proportion to the water quantity (service) received by the household.

The high-income group (HIG), medium-income group (MIG), and low-income group (LIG)[33] areas are found to fall under water consumption range of 75-100 LPCD, and the slums and mixed areas fall under the consumption range of 50-75 LPCD (Figure 3-18 below). Where 23.4% of the population in HIG areas uses water above 135 LPCD, in slum areas only 9.6% of population uses water above 135 LPCD. The consumption of water by various socio-economic classes shows that although a sizeable proportion of households in all the classes consume water below 50 LPCD, it is the lowest-income category that shows very low water consumption (Shaban, 2008, p.8).

Figure 3-18 Water Consumption in Households (By Income Level)



Source: Shaban, 2008.
Note: The income levels were categorized based on household assets over monthly income, which may be under or overreported.

The water consumption thus varies with the income groups, which is in direct proportion to the water received by the groups, highlighting the inequity in service.

> *Households with monthly income of up to Rs. 3,000[34] [the lowest-income category in the study] suffer the most as about 72% of such households are found to be water deficient (less than 100 LPCD [standard used in the study]). Area-wise classification of water deficient households*

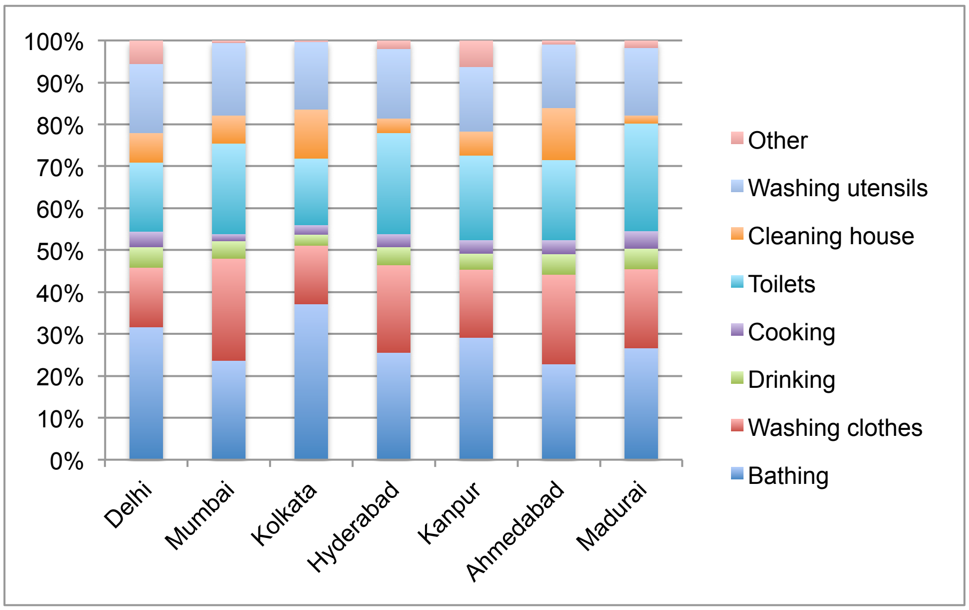
---

[33] Income groups were determined based on the type of development they were located in (from planned buildings to slums), and data collected on annual income and households assets. However, due to the higher possibility of underreporting of income, household assets were used as the primary indicator of income.
[34] Rs. 3,000 = ~US$ 50.

shows that …these are slum areas, which have maximum percentage of water deficient households in all the cities.
- *Shaban, 2008, p.10*

The quantity of water consumed in most of the Indian cities is not just "determined by the user demand but the quantity of water that is supplied" and eventually that reaches them (Shaban, 2008). People attempt to adjust to the quantity (as well as quality) of water available (Shaban, 2008, p.6). Figure 3-19 below shows how the households allocate their water use even within the low water quantities available for the various domestic purposes along with a graphical representation of the different activities that the water is used for.

Figure 3-19 Water Use by Activity (Percent of Total Water Consumption)



Source: Shaban, 2008

If the consumption were to depend on the "water supply", in this case the water service available (much lower quantity than that supplied), that would that also mean that if the water supply were greater, there is a likelihood that consumption would increase over time. Continuous supply of pressurized piped water available to users in countries such as the U.S. does show much higher water consumption compared to that in India.[35]

Duration of Water Availability

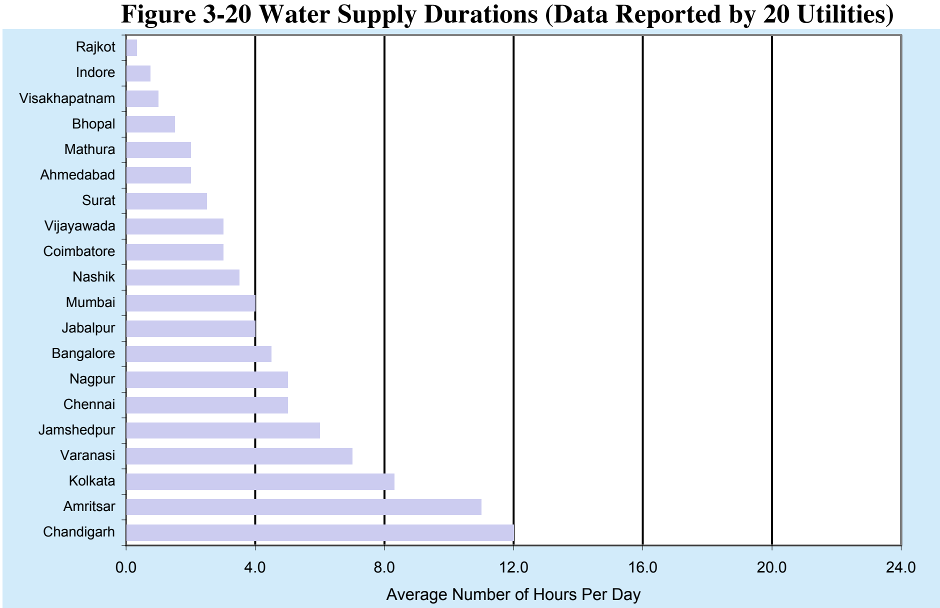
Another metric of water service is how many hours the water is available for especially when the piped network does not supply water on a continuous basis. A survey of municipalities in the state of Maharashtra finds that water is supplied for an average of 1.7 hours a day and many ULBs do not provide water every day (CEPT, 2011). A nationwide 20-utility survey (GOI&ADB, 2007) indicates that utilities supply water for a maximum of 12 hours and an

[35] The U.S. Geologic Survey estimates that the average American, who receives continuously pressurized piped water, uses 80 to 100 gallons of water or 300 to 380 liters per day (Kenny at al., 2009).

average of 4.3 hours a day. The survey further showed that water supply durations varied widely – from 1 hour a day in Rajkot to up to 12 hours a day in Chandigarh (Figure 3-20). In many cities including metropolitan cities of Mumbai, Bangalore, Chennai and Kolkata, water was reportedly supplied only for 4-8 hours a day. These varying durations of water supply can indicate different problems such as malfunctioning physical infrastructure such as leaking pipes where water is lost in transit and not available to all users at the same time, or there is a water resource constraint (insufficient water in the storage reservoirs), or inadequate infrastructure to transport larger quantities of water into the city from a distant water source to meet all of the demand (Andey and Kelkar, 2009; Vairavamoorthy et al., 2007). It may be also be due to the inability of the infrastructure to withstand high water pressures that the utility finds the need to ration water during specific hours for different neighborhoods in a city. Alternatively, based on interviews with utilities, I find that continual extension of piped connections to new users with no corresponding increase in the system water pressure reduces the water pressure at the existing connections and thus its availability.

By supplying water for only a few hours a day, the utilities are performing at significantly low levels than the 2012 service level benchmarks of supplying water continuously, which was also the original intent of the systems.

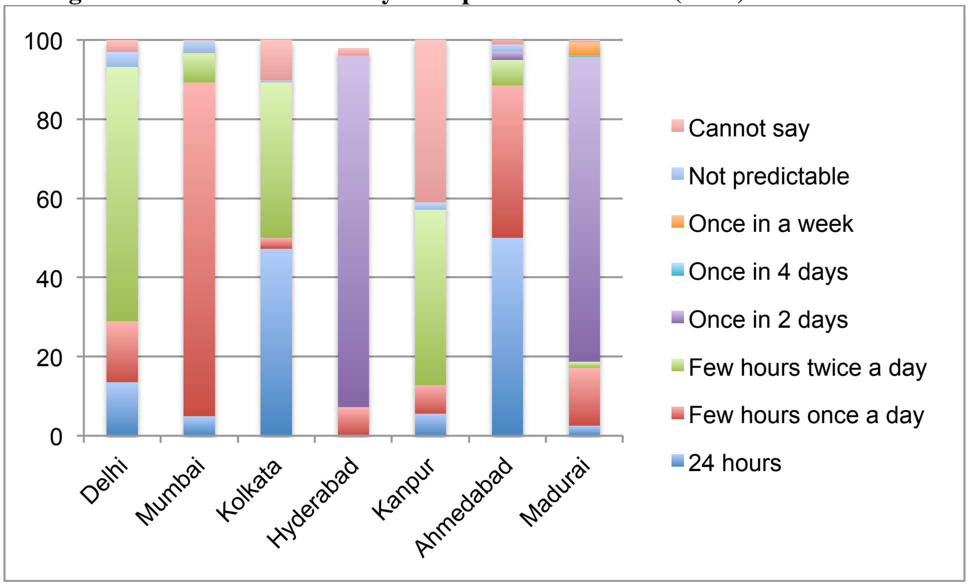
Figure 3-20 Water Supply Durations (Data Reported by 20 Utilities)



Source: ADB/GOI, 2007

On the user side, a household survey in seven cities in India (Shaban, 2008) indicates that about 25% and 27% of the households claimed that water was available for a few hours (less than 4 hours) twice a day, and once in a day, respectively (Figure 3-21 below). About 21% of the households in these cities report that water on tap comes for a few hours in two days (Shaban, 2008).

Figure 3-21 Water Availability at Taps for Households (in %) in Indian Cities



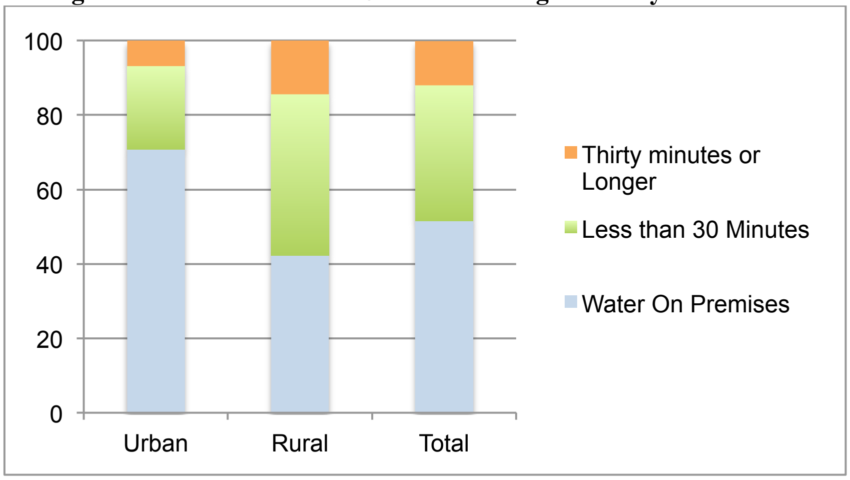
Notes: NA = Not Available
Source: Shaban, 2008

What is noteworthy is that neither do the utility surveys or does literature on water service cite any municipality supplying water for 24 hours. Yet here about 18% of the households reported that the water was available at the tap for 24 hours. When the municipality does not supply water for 24 hours and there are some households that report 24-hour availability at the tap, it indicates that some additional mechanisms are in play. For example, households may be storing water in a private or communal storage tank[36] that enables them to have water availability round-the-clock. More importantly, water seems to be available to the households 24/7 without the utility continuously supplying pressurized piped water.

Water availability to the user is not only related to the running water available at the tap (Figure 3-21 above) but also to the time taken by the household to obtain water; this also includes accessing water at points other than at the tap (Table 3-9 above). Again, at the national level, a household survey (Figure 3-22 below) provides a broader perspective by showing the time taken by users, not only in terms of the duration of the municipal water supply at the taps but also to obtain water from other water access points.

[36] Based on field observations and interviews, the individual tank may be located within the house or on its rooftop and the communal tank may be located on the rooftop of a building or may be under ground.

Figure 3-22 Time Taken to Obtain Drinking Water by Households



Note: The time taken to obtain drinking water for rural households is provided for comparative purposes only. Data for approximately 0.2% of households was recorded as "do not know" or "missing" and is not shown in the chart.
Source: Ministry of Statistics, 2011

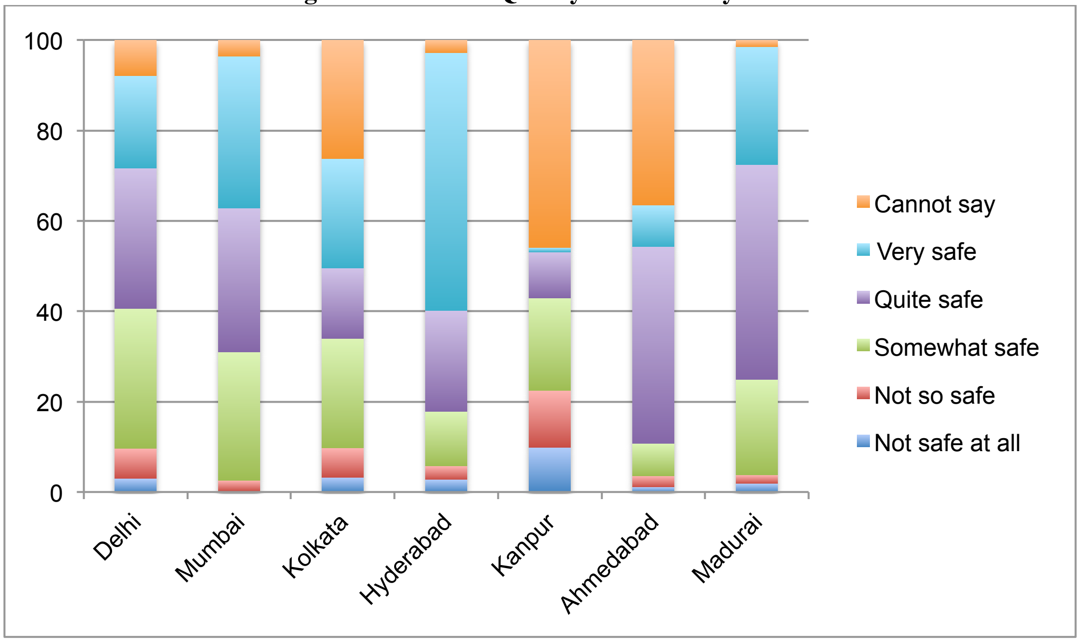
Water Quality: Treatment Provided Versus Received By the User

Municipal piped water supplies are treated at centralized facilities to a level safe for consumption; the 2012 national service level benchmarks target continuous supply of water of drinking water quality. The water includes residual chlorine to provide the necessary level of disinfection as stipulated by the CPHEEO. The water is however not received or necessarily perceived at the same quality by the users triggering the need for additional treatment at the point of its use.[37]

On the user side, Figure 3-23 below shows that only about 54% of the households view municipal water "quite safe" or "very safe". In Madurai, Mumbai and Delhi, about 74%, 65% and 52% of the households, respectively, view municipal water supply "quite safe" and "very safe", but in the case of Kanpur, only about 11% say so.

[37] The reliability of the water quality data provided by the utilities is very low (CEPT, 2011, p.13), hence are not provided here. The ADB&GOI (2007) utility survey reported overall "good" water quality with over 90% samples passing the residual chlorine test. However, CPHEEO has physical and bacteriological standards for water quality, data for which was not available.

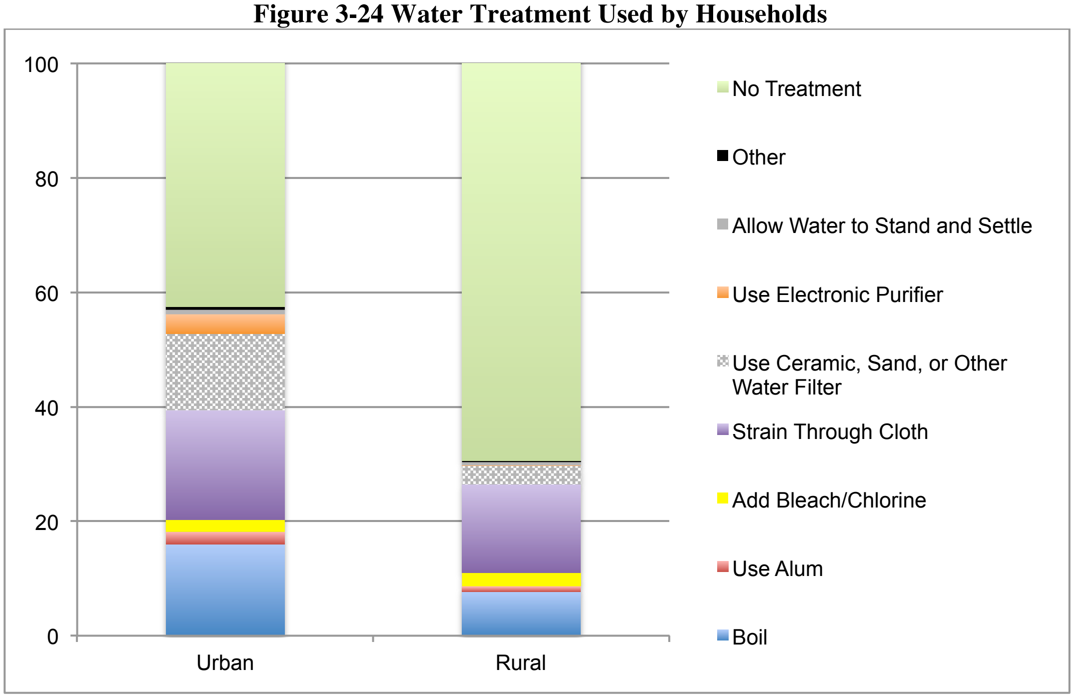
Figure 3-23 Water Quality Perceived by Users



Source: Shaban, 2008

One way the perception of water quality can be studied is by understanding if the households do in fact use water treatment methods. Figure 3-24 below shows the different ways in which households treat water before use. The survey describes the treatment methods as mutually exclusive categories as shown in the figure. Fifty one percent of the urban households do not treat water and the remaining households use a variety of treatment methods, the prominent being boiling and using water filters.

Figure 3-24 Water Treatment Used by Households



Data for rural households is provided for comparative purposes only.
Source: Ministry of Statistics, 2011

Here again, similar to the quantity of the water consumed, the quality of the water available is different in slums compared to other areas in the cities as reported by the household survey study by Shaban (2008). Contamination of municipal tap water has been a common problem, particularly in slums, in Indian cities. Shaban (2008, p.14) reports that the "provider-side" data from Municipal Corporation of Greater Mumbai (MCGM) shows that 8-10% of the samples taken at consumer taps in 1997 and 1998 were contaminated by coliform bacteria and unfit for consumption. On the user side, about 46% of the households in slums "feel" that municipal tap water supply is "somewhat safe". In comparison to Mumbai, about 37% in Delhi, and only 10% in Kolkata considered that piped water is "somewhat safe". As opposed to Mumbai, where none of the households living in slum areas state that the municipal tap water is "unsafe", 2% slum households in Delhi and 2.7% in Kolkata consider the water "not safe at all" (Shaban, 2008).

In summary, the examples of the data, including the reliability of the data, draw attention to the intricate layers of the piped water service where the water supplied is not equal to, but is assumed to be equal to piped water service actually delivered. Further, piped water supply fares poorly in terms both the volume-based standard (135 LPCD) and continuous flow-based standard. The local workings of the piped water service delivery seem to be distant from the national policy design. While the large centralized networks are built typically by the State, operation and maintenance of the system serve as a key facilitator, if not the only driver, of the actual water service on the ground.

Operating and Maintaining the Piped Water Service

To investigate the poor piped water service, I start by using the following operational indicators of utility performance listed as service level benchmarks:

- Extent of metered connections,
- Extent of non-revenue water, and
- Cost recovery through efficiency in bill collection,
- Efficiency of redressal of customer complaints (human resources and capacity)

A study of these operational indicators shows the utility performance has long ways to go to achieve the service level benchmarks, which has a large temporal implication given the scale of the problem. Further, as discussed below, exceeding these indicators alone may not assure reliable water service for all the users.

The CEPT University (2011) conducted a detailed study on the performance of 248 ULBs in the state of Maharashtra by compiling various national and international databases and data sources. Maharashtra is the second most populous state of India with 9.42 per cent of India's population and the third largest state by area in the country. It is one of the richest states in India, contributing to 15% of the national industrial output and 13.2% of its GDP in 2005–06 (CEPT, 2011, p.8). Table 3-11 summarizes how the utilities and ULBs in Maharashtra are performing in comparison to the service level benchmarks recently adopted by MoUD.

Table 3-11 Performance of ULBs in Water Supply in State of Maharashtra

Key Performance Indicators	State	Metropolitan Cities	Class A	Class B	Class C	Nagar Panchayat
Coverage of Water Supply Connections (%)	52	63	48	49	52	39
Per Capital Supply of Water at Consumer End (LPCD)	100	135	124	102	91	109
Extent of Metering of Water Connections (%)	52	52	52	54	49	100
Extent of Nonrevenue Water (%)	31	34	34	31	31	27
Continuing of Water Supply (Hours Per Day)	1.7	3	1.7	1.5	1.4	5
Efficiency in Redressal of Customer Complaints (%)	94	94	95	93	95	96
Quality of Water Supplied (%)	98	97	99	97	98	99
Cost Recovery in Water Supply Services (%)	68	84	57	64	69	57
Efficiency in Collection of Water Supply-Related Charges (%)	68	63	66	67	70	53
Coverage of Water Supply Connections in Slums (%)	24	35	13	29	22	8

Source: CEPT, 2011
Note: Metropolitan cities are large cities that account for two-thirds of the urban population in the state. City classes based on population size: A = Population of >5 million, B = 1-5 million, C = <1 million, Nagar Panchayat is an urban political unit comparable to a municipality for small towns.

I find that "water coverage" for a utility is dominated by measuring individual household connections to the centralized infrastructure system that the utility is operating.[38] Based on utility survey reports discussed earlier, and the study in Maharashtra, the utilities have ways to go before they achieve the service level benchmarks. In Maharashtra, for example (Table 3-11), the water coverage ranges only from 39 to 63% having household connections. "The average per capita supply of water at 100 LPCD is below the standard benchmark of 135 LPCD... Similarly, the duration of water supply is on an average 1.7 hours a day and many ULBs do not provide water every day. However, clamour for increasing per capita supply can be misleading in an environment where there is no metering at the production, distribution or consumption end" (CEPT, 2011, p.11).

Metering

Consumption metering is important for consumers to pay for what they are using, which could help in promoting prudent use of water (ADB&GOI, 2007).

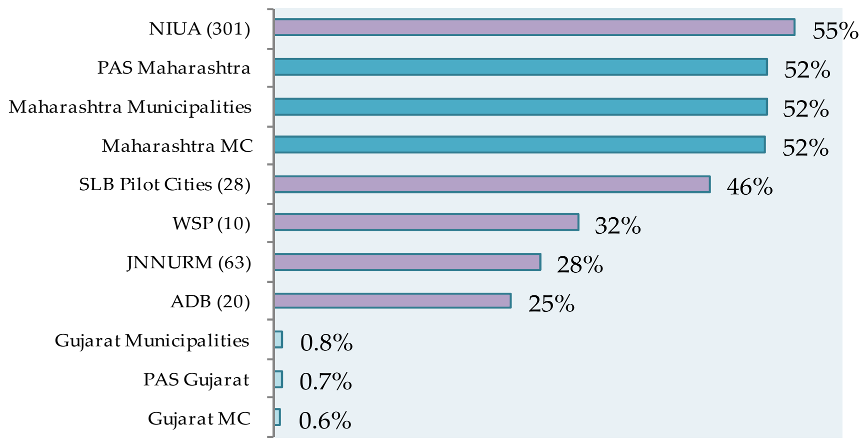
> *Metering of water connections is essential to implement volumetric charges for water. A telescopic tariff structure (referred to as rising block tariffs) is more equitable than a flat charge*

[38] When I inquired about "service coverage", the municipal engineers provided responses in terms of percent of the city population that is covered by the centralized piped network in the city.

based on pipe diameters or those linked with Property Tax assessments. Meters at the consumer end also help proper estimation of water balance and NRW.
- CEPT, 2011, p.26

Based on a performance benchmarking study of utilities and ULBs in Maharashtra (CEPT, 2011), consumer-level metering at the water connection hovers at only approximately 50%. Some ULBs have provided meters only to commercial or industrial connections, as the tariffs for water supply to these consumers are calculated at a higher rate than residential (CEPT, 2011). Compilation of data from different sources on how prevalent the use of water meters is in Indian cities is shown in Figure 3-25. Only an average of 55% of connections are metered. Despite a long way to go to achieve the new service level benchmark of 100% metering (CEPT, 2011, p.35), the study reports 55% metering as "widespread use of water meters"

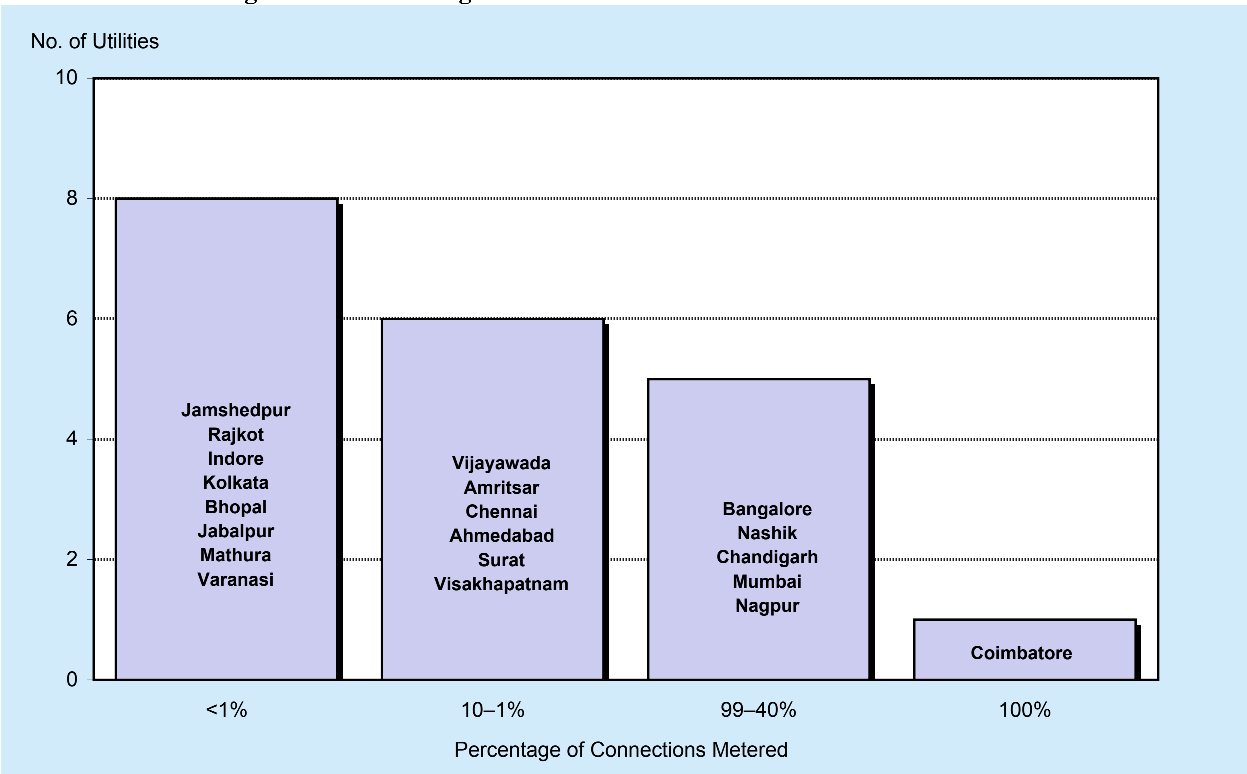
Figure 3-25 Percent of Indian Cities Using Water Meters



NIUA = National Institute of Urban Affairs, PAS= Performance Assessment System; SLB= Service level benchmarks, JNNURM = Jawaharlal Nehru National Urban Renewal Mission, MC = Municipal Corporation
Source: Compiled in CEPT, 2011

Another source (GOI&ADB, 2007) shows a majority of utilities out of 20 having 10% or less consumer metering, while only one utility having 100% consumer metering (Figure 3-26).

Figure 3-26 Percentage of Connections Metered for 20 Utilities in India



The 20-utility survey (ADB&GOI, 2007) identifies metering as the single most important area that requires improvement. Metering is important to fully account for water production and consumption in reducing water that is unaccounted for in the system.

However, metering also involves institutional mechanisms such as ensuring and conducting regular inspection and maintenance of meters as part of the O&M of infrastructure system, recording the meter readings and issuing bills to customers, and collecting water bill payments in a timely manner. As we see below, execution of these functions varies with organizations and the resources (including human resources) available.

Un-Accounted for Water

All of the water supplied by the utility is expected to reach the user as part of the service delivered and is presumed to be metered when produced by the utility and delivered to the users. Metering is a critical component for determining Un-Accounted for Water (UAW). However, infrastructure systems continue to deteriorate with time with reduced capability of delivering the originally intended service, also a function of poor O&M (MoUD, 2009). Further, there are system failures such as leaking or broken pipes, breakdowns at the pumping facility, and inability of the utilities to respond to system failures (GOI&ADB, 2007). Loss of water (UAW) from such failing systems is a common occurrence and is both a physical loss of the water resource itself and an economic loss of a public good that is treated, stored, and delivered at a the cost to the urban dwellers.

Water loss is a key indicator of performance of the physical infrastructure and that of the centralized piped system falling considerably short of its performance goals, not just of reaching individual households, but also transporting water, which is its basic function. The quality of the water transported may also get compromised from external contamination entering in the system through system breaks. Low pressures and intermittent supplies lead to back siphoning, resulting in contamination in the distribution network (GOI, 2002, p.34). It is apparent, then, that building large capital works projects or physical infrastructure for water[39] is not sufficient for reliable water service; operation and maintenance of the system is also key.

O&M involves maintaining the system so that it continues to deliver the service, which was intended at the time it was built and upgrading it to deliver service to new users both by capital investments as well as improving operation and maintenance techniques. Water losses are then an indicator of poor performance of a utility.

The ADB&GOI report (2007) uses UAW as a performance indicator of the physical infrastructure. The following equation for UAW shows that it is dependent on water metering at both the production and at the service or user ends:

> Unaccounted for water (%) = [total annual production (cubic meters) - total annual consumption (cubic meters)] x 100 / [total annual production (cubic meters)].

Full and accurate metering is imperative to gauge UAW. However based on a utility survey (GOI&ADB, 2007), only City of Coimbatore (out of 20-utilities) claims to have both production and service connections fully metered. Bangalore and Mumbai claim full production metering and high, but not full consumption metering (95.5% and 75.0% respectively). Four other utilities have fully metered production but virtually none to only 40% consumption metering. Amidst this, a possible discrepancy in the data questions its reliability:

> *… UAW figures should be interpreted with caution. Given low coverage and low water availability in some utilities, more must be done to reduce UAW levels. This includes 100% metering of production and consumption, repair of visible leaks, elimination of illegal connections, and identification and repair of invisible leaks.*
> *- GOI&ADB, 2007, p.8*

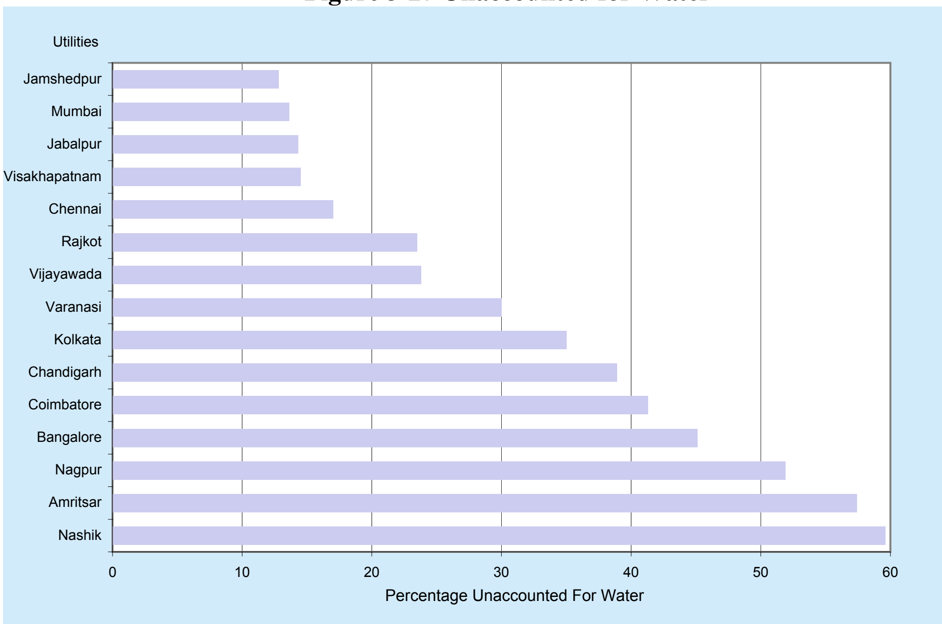
Water that is not metered and hence not billed is called non-revenue water (NRW) considered as water loss (a subset of UAW). Thefts or illegal water connections are examples of NRW. Metering again becomes an important mechanism to fully account for water production and consumption in reducing UAW.

The NRW in the state of Maharashtra ranges from 27 to 34 LPCD; however again the reliability of this indicator is low throughout the state (CEPT, 2011). A nationwide survey of 20 utilities discussed earlier (GOI&ADB, 2007) showed up to 60% of the total water produced was unaccounted for (Figure 3-27). Based on interviews with local municipal engineers in different cities for this study, the UAW actually exceeds 70% in some cities. Another source, the

[39] Typically built and designed by state-level organizations.

international benchmarking network database shows a lower range of NRW of 33 to 41% (IBNET, 2014).

Figure 3-27 Unaccounted for Water



Source: ADB&GOI, 2007

However as I demonstrated in Section 3.4.2, total water supplied is not always equal to, rather it is typically higher than the water that actually reaches and in turn consumed by the user. The UAW in practice would then be much higher than calculated using the above equation. The higher the unaccounted for water, the lower the performance of the water system.

Cost Recovery

Based on my interviews with local municipal engineers, historically cost recovery has not been a priority for local municipal corporations, who typically operate local water service deliveries. Water supply is but just one of the several departments and one of basic urban services that a municipal corporation operates. Funds used to finance water operations are not confined to revenues from water tariffs but also from property taxes, development fees and other sources such as advertisement tax, intergovernmental grants from states, schemes and grants for specific improvements from the central government (GOI, 2012). Water operations may be executed by utilities such as Bangalore Water Supply and Sewerage Board that operate specific urban services such as water and sewerage, which is partly funded by revenues from water and sewerage fees and State grants. However, the central government has acknowledged the limited financial resources for the ULBs to execute the responsibilities:

> *There is a mismatch between functions and finances of Municipalities, which primarily explains the vertical imbalance. Out of [18] functions to be performed by the municipal bodies in India only a few have a corresponding financing source which is utilized only marginally. The 12th Schedule in the Constitution introduced via the 74th Amendment also envisages that functions*

like "safeguarding the interests of weaker sections of society, including the handicapped and the mentally retarded", "slum improvement and up gradation" and "urban poverty alleviation" belong to the legitimate functional domain of urban local bodies. However, there are no commensurate resources with these institutions to discharge these functions.
- Government of India, Report of the Sub-Committee on Financing Urban Infrastructure in the 12th Plan, 2012, p.15

More recently, urban infrastructure reforms have focused on recovering 100% of costs (GOI, 2012).

A basic minimum standard of performance for the Urban Local Bodies should be to ensure full cost recovery of O&M through user charges and at least partial recovery of capital expenditure.
- Government of India, Report of the Sub-Committee on Financing Urban Infrastructure in the 12th Plan, 2012, p.35

The GOI&ADB utility report (2007, p.9) uses "operating ratio" (Annual O&M Costs/ Annual Revenue) as a measure of cost recovery. A low operating ratio (<1) means that the revenues from tariffs cover O&M costs. A ratio above 1 means they do not cover these costs. Only one third of the utilities with operating ratios ranging between 0.44 and 0.82 are found to be able to cover their costs (ADB&GOI, 2007, p.9).

"The worst performers requiring much improvement [range] between 2.82 (City of Bhopal) and 5.33 (City of Indore)], together with nine others with operating ratios of more than 1.0" (GOI&ADB, 2007, p.9). However, I observe that a low operating ratio does not necessarily translate into good quality service for the users, whether it is insufficient number of piped connections or intermittently supplied water. For example, cities of Mumbai and Jamshedpur boast less than 1 operating ratio but the deliver only a few hours of water supply. No ULB or utility provides high quality of water service and has a low operating ratio. Here again, there may be additional institutional mechanisms in play, e.g., recovering all the costs may not necessarily mean injecting the revenues into water service improvements especially with other parallel and necessary functions of the municipality, such as O&M of other infrastructure services or building other new capital works.

Bill Collection

Another measure of cost recovery is the efficiency in collection of bill payments. Higher the efficiency, higher is the cost recovery and better is the financial health of the utility (ADB&GOI, 2007, p.9). The utility survey reports that "Six utilities—Mumbai (189%), Bhopal (178%), Chennai (152%), Vijayawada (114%), Bangalore (112%), and Mathura (106%)—have collection efficiencies of more than 100%, suggesting that past years' arrears are being collected". However, again, this does not necessarily signal a better service in terms of connections and water supply duration discussed earlier. For example, Bhopal with a high bill collection rate exhibits one of the lowest water service, i.e., a couple of hours of water supply (see Figure 3-20). This also indicates, that similar to cost recovery, collections of bills may add to the revenue, but there may be institutional mechanisms beyond financial factors such as say, coordinating with the local planning department to deliver water to new development or improve water to existing development.

Human Resources

All of the above O&M indicators involve not only the functions or activities, but also human resources or staff that actually execute them, i.e., the human resources in the organization. Two thirds of the 20 utilities reported (GOI&ADB, 2007) contracting out some of its operations. Of this group, only Nagpur and Jabalpur reported no service contracts. It is worth noting that the utilities were predominantly government organizations, and it was common to have private entities engaged in different capacities in supplying water. Two of the 20 utilities surveyed (GOI&ADB, 2007) were not public, one was a private operator and another was a local autonomous body; and 13 out of 20 utilities engage in contracts with private companies for work related to operations and maintenance.

Some examples of continuing PPPs are listed below:

> *In Ahmedabad, the private sector is involved in water production and operations and maintenance through a management contract.*
> *In Bangalore, the private sector is involved in the operation and maintenance of the water treatment plant and pumping stations and the wastewater treatment plant through service contracts.*
> *In Chandigarh, The private sector is involved in distribution, billing and collection, and leak repair through service contracts. It has computerized billing and accounting systems.*
> *- GOI&ADB, 2007*

What is striking is that engaging in PPPs does not seem to have any particular pattern of improved water service (such as round-the-clock water service) or utility operations (e.g., 100% metering) as claimed under the proposed reforms. Rather even organizations that are entirely public can have good management practices, e.g., the municipal corporations of Mumbai and Coimbatore have an operation ratio of 0.4 and 0.8 (less than 1) and good financial management. Improved management of utilities therefore does not necessarily seem to be hinged upon engaging with a private operator or being a private entity.

3.4.3 Scale of What Goes Into Delivering the Intended (But Not Delivered) Piped Water Service: A Glimpse of Costs

So far, we have seen how the water supplied by the utility may not necessarily be the same as the water service (quantity or quality) received by the user. Yet, if the central-level policies continue to espouse the singular approach of using traditional centralized and large infrastructure and engaging the private sector, one cannot ignore what goes into the effort of “delivering” or at least intending to deliver that service in terms of the scale of costs for the functions as per the service level benchmarks as discussed in the previous sections (i.e., production and transportation of the water and operating and maintaining the service).

Delivering The Water: The Costs with Incompletely Realized Benefits

The traditional approach of centralized physical infrastructure necessitates designing, building, and operating and maintaining the large facilities and long pipeline networks to produce and transport the water into the city for distribution to the users. Farther the natural water supply source from the city, higher the need for longer water main pipelines and larger facilities for storage and greater the costs.

Table 3-12 below provides some examples of water transportation costs in Rupees per kiloliters (Rs./kl) (reported in a 71-city survey [CSE, 2012]).

Table 3-12 A Range of Water Transportation Costs from Water Supply Source Into a City

City	Source	Distance	Cost to supply (Rs/kl)
Aizawl	River Tlwang	1,000 metres down the valley, 18 km away	53.90
Bengaluru	River Cauvery	100 km from the city	12.70
Chennai	Lakes, groundwater and Veeranam lake	60-235 km	11.60
Delhi	River Yamuna and groundwater	Across the city	8.70
Indore	River Narmada	70 km	11.00
Jodhpur	Indira Gandhi Canal	205 km	8.70
Mussoorie	Springwater: Bhilaru, Jinsi, Khandighat, Murray, Mount Rose and Dhobighat	6-7 km down the valley	16.80
Mumbai	Bhatsa, Vihar, Tulsi, Tansa, Upper Vaitarna	100-110 km	10.70
Hyderabad	River Krishna	116 km	6.40-18

1 kiloliter = 1,000 liters or 1 cubic meter; Rs.1 = $0.017
Source: CSE, 2012

The costs shown in Table 3-12 shows the costs of transporting the water into the cities and do not include distribution within the cities. Further, besides the financial costs, other costs[40] are incurred due to the water losses en route and not all water reaches the users. Table 3-13 below from the same survey shows that the production cost i.e., average cost per kiloliter of total water supplied is in fact higher, when the water losses are accounted for. Water may be lost due to varied reasons such as damage from environmental forces, age, and lack of or limited maintenance or even illegal connections (GOI, 2012). How much water is actually lost varies widely and is reported as unknown (see the following statement in the Twelfth Five-Year Plan 2012-2017):

> *Currently, it is estimated that as much as 40–50 percent of the water is 'lost' in the distribution system. Even this is a guesstimate, as most cities do not have real accounts for the water that is actually supplied to consumers.*
> *- Twelfth Five-Year Plan 2012-2017, Government of India, 2012, p.162*

[40] Water losses indicate loss of a resource as well as loss of the benefit, which would have been achieved if the water would have reached the user as a service.

Table 3-13 Scale of Costs of Water Production with Water Losses

		Cost of total water supply (Rs/kl)	Cost after leakage loss (Rs/kl)	Average (Rs/kl) (Total water supply / After leakage loss)
Metros	Bengaluru	13	21	Total water supply: 7; After leakage loss: 11
	Chennai	12	17	
	Indore	11	17	
	Mumbai	11	15	
	Delhi	9	18	
	Dhanbad	9	11	
	Hyderabad	6	11	
	Jaipur	6	11	
	Rajkot	6	8	
	Vadodara	6	9	
	Meerut	0.8	1	
Class I	Aizwal	54	83	Total water supply: 4; After leakage loss: 5
	Khanna	14	18	
	Alwar	9	12	
	Jodhpur	9	11	
	Kozhikode	8	12	
Class II & III	Nainital	17	20	Total water supply: 3.5; After leakage loss: 4
	Mussoorie	17	24	
	Raman	2	3	
	Uttarkashi	2	3	
	Goniana	2	2	

Note: These costs show the scale of the total cost of drawing, treating, and transporting water from source to users in comparison with the water losses.
Rs.1= $0.017
Source: CSE, 2012

In addition to the water diversion, transportation, and distribution costs, the provider also incurs O&M costs incurred by the local municipalities.[41] The O&M costs would vary with the local utility and depend on several variables such as the city size, the population, water connections, and the utility's budget and other operational setting.

Piped Water Service: Costs for Receiving It and More

The large scale of costs for the infrastructure and its O&M are made toward delivering pressurized piped water service on a continuous basis to all, which is not delivered as seen in the previous sections. Further, the range of costs does not stop here; it extends to the users as well. The households are charged for the piped water service by the local utility (see Appendix B for an example of monthly bills reported by the utilities) and who also pay to adapt or "cope" (Zerah, 2000; Davis, 2005; Ranganathan et al., 2009) with the poor service.

Taking the city of Bangalore as an example, a range of costs (reported by the utility) for a household for obtaining municipal piped water service may include a one-time connection fee of up to Rs. 2,000 and an average tariff of greater than Rs. 20 per month (GOI&ADB, 2007). The costs to the household however do not stop here. Table 3-14 below shows an example of the additional "unintended" costs incurred by different types of households in a community for obtaining water in different ways, e.g., from different sources (water access points) and via different modes in the ascending level of socioeconomic status.

[41] O&M costs can vary widely with jurisdictions. Reliable normalized data for utilities was not available, therefore not provided here.

Table 3-14 A Range of Costs Incurred by Households For Receiving Adequate Water Service (An Example of a Community in Bangalore – in Ascending Socioeconomic Status)

Modes of Water Access	Provider	Cost Incurred by a Household		
		One-time Connection Fee	Ongoing costs	Description of Additional (Coping) Costs
Piped water (2-4 hours every 2 days)	Public	Rs 1,600-2,000 ($27-34)+ prorata charges*	Rs. 6/kL for 0-8 kL; Rs. 9/kL for 8-25 kL; Rs. 30/kL for 25-50kL; Above 50 kL for Rs 36/kL Industrial tariffs vary from Rs 60-70/kL Up to Rs. 300/month**	If water service is intermittent or quality poor, households invest in storage, filters, and purification equipment bear these additional costs.
Hand pumps from a well (very few functioning)	Public	-	Free	May have to queue up for water, quantity may be limited, quality may be questionable; hauling it home is a burden.
Bore well Water stored in mini-water tanks with attached public taps	Public	-	Rs. 44/month (independent of quantity)	Water availability may be inadequate, unreliable quality; user must haul home and store.
Tankers	Private	-	~Rs 50-70/kL (Rs 200-300 per 3-4 kL tanker load) and up to Rs. 1,200/month	User may fill container and haul home or may have water delivered at doorstep. User generally must provide storage. Water quality is uncertain due to weak regulation of tankers.
Individual Bore wells	Private	-	Water is free, but costs a one-time amount of Rs. 2,00,000 or 0.2 million ($3,000) to sink a borewell + recurring electricity costs	May need to be filtered and sterilized. Risk of waterborne disease and toxics if not tested and treated (depending on the purpose of use).
Bottled Drinking Water	Private	-	~Rs 6,000/kL (Rs 30 per 5-L bottle), and up to Rs. 300 /month	This may be a primary source for some; but an added cost for others who rely upon the previous sources listed as primary water sources and supplement an inadequate supply with bottled water.

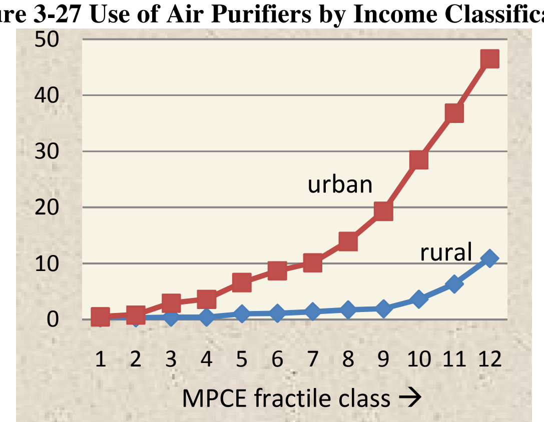
* L= liter, kL= kilolitres; 1 kL = 264 gallons. US$1 = Rs. 58.57; The pro-rata charges are not documented in the 20-utility survey (GOI&ADB, 2007), which included Bangalore.
** Taken from household monthly bill recorded in GOI&ADB, 2007.
Table adapted from Ranganathan et al., 2009.

As the table shows, besides the municipality, there are private actors such as well drillers and vendors involved in water delivery that charge a higher price and make the service more expensive to the households than the municipal piped water. The private water service is entirely unregulated and continues to operate in a market alongside the poorly delivered municipal piped water service.

The table also shows that the costs to the users can vary with where the households get the water from, i.e., mostly through the tariffs, taxes for municipal piped water, and/or the fees to pay the private vendors or retailers (for bottled water). In the case of thefts or illegal connections, users obtain the service for free except for the initial expenses toward making the connection, which may not necessarily guarantee adequate or sustained service.

The costs incurred by the users are not only monetary, but are also in the form of other economic and social costs such as loss of time from waiting in queues to access a communal tap or accommodating the unpunctual times of the daily intermittent (sometimes arbitrary) water service, where the time could be (better) spent making a livelihood or taking care of family responsibilities. Such "coping strategies" (Ranganathan et al., Zerah, 1998, 2000) also involve purchasing tanks to store water when it is available for short durations and boiling or using water filters to treat water before drinking. The coping ability of the users is in direct proportion to their ability to pay, thus disproportionately putting the lower-income population at a disadvantage. For example, Figure 3-27 below shows the higher prevalence of use of water purifiers as a household water treatment method as the income levels increase. Income levels are shown in the form of "MPCE fractile class", which is 12 classes defined based on the monthly per capita expenditure (MPCE), a measure used to classify income levels where average income is not available or not sufficient.[42] For example, in the figure, fractile class 1 refers to 0-5% or bottom 5% of the population ranked by MPCE and fractile class 12 refers to 95-100% of the population ranked by MPCE.

Figure 3-27 Use of Air Purifiers by Income Classification



Source: NSSO, 2014

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[42] MPCE is amongst the most important measures of the level of living of the relevant domains of the population. The distribution of MPCE highlights the differences in level of living of the different segments of the population and is an effective tool to study the prevalence of poverty and inequality (NSSO, 2014).

3.5 An Assessment of Water Service and The Approach to Deliver It

3.5.1 Beyond Centralized Continuously Pressurized Piped Water Service?

The focus of the water standards and the new national service level benchmarks has been on piped water service. The technical manuals and guidelines for water facilities are also catered to centralized pipeline systems to deliver water continuously under pressure. However, at the local level, there are different water delivery mechanisms in play, whether it is a groundwater well or a storage tank (which is a different access point than a tap) or a private tanker (which is different than the local utility) or whether it is using a filter at home (which is different than readily using centrally treated drinking water). These "other" mechanisms are used as "ad hoc" or back up or alternative options to "cope" with the current poor water service. Such coping strategies are widely recognized in the literature as those undertaken by users and households. I find that coping however is not confined to the users alone. The ULBs also resort to coping strategies where they are not able to deliver piped water service, install piped connections, or maintain a fixed schedule for the intermittent water service. These other coping or "alternative" mechanisms are commonly (widely) practiced but rarely documented. One example is municipalities recruiting private tankers to deliver water where the piped network has not reached or recruiting private vendors who operate high quality water kiosks (Indian Express, 2012; KUWSDB, 2011). At the same, rationality in the delivery process prevails when the municipal engineer is attempting to achieve efficiency and deliver the service within the time, budget, staff or other constraints that they face.

Probably, the very nature of these mechanisms, that they serve as an "alternative" to piped systems to deliver water makes them vulnerable to lack of sufficient impetus and resources allocated to them and thus, inefficiencies leading to inadequate service. I find that there are inefficiencies in the process such as exorbitant prices charged by unregulated private tankers (Navya P.K., 2012), which have a greater impact on low-income households who may find the prices unaffordable. There are also uncertainties, say in using alternative water sources such as groundwater where its location and depth is unknown and wells are drilled more on a trial-and-error basis with limited or no monitoring. The use and operation of these delivery mechanisms is unregulated making them subject to risks of inequitable service and adverse effects such as lowering of groundwater tables precluding the sustenance of the service or poor water quality reaching the users.

Groundwater, though part of hydrological cycle and a community resource, is still perceived as an individual property and is exploited inequitably and without any consideration to its sustainability leading to its over-exploitation in several areas.
- Section 1.2 (vi), National Water Policy

The purpose of this mention of these "other" delivery mechanisms adopted by the ULBs is especially to highlight their wide prevalence and due to the potential promise they offer in reaching the vast scale of diverse population *now*. This topic forms the focus of Chapters 5 and 6.

3.5.2 The Approach to Delivery: The National/Local Divide of Policy Design and Implementation

An investigation of piped water service shows different pictures at the central and local level: uniform standards and policy design for the entire nation at the central level whereas variegated and continually poor water service at the local levels, which are very different from the intended standards. The solution prescribed by the central government defines the service objective as supplying water continuously or 24 hours a day, 7 days a week (24/7). This solution is not new, rather it is an intrinsic part of the traditional approach of centralized piped infrastructure delivering water from a distant surface water source on a continuous basis.

The service level benchmarks highlight the importance of well functioning centralized infrastructure and pipeline distribution network systems and commercially viable O&M of the physical infrastructure and management of water supply and service to achieve the intended target. It is noteworthy however, that the benchmarks focus mainly on the engineered facilities (centralized piped infrastructure) and utility performance based on its management practices but do not account for minimizing costs in delivering the stipulated water service or making the service available in a timely fashion. Also, while the benchmarks include 100% coverage of water supply connections, they do not specify making the service affordable especially to low-income communities. With the large diversity of income levels, the service level benchmarks do not include any considerations to the price of the water service or equity. The failure of the current systems to function as per their original design of delivering 24/7 pressurized piped water service is starker in informal settlements and low-income group areas. This makes equity a significant concern, but which has no mention in the singular approach. Further, the heterogeneous physical development that lacks other basic services such as roads, the feasibility of fast implementation in areas that may not favor straightforward installation of pipeline networks has serious temporal implications.

On the institutional side, more recently, the role of large private corporations such as Veolia (a French company) or even the local Jamshedpur Utilities & Services Company in water supply provision has become a topic of debate – on whether the mere involvement of a private entity makes it likely that its water delivery will be efficient (Budds and McGranahan, 2003.) Involvement of private corporations in water supply systems with an intent to improve water delivery and the quality of water service has had mixed results elsewhere in the world (see Chapter 2) and almost always results in higher tariffs with no corresponding improvement in service. PPPs have been proposed whereby private corporations are tasked with specific roles to provide the water service under contract, but these arrangements have themselves been controversial (Davis, 2005; Marin, 2009) and it is not clear that they will be workable in all cities and urban districts. We saw however that the local utilities are indeed engaging with the private sector for different work categories of water service delivery. Again, similar to the water service objectives, private-sector participation is not a new concept. Further, as shown in this chapter, only getting the private sector involved may not be a sufficient condition for improving water service. In this dissertation, I use PPPs in its broad interpretation of a contractual agreement between a public and a private organization where public or state organizations sign a contract or an agreement with one or more private organizations for building, operating, maintaining, or managing any particular aspect of infrastructure service delivery.

The Government of India has been implementing several demonstration projects that continuously supply pressurized piped water (ASCI, 2011; MJP, 2012; World Bank, 2011) in selected portions of at least 20 cities as of early 2014.[43] Consider the example of Hubli-Dharwad, touted as the "first pilot project" that delivers 24/7 continuous pressurized piped water service in India. The project took over six years to cover a population of 10,000 (10% of the city population). At such a rate, it would take at least 50 years to achieve full coverage in the city. Given the current water service situation and the pace of improvements in water service, it would take decades for all of India. In addition, the projects have been controversial in some cases as water prices have increased to cover the costs of improved water supply and quality causing delays and frustrations in the communities (The Times of India, 2012; 2013; The Hindu, 2013).

A recent MoUD report (HPEC, 2011, p.76) has identified large capital investments of Rs. 320,908 crores ($52 billion) for water infrastructure in India, making up 10.4% of total infrastructure investments (after 56% in urban roads and 14.5% on urban transport). Adoption of the 24/7 pressurized piped water service nationwide through the demonstration projects in India has proceeded mostly through funds available through intergovernmental grants such as the JNNURM and the Urban Infrastructure Development Scheme for Small and Medium towns (WSP, 2011).

As part of the Indian Urban Infrastructure and Services report, the High-Powered Expert Committee (2011, p.152) is of the view that these service level benchmarks (other infrastructure services such as sewerage and solid waste, in addition to water) will be achieved within "a period of 10-20 years". The "implementation plan" to achieve the benchmarks is described in terms of financing the effort through different financing mechanisms such as intergovernmental grants and transfer, external finance in the form of debt finance, PPP, and financial intermediaries providing subsidized credit to municipalities while also assuming considerable revenue generation capacity at the local levels through taxes and tariffs (HPEC, 2011). However, the water delivery problem looms *now* and until the 24/7 pressurized piped systems come into place, the population is left to face and cope with the current poor service.

While the national urban development and water supply and service provision policies and guidelines are established at the central level, and large capital works are designed and built by state organizations, the local urban growth and the physical landscape continue to change at a pace that is exceeding water service deliveries. There is still a "vertical imbalance" observed even between the central and state governments with the ongoing centralization of the federal fiscal architecture (Das and Mitra, 2013, p.3). The policies that are initiated at the central level and apply nationwide do not account for the complex set of issues that many water providers are facing, much less the specifics of the local context for implementation. The collateral costs appear in different forms: delays in providing the service as planned, availability of the service to only certain sections of the city dwellers, questionable sustenance of the service in the long term, and likely large financial burdens.

As discussed in this chapter, the current water infrastructure service delivery systems are malfunctioning in many cities in India, and keeping up with maintenance has been problematic.

[43] Based on the documents prepared by the Government of India and the World Bank and reported in newspaper articles.

Providing timely service to government-approved new growth has been only inconsistent, and relying on promises of the developer to provide the infrastructure to their new developments has proven to be risky. Given these on-the-ground realities and the significant challenges posed by the extreme physical and socioeconomic heterogeneity in Indian cities, it is not obvious that the government can deliver on a promise of 24/7 pressurized piped water to all households in a timely manner. Yet an exclusive focus has been placed on new systems of the traditional model (see quote below).

Increased urbanisation will also pose additional problems for water management since urban populations need to be serviced with piped water systems available on a 24 × 7 basis …

- Twelfth Five-Year Plan (2012-2017), Government of India, 2012, p.24

The traditional centralized model has not been successful and has been proven to not sustain over the years. Yet it is reinstated as a new goal with an expectation of a different outcome than experienced so far. Considering the complexities in the water delivery process, the scale of the problem, and temporal implications, focusing only the singular approach may not be able to achieve the much needed reliable water service to all, especially in the diverse and rapidly changing cities where continuous pressurized piped water is not the norm and where developments precede infrastructure service provision.

Chapter 4 Urban Water Service Delivery in India: Re-Diagnosing the Problem

In 2006, the District Commissioner (at the time) took an executive decision of providing 24/7 water supply to people and directed us to do so. We had no clue what that meant. It was the onset of summer… it was hot and the water demand was high and the water pressure suffered especially in areas located in the hills. As directed, in April 2007 we increased the water supply to 24 hours a day by turning on the main valves and keeping them that way for 2 days so that water would run continuously in Lokmanya Nagar. Well it did, but in less than 2 days, there was local flooding from lots of water leaks. A lot of water was wasted. We had turned on the water at the cost of other areas (which did not receive as much water). We had to immediately switch off the valves.

- Paraphrased from communication with a local city engineer, 2013

4.1 Introduction

As apparent from the quote, making water available to users on a continuous basis or 24 hours a day, 7 days a week (24/7) through pressurized pipes takes more than just supplying water continuously. In this chapter, I engage with planning theory and conduct a deeper examination of the water service delivery problem.

Chapters 2 and 3 provide background on water service delivery and the urban water service situation in Indian cities by describing the wide prevalence of poor piped water service and lack of basic water access for millions of people. The problem has been recognized in the literature, observed "on the ground", and covered in the media and in the public debate. At the national level, the problem has been treated as a need to build infrastructure and improve its management and maintenance. The Government of India has thus prescribed a solution: building more pipes and pumps to deliver water to the tap on a continuous basis, and engaging the private sector to manage water infrastructure more efficiently.

While innovative technologies, integrated water resource management strategies, and better urban infrastructure management in general hold promise for improving water service delivery, their introduction has not yet resolved the challenge of providing basic water service to millions of people in India. In this sense, the water delivery problem is not just a matter of urban infrastructure construction and management but also about finding ways to weave through the complex physical and institutional settings to achieve the societal goals set for a community. In addition to designing, building, and operating the physical infrastructure, the planning process is about effectively managing the delivery of service, which must involve balancing equity concerns with economic realities and environmental uncertainties and constraints. There also is an important temporal dimension: given the constraints on taking action and the complexities of many of the possible interventions, one must ask how long must people wait for getting access to reliable water when they need it.

In this chapter I argue that the water service delivery problem has been misdiagnosed by national leaders and is not only a far more complex technological and managerial problem than can be resolved by a private-sector-led building and operations program, but one involving substantial uncertainties, debates over the technologies that can be used, and conflicts over values that include organizational, financial, and political dimensions. This chapter lays the foundation for the case study research that follows, by rediagnosing the problem of urban water service delivery in India as a "wicked planning problem." I review in detail the characteristics of a "wicked problem" and show that the water service delivery problem, described in Chapter 3, exhibits most of these characteristics, drawing upon the classic Rittel and Webber article as well as several refinements and extensions that have appeared in the literature in the years since the seminal work's 1973 publication.

As explained in Chapter 1, this concept, coined by Rittel and Webber (1973), refers to a problem for which there is no definitive problem definition because various stakeholders from the user, the policy maker, the local municipal body, or the private water provider view the problem from different value frames and therefore have different understandings of the nature of the problem. Furthermore, the nature of the problem may change over time, along with the resources available to address it. As a result, there is no single "right answer" to the problem; rather, I argue, that the approach to addressing the problem must be broadened, which may lead to incorporating more context-specific ways and greater collaboration, recognition of alternative viewpoints, and explicit attempts to manage conflict. A wicked planning problem cannot be solved by a straightforward "optimization" or a single intervention but requires ongoing planning, management, and collaboration with stakeholders. Taking the temporal concern into account suggests that active support of a wider range of options could be highly desirable, likely as a transitional strategy while the continuously supplied pressurized piped water service reaches all the urban households.

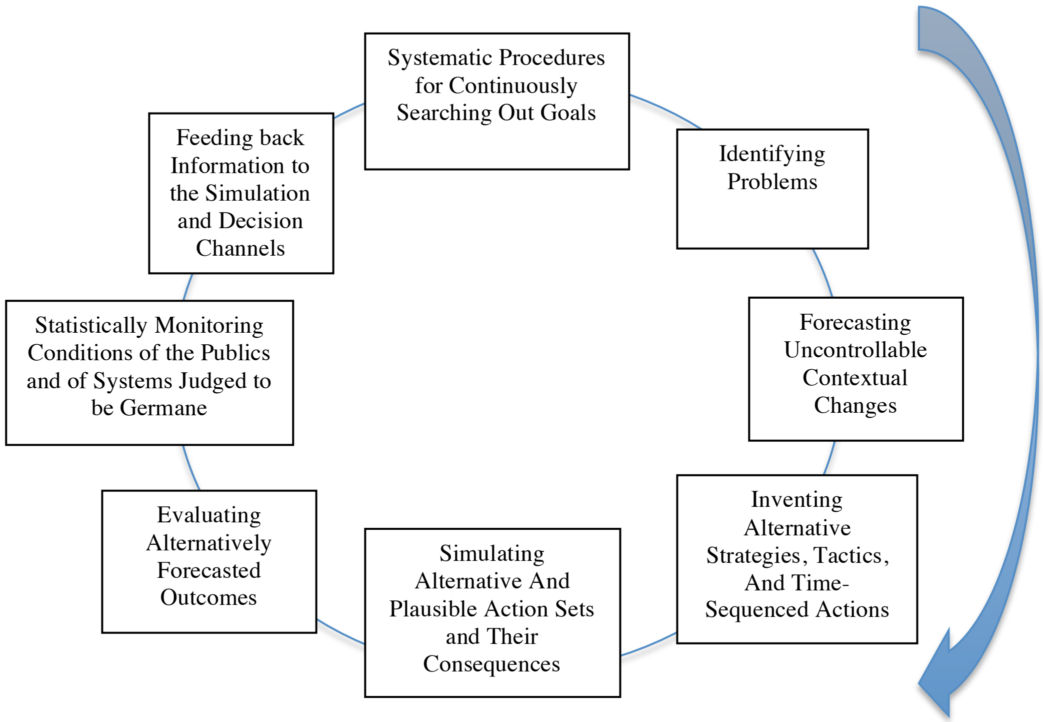
4.2 Urban Water Service Delivery in Indian Cities: A Wicked Planning Problem

Levy (2013) states that the need for planning comes down to two words: complexity and interconnectedness. Complexity is the condition that justifies planning as a separate profession and as a separate activity of government. Interconnectedness is the condition that justifies planning as an approach, which connects different aspects of a problem at the same time to address a certain problem. I use this planning frame and view urban water service delivery as a planning problem with its complexities at the supply and demand sides and the physical infrastructure and institutions that are involved in the delivery process and with the interconnectedness from the source to the user.

A "wicked problem" (Rittel and Webber, 1973) encompasses more than the scientific or rational means and explanations of a problem. This section elaborates where the wickedness of the urban water service delivery lies by using a planning framework. The wickedness and the planning framework lend to opening up to a wider set of considerations for the research approach in this dissertation and the case study in Chapters 5 and 6.

Horst Rittel and Melvin Webber's classic 1973 paper, *Dilemmas in a General Theory of Planning*, set out to challenge the science and engineering approach to planning, especially government planning aimed at addressing social problems. The authors argued that despite the successes of the modern city builders, the "rational" planning processes that planners were attempting to transplant from the sciences (Figure 4-1) were being challenged in many arenas and in fact were bound to fail, because in the terminology invented by the authors, most planning problems are "wicked." By this they meant not a moral judgment about the nature of the problem but an assessment of its complexity, ambiguity, open-endedness, and potential for conflict.

Figure 4-1 The "Rational" Planning Process Challenged By Rittel and Webber



Created based on concepts in Rittel and Webber (1973)

4.2.1 Where Does The Problem Lie?

Here, a part of the problem lies in the diagnosis of the problem. The water provision problem in urban India is defined by the Government of India as a physical and managerial one (Chapter 3). The problem is seen as a lack of reliable water service resulting from a lack of physical infrastructure for water delivery together with a lack of local capacity to deliver such infrastructure and manage it efficiently. The government therefore has prescribed "solutions" in the form of the following policy interventions and approaches to implement them:

- first, specifying a service objective of continuously supplying pressurized piped water service. Here service availability at the user end, i.e., water available 24/7 or on a continuous basis to a user is conflated with continuous water provision on the supplier or utility end, i.e., the water provider or the utility will be continuously supplying pressurized piped water;

- second, presuming a singular physical water delivery approach (centralized infrastructure with pressurized piped systems), which stems from the conflation of the specific water service objective with the physical infrastructure used to achieve it; and
- third, proposing a favored institutional arrangement (expanding the role of private corporations in urban water service delivery signaling a particular form of public-private-partnerships or PPPs).

The interventions manifest a "singular approach" for the entire country, i.e., using only one type of service objective, one physical approach, and emphasizing one type of institutional arrangement in improving water service reliability. Table 4-1 summarizes how the government has defined the problem and prescribed the solutions.

Table 4-1 The Water Problem and Prescribed Solutions As Articulated by the Central Government

Identified Problem	Prescribed Solution	Rationale
Poor access to water, unreliable availability, questionable water quality in many parts or urban areas	Build new or additional waterworks and continuously supply pressurized water through pipes	Norm in the developed regions
Aging, poorly functioning waterworks (treatment plants, pipes, pumps, etc.)	Build new waterworks of the same type to replace aging systems (where they exist); improve system management	Emulating the norm in the developed regions
Costly inefficient service provision by government agencies: low technical capacity and poor performance of the agencies	Increase the role of private sector, through contracted services or even through transferring ownership of assets to private corporations*, Sometimes limit role of government to setting objectives, facilitating processes, and evaluating performance	Ideological belief that the private sector should be inherently involved in service provision because it is less prone to political interference and inherently incentivized to be more efficient than government.

* Extreme case of private sector participation (see Chapter 2), where private corporations make financial investments toward owning, building, and/or operating the systems. More recently, the focus has shifted to delegating certain work responsibilities to the private corporations rather than transferring ownership of assets.

By specifying the water problem as a straightforward problem of lack of infrastructure and management systems, the government's perspective reflects a myopic view of the problem and the engineering and management solution it has prescribed. As I discuss below, the understanding of the urban water service delivery problem as posited by the central government is unduly narrow, and a broader view of the problem would open up additional ways of handling the problem at scale, quicker, and potentially at lower cost.

4.2.2 Urban Water Service Delivery As A "Wicked Planning Problem"

As Rittel and Webber explained, wicked problems are ones where stakeholders have different values and different views of what the problem is, leading to differing and often contradictory solutions; in addition, the solutions are uncertain, but often are not ones where experimentation can be done, either because the impacts are large or because they have permanent effects that change the trajectory of events. Adding to the complexity, the conditions in which a "wicked" planning problem arises are important and substantively unique, so that transferring experience from one location to another is perilous; further, the contextual conditions are subject to change over time due to multitudinous factors, making measurement of the problem difficult and ambiguous and measurement of interventions' effects inconclusive. Water service delivery is one such problem. In Table 4-2, I outline some characteristics of a wicked planning problem and elaborate on how India's water service delivery problem exhibits the characteristics of a wicked planning problem.

Table 4-2 Water Service Delivery as a Wicked Planning Problem: Some Applicable Characteristics

Characteristics of Wicked Planning Problem listed by Rittel and Webber (1973)	Associated Characteristics of Water Service Delivery
No definitive formulation of problem	The problem is defined differently by different stakeholders; depending on how the problem is viewed it is an infrastructure problem, a management problem, or an equity problem, and more.
Solutions are not true-or-false, but good-or-bad	The problem has a moral dimension of being good or bad due to the implications it has for the poor, those in informal housing and slums, and long-time versus new city dwellers.
No immediate and no ultimate test of a solution	The government has proposed 100% coverage of 24/7 individualized pressurized piped service as a benchmark and its experts have estimated a timeline of 10-20 years (HPEC, 2011) to achieve it, however there is no immediate way to test whether this can be accomplished. Further, even once built the effectiveness of the solution can be gauged only over time, as the O&M of the infrastructure ensues. Also, even if the service is delivered and sustained as intended over time it is likely that with the rapid changes e.g., in the city size, population growth and development patterns and household incomes, it will not be possible to immediately measure the efficacy of the current proposal due to too many confounding changes.

Characteristics of Wicked Planning Problem listed by Rittel and Webber (1973)	Associated Characteristics of Water Service Delivery
Every solution is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly	Building water infrastructure requires major investments and sets the served area on a particular pathway from which it may be difficult to retreat. Further, the effectiveness of the built infrastructure solution can be gauged only over time, as the O&M of the infrastructure ensues in the social and political context, and if the service is delivered and sustained as intended.
No enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan	Water service delivery is a “moving target” due to the changing availability of water, the changing urban development and increasing water demand. The uncertainties associated with water as a natural resource in itself and the rapid urbanization that is exceeding the pace of water service delivery make it a weak candidate to have a set of specific operations in a plan.
Every wicked planning problem is unique	The heterogeneous urban development in India lends to unique urban contexts making delivering water service to each city a unique problem. The uniqueness lies in the physical diversity of the different living conditions including formal versus informal and planned versus not unplanned including access to water supply and difficulties of installing pipes, as well as socioeconomic diversity from low- to high-income users.
Problem is considered a symptom of another problem	Lack of water service is a fundamental problem in itself. Embedded herein is the problem of poor water service delivery can be seen as a symptom of other problems such as lack of urban planning or limited coordination between urban infrastructure service delivery and new development, or exceedingly fast growth.

There is no definitive formulation of a wicked problem

“For any given tame problem, an exhaustive formulation can be stated containing all the information the problem solver needs for understanding and solving the problem” (Rittel and Webber, 1973, p.161). For water service delivery, however, the formulation of the problem itself is a challenge. The identification of the problem and prescribing a solution to the problem by the Government of India (Table 4-1) is but, just one formulation of the problem. Table 4-3 below shows the different ways in which the urban water service delivery problem is identified and a solution is perceived by different stakeholders.

Table 4-3 The Water Service Delivery Problem and Potential Solutions As Proposed by Different Stakeholders

Identified Problem	Proposed Solution	Rationale
Service is unreliable even when pressurized pipes are in place	Replace the local government with private contractors assuming it has failed in operating and maintaining the service and replace it	The local government is incompetent and should be removed or its role should be reduced
	Give local government bodies a clear mandate, backed by technical assistance and funding, to fix leaks; better coordinate infrastructure capacity and urban development	Local government capacity can be built up to address the problems by decentralization
Water prices do not recover costs	Subsidize water prices using other sources of revenue or intergovernmental grants	Belief that water is a human right and should not be treated as an ordinary commodity (sometimes, even a commodity)
High cost of new centralized water infrastructure	Borrow money and raise tariffs to pay for costs	Belief that it is the only way to achieve water service experienced in developed regions
	Provide water using new likely cheaper technological solutions or a combination of solutions	Belief that new large centralized infrastructure will increase costs to unaffordable levels for many
Lengthy time required to deliver reliable water service	Provide water through solutions that are faster to deliver	Belief that there are many acceptable ways to assure that water is available when needed.
Uncertainty about quantity of freshwater available for use	Track and utilize emerging technologies that could solve this problem	Belief that technologies that currently are unavailable or costly or are not provided sufficient impetus (e.g., water recycling) will become more affordable and easier to implement as the technologies develop
	Manage or reduce demand	Population growth, other demand for water, together with climate change will outstrip rate of infrastructure service delivery and technology change and thus necessitate demand management

As Table 4-3 shows, there are multiple problems that have been identified under urban water service delivery, and there can be more than one way of addressing each problem. While the central government has seemingly embraced infrastructure expansion and private sector involvement as a strategy for increasing expertise and efficiency, others challenge this view. The plurality of water delivery mechanisms, analyses of the problem, and preferred solutions put forth at different levels of political organizations pose a challenge to the implementation of the central government's policy.

There are additional perspectives. For example, based on my interviews with officials at municipal water departments, some focus on water provision as a human necessity and see this as creating pressure for keeping water affordable, thus making service coverage for the poor a central issue; some others focus on the costs of growth and sprawl and the pressures they put on the water delivery system, making urban growth management an overarching concern. I see that length of time needed to build new infrastructure is also an important consideration, given the scale and heterogeneity on the ground that is to be served. Still others step back from the water delivery problem and argue that the bigger issue is that water supplies are uncertain, particularly in light of climate change and extreme weather patterns, and that this necessitates rethinking water use from the demand-side rather than solely on capacity increase on the supply-side. Some point out that water conflicts among different jurisdictions add to the uncertainty about supply and that these conflicts are not resolved by simply providing piped connections. Still others argue that policy should focus on reliability of service rather than focusing on continuous provision of pressurized piped water. Thus, there is no definitive formulation of the water service delivery problem.

Solutions to wicked problems are not true-or-false, but good-or-bad

"There are conventionalized criteria for objectively deciding whether the offered solution to an equation is correct or false. The criteria can be independently checked by other qualified persons who are familiar with the established criteria; and the answer will be normally unambiguous" (Rittel and Webber, 1973, p.162). However, for a wicked planning problem there cannot be a set of standard criteria that could be used to develop a solution, because not all of the aspects of the problem are scientific or even quantifiable. The water service delivery problem exhibits such characteristics. Rather there are complex social aspects for which there are trade-offs, and decisions need to be made using judgment, more than set formulae. For example, one component of water service delivery is the water supply source, which may be a lake, a reservoir, a river, or a groundwater aquifer that does not just have its own natural, hydrological features such as basins and watersheds, but which also passes through different political boundaries or jurisdictions. Use of water then is not only about physical availability but also about the different objectives, purposes and preferences of those jurisdictions – a matter recognized by the central government:

> *Inter-regional, inter-State, intra-State, as also inter-sectoral disputes in sharing of water, strain relationships and hamper the optimal utilization of water through scientific planning on basin/sub-basin basis.*
> *- Section 1.2 (viii), National Water Policy*

The above quote from the National Water Policy brings out the contrast between how an optimization process, which can ideally result in a "correct" solution may not proceed as smoothly due to political relationships and priorities resulting in a good or bad consequence. Thus, the solution to a water service delivery problem cannot be true or false, rather they turn out to be good or bad from the perspective of the various stakeholders.

<u>There is no immediate and no ultimate test of a solution to a wicked problem</u>

“For tame-problems one can determine on the spot how good a solution-attempt has been. More accurately, the test of a solution is entirely under the control of the few people who are involved and interested in the problem” (Rittel and Webber, 1973, p.162). However in the case of the urban water service delivery problem, with no definitive formulation or criteria for the solution to the problem, the solution cannot be evaluated with a particular test.

In the case of large centralized infrastructure for new piped water systems, the question is if the intended infrastructure service can be delivered in a reasonable period and maintained over a reasonable useful life, then renewed, in the Indian context. It is clear that there is no immediate way to test it, only a set of assumptions that can be made about what could make it succeed (or what could go wrong for it to fail). Furthermore, given the rapid change in the context, it is unclear that it would be possible to measure success in 20 years or even further in the future.

<u>Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly</u>

For pressurized piped systems, the prescribed solution involves large centralized water infrastructure systems embody the traditional engineering approach and consist of large and costly capital works. However, the water service delivery problem is such that one cannot build that infrastructure and see how it works and then easily correct it after unsatisfactory performance. Further, such centralized water delivery approach calls for large lumpy infrastructure, which is expensive and likely locks in the direction of investments for many years going forward. Rittel and Webber use the very example of infrastructure (below):

> *Large public-works are effectively irreversible, and the consequences they generate have long half-lives. Many people's lives will have been irreversibly influenced, and large amounts of money will have been spent--another irreversible act. The same happens with most other large-scale public works and with virtually all public-service programs.*
> *- Rittel and Webber, 1973, p.163*

Also, since the ability to operate and maintain the system are at issue, one cannot evaluate performance in a short time, rather it takes years of operation to assess whether the set up will be sustainable over time and able to provide the intended benefits. The effectiveness of the solution can be gauged only over time, as the O&M of the infrastructure ensues, and if the service is delivered and sustained as intended. This also includes O&M carried out by a private company. In the case of a private enterprise, as profit-making is its primary goal and typically its revenues are collected from the users in the form of water connections and regular tariffs, there is a possibility of fee hikes, which may not be affordable for all. This then conflicts with the very goal of delivering water service all users. There are several examples where such cases have led to public opposition and protests (Manthan, 2010, p.5-6).

Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan

Delivering water service in India is a "moving target" due to the changing water supply side and the changing urban demand and its conditions that need to be met (Chapter 2). On the supply side, the availability of water cannot be assumed to be a given all the time due to growing water stress from drying up of surface water from increasing temperatures or lowering of groundwater due to excessive withdrawals (UNICEF, 2013). Ongoing pollution of water from various anthropogenic activities render the water unusable and induce water stress and costs for treating it for safe consumption. Water supplies are vulnerable to various natural and anthropogenic influences, from the effects of drought to pollution from industry or farming. Thus even when a source has been earmarked for human consumption, the availability of usable water cannot be guaranteed. The availability of freshwater itself continues to change.

On the other side, the urban water demand is not just quantitatively increasing but there is a significant qualitative factor to it – its spatial distribution, the location of the demand by being concentrated in some cities and regions over others, the diversity of the dwellings and structures that the population lives in – from thatched or tin roof to concrete structures, and in the nature of the urban development from formal dwellings, unplanned concrete apartment buildings, to informal settlements and extralegal buildings. Further, the quality or the structure of the building does not necessarily indicate whether it is formal or informal. Such demand conditions are not static, there are continual and rapid changes occurring in a neighborhood, which may not have basic infrastructure services such as even roadway access or connectivity or sewerage, which also bear upon construction of new water lines or extension of the existing ones. Besides structural challenges, the large proportion of urban poor in Indian cities raises questions about affordability of infrastructure service, as basic as water.

Meeting the water demand under such dynamic urban conditions and at a large scale cannot have a rigid set of potential solutions that can be all enumerated; they are bound to change and debunk any criteria developed.

Every wicked problem is essentially unique

Every context within which the water needs to be delivered is different, especially if there is large scale of urban development growing with time and there is no water infrastructure present. The urban development context in Indian cities is highly diverse in terms of its distribution, density of population, and physical forms. With the dynamic conditions of growing urbanization, every neighborhood has its own characteristic of population that is low-income or high-income or a mix of both where planning for new infrastructure needs to consider the costs and also affordability of the resulting service. Further, the heterogeneity in the urban development including the informality, unplanned developments, and lack of other basic infrastructure services raises the need to examine the water service delivery problem in that context. This diversity makes a single solution hard to implement without significant adjustments: context matters and one size does not fit all.

This context adds several, specific variables that are unique to that context. The context includes rate of densification, peripheral growth, density of development, local poverty levels, share of development that is extralegal, climate impacts, water supply characteristics, etc. which strongly affect what actions are needed. Planning water service delivery in that context also has to consider a wide range of variables, to name a few: availability of the water at the supply source, which is dependent on natural phenomena such as precipitation and drought, which could vary due to climate change; the availability of financial and technical resources to design and build the physical facilities expecting that they will function to deliver water to all users as intended; and the urban context that has a growing population and diverse development.

Every wicked problem can be considered to be a symptom of another problem

The lack of basic access to water is a fundamental problem in itself. What lends to the poor urban water service is its poor delivery. Continuously supplied pressurized piped water service through individual connections is presumed to be the only way to deliver water to all, however it fails to manifest owing to different other problems. I see one stark problem of lack of or limited interaction between local planning of urban development and of water delivery processes.

Providing piped water service is not only about providing a piped connection to the infrastructure network but also ensuring that the connections are functional to deliver water service. The *Guide to Project Preparation, Implementation, and Appraisal* for Achieving 24/7 Continuous Water Service (MoUD, 2009) summarizes the condition of the physical infrastructure in India and how its condition depreciated resulting in poor water service:

> *Until 30 or 40 years ago, there were urban areas in the country that received 24/7 [continuous] supply. Operations deteriorated as service providers came under pressure from rapidly increasing urban populations, financial, technical and other constraints arising from the state of institutional incentives, lack of additional bulk water supply infrastructure, etc. Intermittent supply was progressively introduced as the norm to cope with these difficulties and this form of operation led to rapid deterioration in the urban water supply infrastructure.*
> *- MoUD, 2009, p.5*

Compared to installing pipelines within planned neighborhoods or in areas where new development is anticipated (mostly observed in developed regions such as the U.S.), providing piped water connections can be a challenge. This is particularly within the diversity and scale of the rapidly growing areas in India, many times with unplanned development:

> *The haphazard build-up of settlements and high population densities, some of which are water stressed and lacking sanitation, also is a factor. Peri-urban developments for example are an area where the municipal water agencies are often particularly uncertain how to provide and to pay for water service.*
> *- India, Assessment - Water Supply and Sanitation by Government of India, 2002, p.62*

Given India's rapid urbanization, its already stressed water delivery systems, the increasing demand in built up areas and the difficulties in providing services to extralegal development and peri-urban development, I find a distinct lack of link – the link of concurrency (Kaiser et al., 1995), i.e., meeting the demand through planning and implementation of water delivery facilities concurrently with the urban development. For example, from my interviews with regional and local officials and field observations, I find that the link is weak or nonexistent. The water department in a municipality operates and maintains the piped infrastructure and provides water connections to households while the planning department of a municipality approves new development and/or issues permits including any change in land use (e.g., change from agricultural to urban land). The water provision and land development processes continue in parallel with minimal overlap or coordination until the point at which the urban development department informs the water department or the utility of its approval of a new development in place and expects the utility to provide service:

> *We approve development schemes and notify the [municipal] corporation to provide water connection [to the land parcel]. We do not need to consult with them before approving the development*
> *– Interview with a regional urban development agency*

> *We get notified when a land parcel is developed to provide a water connection. We hear from the development agency after the development scheme is approved.*
> *– Interview with a local engineer*

One result of this lack of coordination is that the development often is occupied before infrastructure is in place, and is far from the concept of concurrency (infrastructure service provision concurrent with the development[44]). In many cities in India, infrastructure service lags development by a few months to a couple of years. Based on interviews I conducted for this study, the problem is exacerbated in the cases of private developers who build new homes or townships and promise to provide piped water service to new residents but fail to do so. In cities such as Mumbai, the municipal corporation provides an Occupational Certificate to the developer after all the procedural paperwork on the new development is final and when infrastructure services such as water connections are provided. Only after an Occupational Certificate is issued are the residents supposed to move in. However, in several cases the developers provide the buyers an option of moving in to new apartment buildings even when there is no Occupational Certificate. Keen residents move in, even with the knowledge that the municipality has not issued the Occupational Certificate for the apartment building and that there is no water service. The burden of water service then falls upon the residents, in which case they have to purchase water from independent tanker-operators at a higher price for uncertain time periods varying from a few months to even a few years.

4.3 Applying The "Wicked Problem" Framework

The "wicked problem" framework has been applied to several fields from environmental problems (Balint et al., 2011), urban design (Garde, 2008), to natural resource problems (Bellamy et al., 2006), problems overlapping between natural and political ecologies (Acey, Norissa, et al.) to theoretical concepts in planning theory (Verma, 1996; Healey, 2009).

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[44] An example is the concurrency policy in the U.S. (Kaiser et al., 1995) requires that public facilities be available concurrently with development.

Balint et al. (2011) analyze failed environmental planning efforts and recommend developing "a learning network among the stakeholders, using an adaptive, iterative, deliberative, analytical, participatory process" (p. 2, italics in original). In the article on "The Pragmatic Tradition in Planning Thought", Healey (2009) points out that "U.S. academic philosophy increasingly privileged an analytic mode of thought grounded in mathematical logic over engagement in the messy practicalities of personal and public life"…with a "a narrower focus on the autonomous, rationally acting individual". Healey describes this shift as follows:

> *This shift in intellectual climate, in turn, had a reductive influence on the developing conceptions of rational policymaking method. What had started out as a search for a broadly rational way to address "wicked problems" (Blanco, 1994) became redefined in practice as a taming of wicked problems into a particular set of assumptions that could then be manipulated in the formal logic of mathematical models (Rittel and Webber, 1973). The early sensitivity to context and to the project of developing a critical and creative democratic intelligence through governance practices got lost in the search to ground public policy decisions in scientifically objective and/or deductive, mathematically robust logic.*
>
> *- Healey, 2009, p.281*

As Rittel and Webber (1973) characterize the wicked problem, they argue that there is no single solution that is "best" for wicked problems, and the problem may never be "solved" definitively, although it may be "resolved" for a time. Rittel and Webber went on to suggest that expert judgments are likely to prove unworkable for wicked problems, since they impose the expert's values without acknowledging the underlying differences in values and perspectives of the many stakeholders. They suggest that planning processes that provide for the expression of differences in context and allow individual choice to be expressed are more likely to be robust when wicked problems are being confronted. They argue for collaborative approaches and multiple choices. Subsequent scholars of planning theory have studied in greater detail how the problem can be approached and addressed.

Especially on planning problems – directly relevant to this research, one way forward involves acknowledging dynamism and advising on mechanisms for coping with uncertainty in planning (Christensen, 1985; Healey, 2009). Christensen's work (1985) built on the Rittel and Webber insights and aimed to help planners better classify the nature of the problem and the potential solution sets. Christensen acknowledges that there is no clear agreement about how to address such problems and offers a framework that can differentiate the characteristics of wicked planning problems. The framework consists of a matrix to clarify the variable planning problem conditions. As Figure 4-2 shows, the matrix is divided along two dimensions. The vertical dimension is "technology" meant very broadly as the knowledge of how to do something or the means. The horizontal dimension is "goal", the purpose, desired outcome, or end. Each is dichotomized according to certainty and uncertainty. The key variables of the matrix are means, ends, and uncertainty that go to the heart of planning. The real world is not of course that tidy. The line that divides means and ends often blurs.

Figure 4-2 Prototype Conditions of Planning Problems

		Goal	
		Agreed	Not Agreed
Technology	Known	A	C
	Unknown	B	D

Source: Christensen (1985).

If the goal is agreed upon and the planners know how to achieve it, then planning becomes a learning process (A); if there is no agreement then planning becomes a bargaining process (C). When the problem is known but the solution is unknown, innovation is needed (B). Finally there are situations when there are multiple unarticulated goals and no known effective means to achieving them (D). Cases of uncertainty over means and ends arise from competing goals, each associated with competing technologies (Christensen, 1985). Here, the water service delivery problem as defined by the central government resides in box A with a set technology of 100% coverage of pressurized piped water however, the local context seems to demand a different and innovative approach where the goal of providing clean water to all, now in a reliable manner may not necessarily be through centralized pressurized piped systems thus, the technology or means are not necessarily unknown nor are they are agreed upon. The gap between central-level policy design and the local policy implementation makes both the means and ends uncertain; there is little agreement (box C) between what is pre-decided and what is observed on the ground, may it be due to insufficient technical resources, water supplies, inadequate regulation, or poor financial health to continue O&M of the infrastructure system.

In addition to prototyping the conditions of a planning problem that Christensen introduced, Horn and Webber (2007) elaborated on Rittel-Webber arguments and researched on building a dynamic resolution process for wicked problems building as well on Russell Ackoff's idea (1974) of a "social mess".

> *We have also come to realize that no problem ever exists in complete isolation. Every problem interacts with other problems and is therefore part of a set of interrelated problems, a system of problems. ...I choose to call such a system a mess.*
> *- Ackoff, 1974, p.6*

A social mess is a set of interrelated problems and other messes. Complexity— systems of systems—is among the factors that makes social messes resistant to analysis and, more importantly, to resolution. Horn and Webber present tools to help surfacing of competing ideas, supporting of individual choice, and for collaboration and conflict resolution to occur.

In addition to being overwhelmed by complexity, working groups fail to resolve these issues because they often fall victim to the bureaucratic silo effect: decision-makers fail to look beyond the boundaries of their own interest group, organization, department, etc., or they believe that it's the responsibility of someone in another silo to fix the wicked problem at hand.
- Horn and Webber, 2007, p.3

Horn and Webber point out that in addition to the conflicts, ambiguities and uncertainties that wicked problems entail, those seeking resolution may also face significant political, cultural, economic, or environmental constraints. Furthermore, they may need to involve "problem-solvers" who are out of touch with those who would be affected, work with parties who are resistant to change, and engage with stakeholders who may have significant conflicts of interest.

Another approach to cope with wicked problems is identified in the form of different strategies by Roberts (2000) that include collaboration – which overlaps with Rittel and Webber (1973) suggest and which seeks to maximize inclusiveness and knowledge sharing in the solution/problem formulation process. This strategy may involve extensive meetings and may end up being a time-consuming and sometimes indecisive process. Roberts also discusses an authoritative strategy that vests power with smaller enlightened group of decision makers to reduce complexity. The disadvantage here is that authorities and experts charged with solving the problem may not have an appreciation of all the perspectives needed to tackle the problem. The final competitive strategy is with opposing points of view presented against each other. The advantage of this approach is that different solutions can be weighed against each other and the best one chosen. The disadvantage is that this adversarial approach creates a confrontational environment in which knowledge sharing is discouraged with a risk that the parties involved may not have an incentive to come up with their best possible solution. .

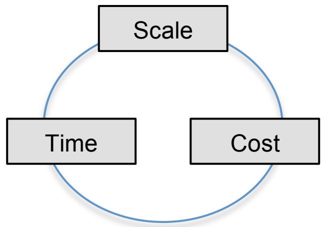
I see that Roberts' strategies may be applied toward addressing a large set of problems, not just wicked planning problems. These strategies, along with Christensen and Horn and Weber's research provide valuable insights into the concept of coping with or addressing wicked planning problem and of an approach that is cognizant to the "means" and "technology", which can respond and adapt to the local context.

4.4 Addressing Urban Water Service Delivery as a Wicked Planning Problem

Millions of urban Indians are without reliable water service, so water needs to be delivered right now, but it also needs to be delivered in a manner that can be sustained over time and can grow to handle increasing demand. Urban water service delivery is seen as a technological and management issue or a social issue, economic issue or a political/ institutional issue with limited parallel approaches to address other challenges. The outcomes from such individual approaches seem to address one set of problems while compromising on another, and thus blurring the basic goal of service reaching the user.

Given the various moving parts of the problem, the first step is defining what addressing the wicked planning problem of water service delivery would mean. Would it be supplying 24/7 pressurized piped water service through individualized piped connections for all or would it be achieving reliable water service to all, now[45]? The critical issues of delivering water center around the scale of the water demand and its heterogeneity in a short time with cost considerations (Figure 4-3).

Figure 4-3 The Critical Issues of Delivering Water



There is a need to address the different dimensions of the problem at the same time. The physical burden given the scale and the heterogeneity has a financial component, which also bears upon the technology and the physical infrastructure used. Therefore, this study broadens the considerations by a process that involves:

- Addressing all the metrics of water service (i.e., access, quantity, and quality) that meet the water needs of *all* of the urban dwellers – regardless of the physical means and accounting for equity;
- Delivering water to all users in a timely manner – now – taking into consideration the financial burdens; and
- Going beyond the type of the organization, whether public or private or other, and accounting for institutional mechanisms to meet users' needs.

[45] Even while the 24/7 continuous supply of pressurized piped water is being made available to all urban households in India.

Chapter 5 Urban Water Service in Hubli-Dharwad: A Case of Two Different Water Delivery Processes

5.1 Purpose of Chapter and Overview

Having examined at the urban water service delivery in India as a wicked planning problem (Chapters 3 and 4), in this chapter I study the problem in a specific urban context using the cities of Hubli-Dharwad. Chapter 1 presents my hypothesis that there can be another approach, which can lead to other ways to provide water that meet users' needs, and offer physical delivery approaches that are faster and likely cheaper and institutional approaches that can ensure service delivery now, and over time. In the case of Hubli-Dharwad, the "singular approach" proposed by the central government is being implemented in a portion of the city and it has not been implemented in another. To test my hypothesis, I investigate the two water service delivery processes: one, the process of continuously supplying 24/7 pressurized piped water using a specific type of public-private-partnership (PPP), and second, the process of providing other types of (non-24/7 pressurized piped) water service, which may include other types of water service and delivery processes. The study allows me to evaluate if the approaches account for time, scale, and cost considerations, and deliver or have a potential to deliver reliable water to all of the city dwellers, now and sustain over time.

Before studying the two water service delivery processes, I introduce the case study by presenting an important backdrop of the urban demand conditions and the institutional context to understand the outcome of the water delivery processes that I study in the rest of the chapter.

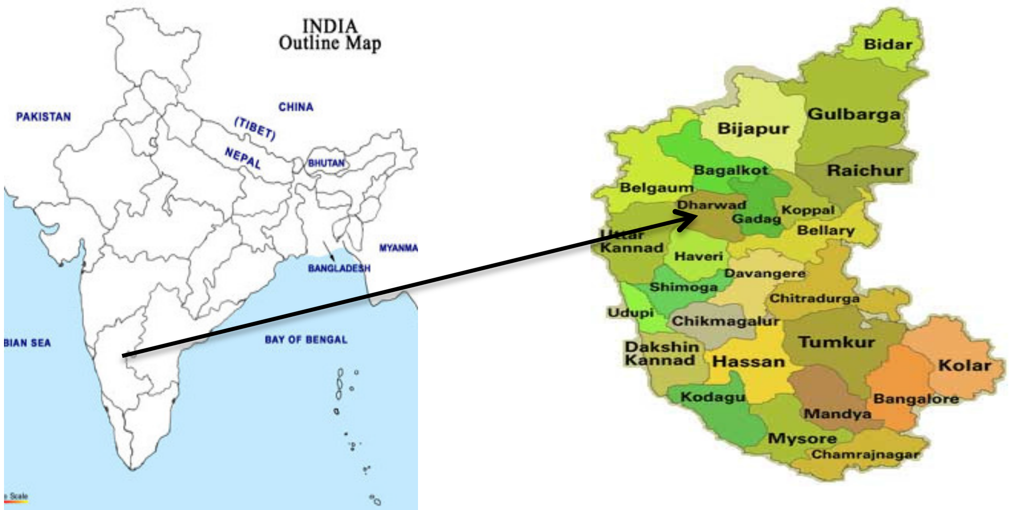
The chapter is based on a review of relevant literature on the cities of Hubli and Dharwad, in particular reports and government documents that discuss the cities' water service, the institutions responsible for delivering water service, and the cities' urban planning and development. The chapter is also based on and supported by information gathered from interviews with water providers and other practitioners and experts and field observations. Historic information on the water infrastructure system in Hubli-Dharwad is drawn upon a project report by Wilbur Smith Associates Pvt. Ltd. (2003) and a water resource study report by Hollingham (2011) that also uses studies presented at the Bhageerath Workshop on Water and Sanitation Problems in Hubli-Dharwad Cities by Kulkarni, Polisgowdar, and Reddy (2001). The discussion of the current situation draws upon recent publications on water service in Hubli-Dharwad by Kumpel and Nelson (2013) and Burt and Ray (2014), which present findings from a user survey (n=4,000) conducted in select portions served by the 24/7 pressurized piped water pilot project and equivalent representative portions of the remaining parts of the city. In addition, the chapter draws upon Jayaramu and Devadiga et al., (*forthcoming*) in which we present a trajectory of how the KUWSDB's operations affected water service in Hubli-Dharwad.

5.2 An Introduction to Hubli-Dharwad

The cities of Hubli-Dharwad are located in the southern Indian state of Karnataka. Situated in the Deccan Plateau in southwest India, the state of Karnataka is the eighth largest Indian state[46] (KUWSDB, 2012) with an area of 191,976 square kilometers (~74,122 square miles)[47]. Karnataka is the ninth most populous state with a population of 61 million (Census 2011).[48] The state is divided into 30 districts (KUWSDB, 2012) and the twin cities are located in the Dharwad District (Figure 5-1).

Figure 5-1 Location Map of Hubli-Dharwad

India | **State of Karnataka and Hubli-Dharwad**



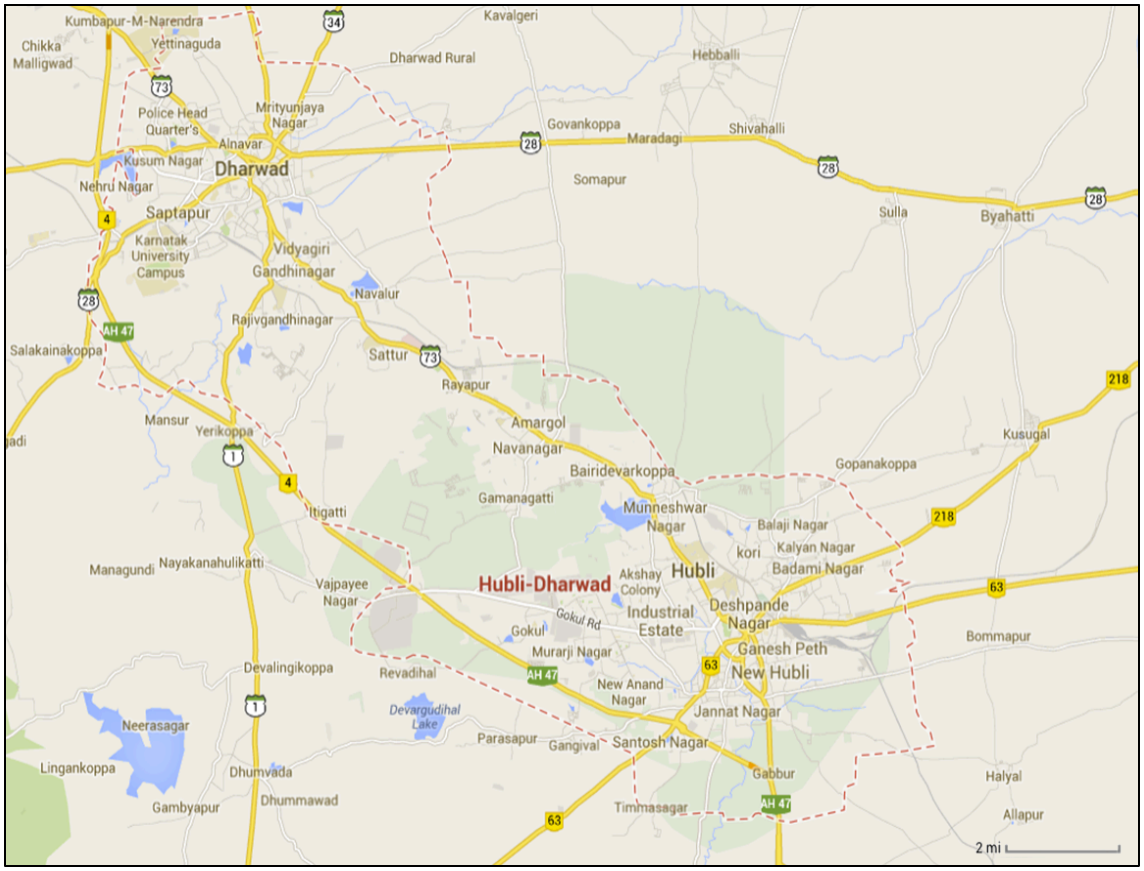
Hubli and Dharwad are located approximately 20 kilometers apart (Figure 5-2). Hubli is a commercial and industrial hub while Dharwad is an educational and administrative center with colleges, universities and government offices (Ramachandra and Aithal, 2012).

[46] Out of 28 states.

[47] For reference, the state of Karnataka is approximately 3,000 square miles larger than the State of Washington in the United States that has an area of ~71,000 square miles.

[48] For reference, California, the most populous state in the U.S. has a population close to half of that of Karnataka (~37 million) and has an area of more than half (163,695 square miles).

Figure 5-2 Cities of Hubli-Dharwad



Hollingham (2011) notes that the area is characterized by a monsoonal climate and data in Hubli-Dharwad over a 20-year period (1980-1999) showed rainfall occurring from April to October ranging from 400 to 1,100 millimeters (mm) with an average of 768 mm (~30 inches). More recent data from 2004 to 2010 from the Indian Meteorological Department (2011) shows a higher average rainfall of 817.6 mm (~32.2 inches).[49]

5.2.1 The Growing Heterogeneous Urban Development

Hubli-Dharwad represents one of the fastest urbanizing regions in India, regions that are commanding over 50% of nationwide investments in capital infrastructure development. Urban water demand is increasing along with urban development, which is manifesting both in scale and diversity.

A spatio-temporal study of the urbanizing landscape in Hubli-Dharwad (Ramachandra and Aithal, 2012) reveals a significant increase in the built-up area during the last decade and a consequent decrease in the natural vegetation cover.[50] Spatial urban growth exhibited moderate

[49] Precipitation in India ranges from 500 millimeters in Rajasthan on the west to 3,798 millimeters in coastal Karnataka in the south (CWC, 2010).

[50] Natural vegetation cover includes rural and urban land features. Rural land is mainly used for agriculture, grazing, and horticulture. Large industries and quarries also exist in the rural areas. Changes in the rural landscape driven by urban development include road and highway construction, and infrastructure development such as irrigation

changes in the urban core over 10 years (2000-2010) with aggregated growth and a spread-out pattern of concentrations of urban areas toward the periphery. The growth also reflects extralegal housing (not authorized by the government) that was developed to accommodate people displaced by inner urban development and migrants from relatively far off rural areas. The extralegal communities have poor water supply, electricity, and sanitation services (Brook et al., 2003).

The urban area has experienced not only a spreading out of urbanization but growing population density, which has increased by about 15% over the decade 2001-11 (Table 5-1).

Table 5-1 Population Size and Density in Dharwad District*

Population Size		Population Density (Persons per sq.km.)	
2001	**2011**	**2001**	**2011**
52,850,562	61,130,704	276	319
Growth Rate	~7.2%	-	~15%

*Hubli-Dharwad (pop. ~1 million) is located within the larger Dharwad district shown in Figure 5-1.
Source: Karnataka Census, 2011

Heterogeneity in the development pattern is evidenced in the different types of dwellings and how they are differentiated, for example, the material of the housing structure bears upon the how "permanent" the structure is (Figure 5-3) and its condition as the Census defines it (Table 5-2). My field observations indicate that the diverse housing structures do not have a defined or consistent developmental pattern or they may or may not have basic infrastructure services such as operational roadways, access, or drainage ways along which centralized water networks are typically installed.

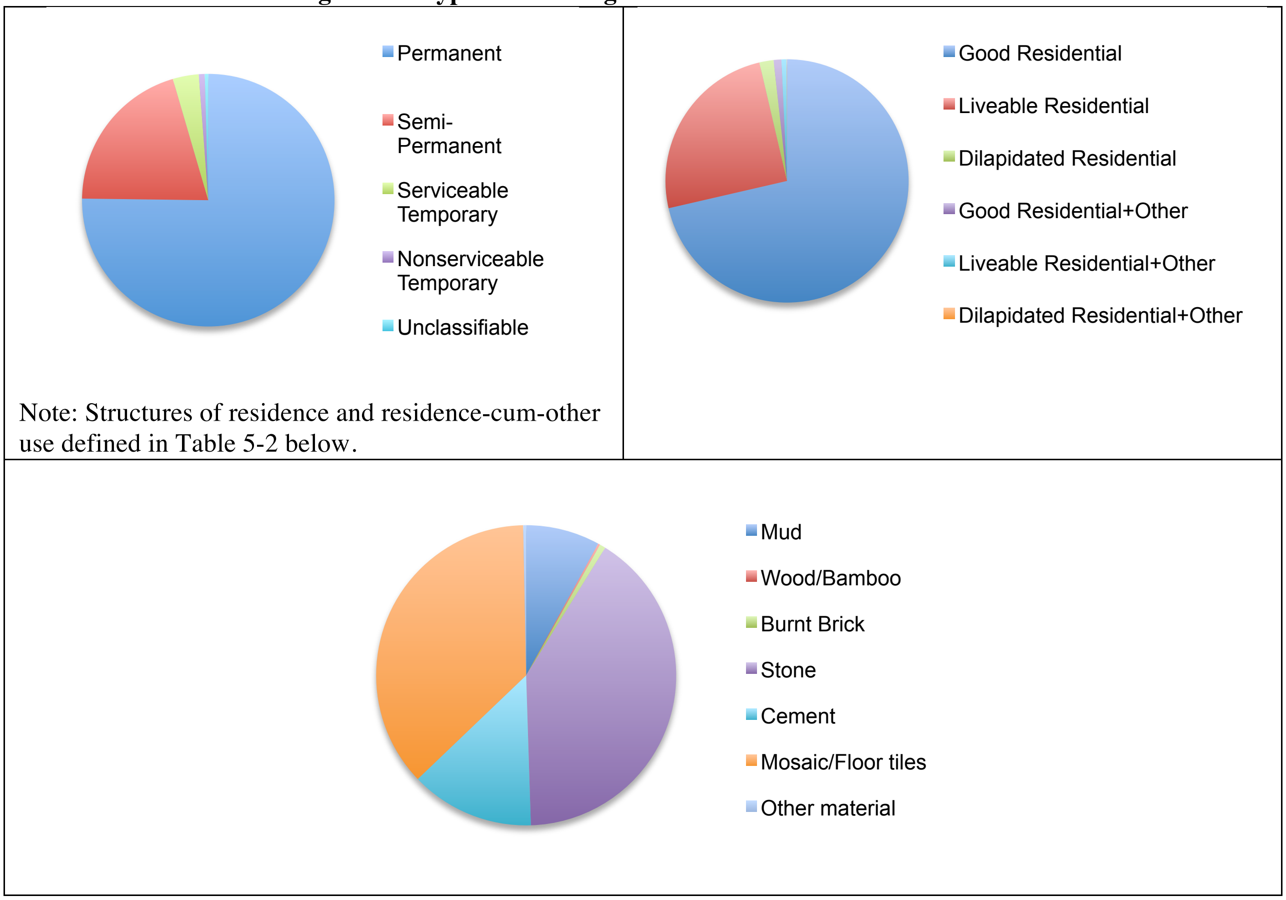
Table 5-2 Types of Urban Households: Some Categories as Defined in the Census

"Permanent": Houses with wall and roof made of permanent materials; wall can be made of G.I., Stone packed with Mortar, Stone not packed with Mortar, Metal, Asbestos sheets, Burnt bricks, Stone or Concrete. Roof can be made of hand-made tiles, machine-made tiles, Slate, G.I., Metal, Asbestos sheets, Brick, Stone or Concrete.
"Temporary": Houses with wall and roof made of temporary material. Wall can be made of grass, thatch, bamboo etc., plastic, polythene, mud, unburnt brick or wood. Roof can be made of grass, thatch, bamboo, wood, mud, plastic or polythene.
"Semi-Permanent": Either wall or roof is made of permanent material and [the] other is made of temporary material.
"Serviceable Temporary": Wall is made of mud, unburnt brick or wood.
"Non-serviceable Temporary": Wall is made of grass, thatch, bamboo etc., plastic or polythene.

Source: Census of India, 2011

projects, power plants and so on. Urban land is the land used for residential and commercial purposes as well as small industries. It also includes green belts where there are parks and playgrounds. In addition institutional structures of particular government and educational institutions tend to be concentrated in the urban areas. Simultaneously, urban areas demand heavy infrastructure to cater to specific needs of large urban populations such as transportation and health. (Brook et al., 2003).

Figure 5-3 Types of Housing Structures in Dharwad District*



Note: Structures of residence and residence-cum-other use defined in Table 5-2 below.

*Hubli-Dharwad (pop. ~1 million) is located within the larger Dharwad district shown in Figure 5-1.
Source: HH-Series Tables 2, 5, 6 and 13, Census of India, Karnataka Census, Census, Dharwad District, 2011

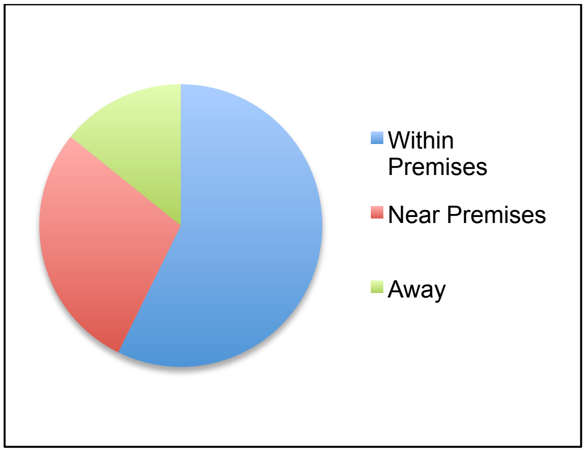
The household data includes slum households shown in Table 5-2 for the state of Karnataka. One source (Huralimath, 2013) cites an increase in slum areas in Hubli-Dharwad from 94 in 2003 to 105 in 2013. A decade ago (2004-2005), Karnataka had over 7.9% of urban poor in India (2004-2005) and its slum population at 3.6 million in 2011 is projected to increase to over 4 million by 2017 (Planning Commission, 2011).

5.2.2 Water Service: Different Access Points and Community Arrangements of Water Provision

Piped water service does not reach all of the households. The different types of housing structures and their location in the city, for example in terms of whether the house lies in a formal neighborhood or an informal settlement, there are also different ways in which people access or obtain water affecting the service they receive.

One other way to view water service is reported by the Karnataka Census (2011) as different types of "water supply sources" for households in Dharwad district, one with respect to the dwelling premises and the other with respect to access points (Figures 5-4 and 5-5).

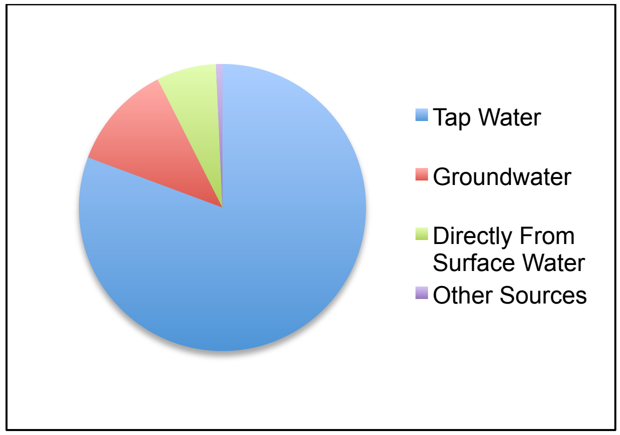
Figure 5-4 Access to Water Within and Outside Household Premises*
(Dharwad District)



Source: Karnataka Planning Commission, 2012

* Examples of water access within premises are piped connection and a private groundwater well. Water access near premises can include a communal tap or a water tanker delivering water in close vicinity.

Figure 5-5 Water Access Points for Households (Dharwad District)**



Source: Karnataka Planning Commission, 2012

** The figure shows three broad categories that comprise of subcategories of water sources as follows: Tap water (from treated and untreated sources through centralized infrastructure), groundwater (available through handpump, tube well or a bore well through decentralized facilities), and directly from surface water (such as a spring, river or a canal, tank, pond, or a lake).

The figures present the water supply sources as a diverse range of water access points that can be within or outside the premises. The actual water source can be a tap or a groundwater well within or outside the premises, or other sources outside the premises. Tap water (whether individual or other) typically connects with the centralized water infrastructure operated by the local municipality. In 2003, a consultant reported yet other statistics on water supply sources – that 15% of the population obtained water from public stand posts[51], 10% of the population in Hubli-Dharwad received water through tankers,[52] and 30% remained uncovered and relied upon hand pumps or “other sources” (Wilbur Smith Associates Pvt Ltd., 2003).

The tap for a household (Figure 5-5) may be a shared or communal tap; it is only one of the various access points, which consists of a piped connection to a centralized infrastructure system that delivers water from a surface water source. The water is available on an intermittent basis at varied times for a few hours once in three to five days a week.

Due to the intermittent and variable water service at the tap, households resort to different mechanisms to cope with the service. Once such mechanism is using storage tanks to store water when it is available for later use or use when the water is not running at the tap – a “simulated”, and not necessarily a pressurized piped, 24/7 water service. Figure 5-6 shows an example of storage tanks in Hubli-Dharwad.

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[51] Connected to the centralized water infrastructure system operated by the local municipality.
[52] Water delivered through tankers may be operated under contracts with the local public provider and cannot be presumed to be operated only by independent private vendors.

Figure 5-6 An Example of Storage Tanks on Roof Tops in Hubli-Dharwad

Woelfle-Erskine (2012) developed a typology of water access and coping mechanisms that households have resorted to due to the poor water service. The typology is consistent with Burt and Ray's research (2014) in Hubli-Dharwad that roughly characterized water access points into the following three types:

1) Shared public taps: "The most inconvenient" access point used either by a small or a large number of families, are observed only in low-income neighborhoods;
2) Private taps but no overhead storage tanks: Households with a private tap (legitimate or not) but no overhead tank correspond with the better-off low-income households, as well as some middle-income households;
3) Both private taps and overhead tanks (Figure 5-6): Overhead tanks mimick continuous piped water, i.e., allowing for access to water in the tank water stored when water is available at the tap for later use and forms the most "convenient forms of access". This option is available almost exclusively to upper income households. In all these cases, collection and storage for the sake of reliability and ease of access are informal services provided from within the household.

Such diverse ways in which water demand is distributed and the different forms and quality of water service continue to proliferate and exceed the rate of provision of reliable continuously supplied 24/7 pressurized piped water service. While the 24/7 continuously supplied pressurized piped water service is being planned and until it is becomes available to all, different physical modes (e.g., water sources and storage or treatment facilities) and institutional mechanisms seem to be in action that provide 24/7 water service. However, such service is not available to all, plus it comes with costs. For example, based on a recent market survey[53], the costs to adopt such mechanisms range from approximately Rs. 6-14 per liter for a tank depending on the material such as plastic and concrete plus installation of Rs. 5,800. Further, the "simulated 24/7 service" is still contingent upon the vagaries of the municipal piped water service, whereas those with no access to piped water rely upon "other sources" as described earlier in the section.

[53] Preliminary research and market study led by Burt, Z. in 2013.

Preliminary results of a user survey (n=~4,000) indicated that users had a greater willingness to pay for incremental improvements in water service (Burt et al., 2014). The survey results indicated that water users have a positive willingness-to-pay for incremental improvements in frequency, duration and punctuality of water deliveries and for water quality improvements (which might be complicated by taste preferences). At the same time, experiencing continuous water service has a large, positive effect on the willingness-to-pay for continuous water service (Burt et al., 2014), which is 24/7 water service at the user-end and may not necessarily be achieved only by continuously supplying it through a citywide centralized pressurized piped system.

> *In a rapid survey conducted in 2003 by Samaj Vikas Development Support Organisation (SVDSO) Hyderabad as part of a pre-appraisal study, 67 per cent of the households in the three cities [Hubli-Dharwad and Belgaum] merely wanted a more reliable supply with specific timings and pressure.*
>
> *- Sangameswaran et al., 2008, p.63*

The quote above seems to indicate the government's conflation of continuous supply of pressurized piped water and regularity or certainty in the current intermittent schedule, while the households seem to prefer faster improvements in water service than 24/7 pressurized piped water.

When self-provision and private vendors are relied upon to cope with the prevalent poor water service, it is important to understand who is delivering it, more specifically how the government is delivering piped water service – the primary approach espoused by the government. At the city-wide scale, the municipal piped water reaches over 65% of the households through piped water, which however does not mean that piped systems is the only way the municipality delivers water. In the next section, through the relevant institutional backdrop, I discuss some key actors and reforms related to piped water delivery.

5.3 Some Key Organizations in Water Delivery, A Backdrop on Piped Water Operations, and An Introduction to Some Key Urban Water Reforms

5.3.1 The Key Actors

The organizations primarily involved in delivering water in Hubli-Dharwad is the Water Department of the local Hubli-Dharwad Municipal Corporation (HDMC) while that involved in urban development is primarily the Hubli-Dharwad Urban Development Authority (HDUDA). The Town Planning Department at HDMC issues permits for developments in the cities (Table 5-3).

Piped water is delivered through a centralized water distribution system, which is operated and maintained by HDMC formed under the Karnataka Municipal Corporations Act of 1976[54]. Under

[54] Under the Government of India Act of 1850, the Hubli-Dharwad Municipal Council was established on August 15, 1855. HDMC was constituted in the year 1962 by combining the two cities separated by a distance of 20 kilometers.

the 1976 State Karnataka Municipal Corporations Act, HDMC provides water for "domestic purposes", which is clearly stated to exclude "…water use for any trade, manufacture, or business, gardens or for irrigation, for building purposes, for public baths or tanks for ornamental purposes, for consumption and use by inmates of hotels or boarding houses or persons resorting to cinema; for constructing or watering streets, or washing vehicles, for flushing drains."[55] This responsibility therefore strictly covers meeting only basic daily water needs of the city dwellers. Providing water service within Hubli-Dharwad is only one of the several responsibilities of HDMC; others include sewerage, storm drainage, and solid waste management. Government reports (GOI, 2012; HPEC, 2011) and my interviews indicate that the local municipal corporation is partly funded by revenues from user fees and local taxes such as property taxes and development permit fees, and a majority by state grants and subsidies.

The water distribution system in Hubli-Dharwad is part of a large, centralized infrastructure system (discussed further in Section 5.4), which is built by the state Karnataka Urban Water Supply & Drainage Board (KUWSDB)[56] that regulates and develops drinking water and drainage facilities in the urban areas of the state. KUWSDB provides financial assistance by way of loans and advances to urban local bodies (ULBs) such as municipal corporations for (among other activities), in this case HDMC, assisting in providing water supply and drainage for urban areas. KUWSDB is responsible for "providing adequate water supply from assured and safe sources of supply[57] and also proper sanitation to all the ULBs of the state" (KUWSDB, 2014).

For the facilitation and creation of the urban water infrastructure to all the ULBs[58] through KUWSDB, it is the state Urban Development Department (UDD) that is responsible, while in terms of infrastructure projects under schemes of multilateral agencies (Sangmeswaran et al., 2008) it is the Karnataka Urban Infrastructure Development Finance Corporation (KUIDFC), which is the channeling agency. KUIDFC was established as a public limited company[59] under the 1956 Companies Act. KUIDFC has been functioning as the main arm of the Government of Karnataka (GoK) on urban infrastructure development projects and as the GoK's interface with external lending agencies such as the World Bank.[60]

The state UDD also offers technical assistance for the preparation of master plans and development schemes/layouts by regional Urban Development Authorities (UDD, 2011). The local Hubli-Dharwad Urban Development Authority (HDUDA) is designated as the planning authority under the 1961 Karnataka Town and Country Planning Act. HDUDA prepares development plans for Hubli-Dharwad; approves residential, commercial, and industrial development plans, and prepares and approves plans for parks and playgrounds. HDUDA is also

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[55] Chapter XII, Water and Sewerage of the 1976 Karnataka Municipal Corporations Act, Section 193.
[56] Formed under the 1973 Karnataka Urban Water Supply & Drainage Board Act.
[57] The water supply resource is harnessed for irrigation and drinking water purposes by the Water Resources Ministry of Karnataka or the Karnataka Water Resources Department headed by the Minister for Major and Medium Irrigation (Karnataka Water Resources Department, 2013).
[58] Outside Bangalore Metropolitan Area
[59] A type of a publicly held company and a limited liability company whose shares may be sold and traded to the public.
[60] Urban Development Department, GoK, available at http://www.uddkar.gov.in/KUIDFC

involved in construction of housing for all sections of the population and "development of major infrastructure facilities"[61].

Table 5-3 Organizational Context on Water Service Delivery in Hubli-Dharwad

Institutional Level	Name	Broad Responsibilities
Local	Hubli-Dharwad Municipal Corporation (HDMC)	Water Department: Operates and maintains and conducts extensions of physical infrastructure Town Planning Department: Involved in administration and issuance of permits to developments
	Hubli-Dharwad Urban Development Agency (HDUDA)	Prepares and approves zoning and development plans, prepares and implements development plans (residential, commercial, etc.), inspects buildings
State	Karnataka Irrigation Department or Water Resources Department	Harnesses surface water for irrigation and drinking water purposes, resolve interstate water disputes
	Karnataka Urban Water Supply and Drainage Board (KUWSDB)	Regulates and develops drinking water and drainage facilities, water policies, investments and plans of water supplies
	Urban Development Department (UDD)	Has a vision of creating and improving economically vibrant, efficient and sustainable basic infrastructure for better quality of life inclusive of all urban habitats in Karnataka

In summary, HDMC operates and maintains the city's water distribution system, which includes surface water reservoirs in the city, pumping facilities, and the pipeline network that delivers drinking water to users (Jayaramu et al., *forthcoming*; Raju, et al., 2007). The state KUWSDB is responsible for bulk supply and maintenance of water supply systems, and design and implementation (constructing) of water supply schemes in Hubli-Dharwad. KUWSDB also provides financial assistance by way of loans and advances to HDMC for (among other activities) assisting in providing water supply and drainage for urban areas. On a parallel track, HDUDA approves new urban development.

Water Service Operations Under HDMC

Until March 2003, HDMC operated and maintained the water distribution system and KUWSDB was responsible for bulk supply and maintenance of water supply systems. This led to interdependence accompanied with co-ordination problems and conflicts between the two agencies during execution of work (Raju et al., 2007, p.6). As a study funded by the KUIDFC "to understand the water supply situation and trends before implementing the [24/7 pressurized piped water] scheme" in Hubli-Dharwad put it (Raju et al., 2007):

> *It was difficult to see any of the agencies having an overview, rather each agency blamed the other for inefficiency. Although efforts were made to resolve, the effect seem[ed] to be minimal. Implications of problems in one agency will trigger the problem in another. For example – HDMC was tied up in spending; according to the Karnataka Municipal Corporation Act of 1976, it cannot do any execution work beyond 50 lakh [or Rs. 5 million or $82,583]. So, they*

[61] HDUDA may be involved in installing water infrastructure for new housing developments, which are then transferred to HDMC.

cannot attend to major repairs and were dependent on KUWSDB. Another major problem faced by HDMC was high volume of unaccounted for water, which drastically curtailed the supply till 2002. Though 64 MLD[62] of surface water was drawn, the actual quantity supplied was 26 MLD in Hubli and 19 MLD in Dharwad excluding 40% of unaccounted for water.
- Raju et al., 2007, p.23

Based on a GoK 1985 Order[63], the users[64] were charged a water connection fee from 1985 to 1995 that consisted of two parts: a connection fee for a house connection with the water main (Rs. 55 or $0.91) and a refundable deposit of Rs. 50 ($0.82). In 1995, HDMC approved a resolution to add an annual service fee, which increased the total water connection fee by 12.5% (HDMC, 1995). The connection fees were thus revised from Rs. 55 ($0.91) to Rs. 175 ($2.88) in 1995 (Table 5-4).

Table 5-4 Water Connection Fees in Rupees (1985 - 1996)

Year	Service Charge	Cost of Connection from Public main	Refundable Deposit	Total Connection Fees
1985-95	---	5	50	55
1995-96	100	25	50	175

Source: Jayaramu et al., *forthcoming*

Within a year, a new 1996 GoK Order introduced another change (Jayaramu et al., *forthcoming*): the refundable deposit (Rs. 50) was changed to a non-refundable deposit in the form of a one-time connection charge of Rs. 2,000. This change resulted in a steep increase (~1,100%) in the connection fees from Rs. 175 ($2.88) in the year 1995-96 (Table 5-4) to Rs. 2,259 ($37.14) in the year 1996-97 (Table 5-5). Since 1996, there had been an increase in the connection fees every year due to the stipulated 12.5% annual increase in the service charge.[65] In over eight years (1996-2004), under the connection policies, the overall connection fee increased from Rs. 2,259 ($37.14) in 1996-97 to Rs. 2,591 ($42.78) in 2003-04 without a corresponding improvement in water service.[66] For reference, the poverty line in India is drawn at monthly consumption of Rs. 538.6 ($8.76).

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[62] MLD = million liters per day

[63] Based on the GoK1985 Order in Hubli-Dharwad, the onus of obtaining water connection rested with the owner of the house, lessee or occupier of the house. The Order stated that, "the owner of the house, lessee or occupier of the house who desires to have supply of water should make an application for house [water service] connection in the prescribed form and [submit] documents [to HDMC] through a licensed plumber". A licensed plumber, after obtaining necessary approval from the local body such as the HDMC, would install a pipe connection from the water main [pipeline network] up to the meter point at a price paid by the applicant. The Order prohibited more than one water connection for a household, whereas a multi-family building or an apartment building would be eligible for more than one connection.

[64] Includes authorized and unauthorized layouts and slums; how water is delivered to such diverse households is described in Section 5.4.5.

[65] This increased service fee was stipulated to be spent on installing new connections and for maintenance.

[66] For reference, about 40 to 45 million persons are on the border line of poverty. In 2004-05, 80.8 million people out of an estimated urban population of 309.5 million person were below the poverty line in that their per month consumption was less than Rs. 538.6 (Planning Commission, 2011).

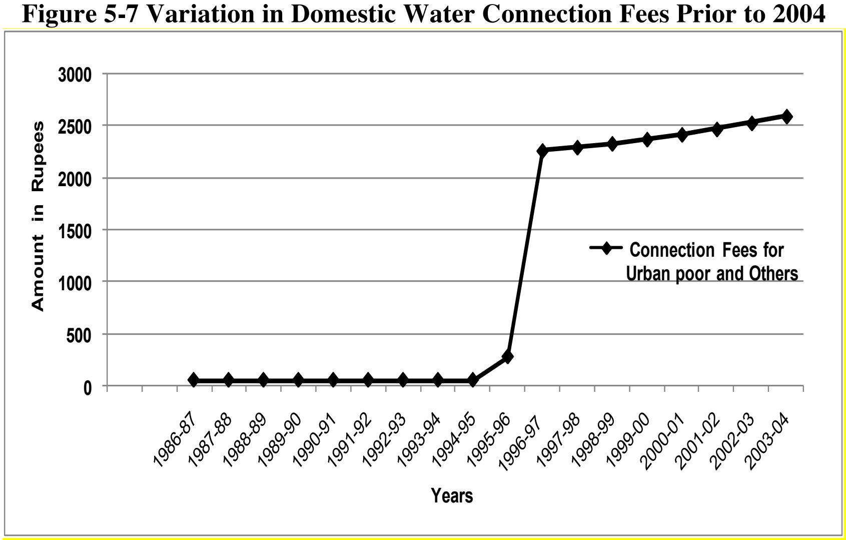
Table 5-5 Domestic Half-Inch Water Connection Fees in Rupees (1996 - 2004)

Year	Service Charges	Cost of Connection from Public Main	One-time Connection Charges	Total Connection Fees
1996-97	113	146	2,000	2,259
1997-98	127	165	2,000	2,292
1998-99	142	185	2,000	2,327
1999-00	160	208	2,000	2,368
2000-01	180	234	2,000	2,414
2001-02	203	264	2,000	2,467
2002-03	228	296	2,000	2,524
2003-04	257	334	2,000	2,591

For reference, Rs. 2,000 = ~$33

The connection fees were the same, and increased uniformly for all users regardless of the affordability factor or income levels (Figure 5-7) with no parallel improvement in service.

Figure 5-7 Variation in Domestic Water Connection Fees Prior to 2004



During the period between 1985 (when the state policy on water connection fee was adopted) and 1995 (when the fee increases were introduced), Jayaramu et al. (forthcoming) find that the water connection policies seemed to focus more on price increase than on improving water service delivery, while unregulated water delivery practices continued (see quote below):

This was evident from the water service to existing customers where the water availability reduced to fewer (one to three) hours, once in six to seven days. Access to piped network remained at 65% of the total population. . Although people relied heavily on groundwater through use of private bore wells, the high hardness levels in the bore well water especially in the city outskirts increased the demand for piped water connections. However, there was limited or no information available to the public on obtaining a water connection. The lack of transparency and ambiguity about the procedure on obtaining a new water connection encouraged unauthorized middlemen to provide water connections, which were illegal. Residents *recruited independent/unlicensed private plumbers who did not use technical knowledge or any well-defined water connection methods to install the connections. Further, lack of supervision of the installation process resulted in poor quality of water connections with profuse leakages (see figure below).* [67]*While, unauthorized connections were being installed, HDMC denied water connections to the urban poor due to the unauthorized nature of their layouts and insecure tenure.* [68]

-Jayaramu et al., forthcoming, p.8-9

An Example of Leakage from a Poorly Installed Water Connection

At HDMC, shortage of staff in the maintenance department hindered efficient installation of water service connections. A customer survey conducted by HDMC in 2002 revealed 21,072 illegal water connections (over 30.5%) against the 68,997 legitimate connections. The survey also revealed a strong need for transparent and customer-friendly connection policies especially for the urban poor. Besides residents in formal housing, water connection policies also needed to cater to bulk consumers such as retail and industries.

- Jayaramu et al., forthcoming, p.9

By 2001-02 collected revenues covered only 19% of O&M costs (World Bank, 2004) largely due to nonpayment of bills by households.

…More than 1500 households in Hubli-Dharwad have received bills for arrears of Rs. 15,000 – Rs. 20,000 each (US$273-455). Such large amounts owed in arrears could only have been accrued over a period of several years

- Burt and Ray, 2014, p.163

Arrears had increased and worsened over time [before 2003].

- Interview with KUWSDB

In terms of service, daily water deliveries eventually became weekly deliveries and, at the height of scarcity during the dry seasons of 2001 and 2002, regular deliveries occurred only once every

[67] Here, the lack of institutions, including regulation may be due to lack of technical knowledge, capacity, or other resources. This is also addressed as part of the unregulated private water deliveries mentioned later in this chapter.

[68] A common phenomenon in Hubli-Dharwad.

12-15 days (Times of India, 2002a; WSP, 2010). As Burt and Ray report below, this fomented massive outrage among residents:

> *… not long before he was replaced, the Chief Executive Engineer of HDMC was brought out of his office and tied to a pole as part of a public shaming executed by mobs of angry residents (personal correspondence). This reaction at the failure of the government-run utility established the power of the insurgent masses and has not been forgotten.*
>
> *In order to quell angry residents the Water Resources Minister announced on March 17, 2002, that the frequency of water delivery would be increased to once in five days by March 30 (Times of India, 2002a). By April of that year, HDMC officials admitted that once in five days would not be feasible but that once a week was "possible" (Times of India, 2002b).*
>
> *- Burt and Ray, 2014, p.157*

Such performance of HDMC was manifesting in the context of decentralized proposed under the 74th amendment to the Indian Constitution (described in Chapter 3). GoK had passed statutory orders in 1994 and 1995 requiring the handing over of the maintenance of all water supply schemes by the KUWSDB to the ULBs. The process has been completed in most areas barring a few (Sangmeswaran et al., 2008, p.61). However, as discussed further below, this process took a different turn in Hubli-Dharwad. The water service never improved under HDMC; in fact the responsibility of local water service delivery and operations no longer remained with HDMC. The efficacy and the true intent of the decentralization process can be questionable at best also from the following quote:

> *If true decentralisation means the transfer of political, administrative and fiscal responsibilities to locally elected bodies in urban and rural areas and the empowerment of communities to exert control over these bodies, this has not been achieved.*
>
> *- Working Group on Decentralization, 2003*

This adds to the complexity in formulating the water service delivery problem: first, of who actually formulates it and second, how they formulate it, and thus propose to approach in a certain way to improve the water service.

5.3.2 State Urban Water Reforms: Key Policies

Karnataka has been one of the most active (but not the only) proponents of urban sector investments and reforms since the mid-1990s (Ranganathan et al., 2009, p.53). One reason for this is that a gradual reduction in central government budgetary allocations and guarantees for public investments placed the burden of urban infrastructure investments squarely on states. In Karnataka, deteriorating state finances coupled with low capacity of municipalities to invest in infrastructure in turn propelled interest in cost recovery, external funding, and private-sector participation (Ranganathan et al., 2009, p.53; Kundu, 2001).[69]

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[69] The 12th Finance Commission recommended that the central government stop providing guarantees to states making them directly borrow from international finance institutions or the market.

In the late nineties, the state government expenditure in India had increased rapidly: aggregate State-government expenditure increased from 13.9 percent of the state GDP in 1996-97 to 15.4 percent in 2001-02. Since revenues were stagnant if not falling, the viable alternative was higher borrowing to support expenditure, leading to deficits at unsustainable levels (Mitra, 2010, p.125). GoK had approached the World Bank for financial support for its reform program in 2000 (Mitra, 2010, p.27).

In parallel, Sangmeswaran et al. (2008) identify Karnataka as being at the forefront of reforms in terms of policy measures and legislative changes adopted as well as in terms of the large number and variety of projects taken up. For instance, around the same time as soliciting international financial support, Karnataka adopted a state water policy as well as an urban drinking water and sanitation policy in 2002, and amended the Karnataka Municipal Corporations (Water Supply) Rules to provide a legal entry to private operators in urban water delivery systems. While the water policy focused on water resources management of the State, the urban drinking water and sanitation policy was concerned specifically with urban water service. In 2004, Karnataka became the first State in India to initiate a structured approach to private sector participation in urban water supply (Mitra, 2010, p.135) along with commercialization and corporatization of water service operations, which was institutionalized in the state policies:

Given that piped water supply is expensive, it is necessary both for natural resource sustainability and commercial viability of operations to recover from the users of water, the full cost of providing service. The longer-term objective is to establish an appropriate cost recovery mechanism through adequate tariff to ensure that revenues cover operations and maintenance costs, debt service plus a reasonable return on capital. In the medium term, however, subsidies will continue to be needed and will be focused in areas such as pockets and communities of extreme poverty and investments with large-scale externalities like wastewater treatment.
- Karnataka State Water Policy, 2002

To improve efficiency in service provision, continuously update technology and ultimately bring in private investment into sector, the GoK will actively encourage private sector participation.
- Karnataka Urban Drinking Water and Sanitation Policy, 2002

Particularly relevant to private sector participation, Section 6.14 of the State Water Policy states the following, reflecting the broader role private enterprises can play in water delivery:

Private sector participation will be encouraged in various aspects of planning, investigation, design, construction, development and management of water resources projects for diverse uses, wherever feasible. Private sector participation will help introduce corporate management in improving service efficiency and accountability to users. Depending upon specific situation, various combinations of private sector participation, in building, owning, operation, leasing and transferring of water resources facilities will be considered.

The following quotes from the policies demonstrate the emphasis on commercialization of water and complement the above quote concerning corporate management:

Water rates for various uses will be revised in a phased manner and fixed so as to cover at least the operation and maintenance charges of providing services.
- Section 6.15 of the Karnataka State Water Policy, 2002

Tariff will be structured in a manner such as to disincentivise excessive consumption and wastage of water, whilst ensuring at least a minimum "life line" supply to the poor.
- Karnataka Urban Drinking Water and Sanitation Policy, 2002

…In a realistic time frame of about five years, efforts will be made and ULBs encouraged to achieve 100 percent metering and volumetric pricing based on long run marginal costs.
- Karnataka Urban Drinking Water and Sanitation Policy, 2002

Besides the water related policies, the more recent state Urban Development Policy (2009) shows supplying water continuously as a principal aim:

The overall objective must be to improve the efficiency of the supply and distribution systems, reduce water losses and aim for 24/7 supply in the long run.
- Karnataka Urban Development Policy, 2009

As part of the urban water reforms, GoK issued a pro-poor policy with the aim of providing concessions to the urban poor with respect to water supply in the context of the Karnataka Urban Water Supply Improvement Project (discussed further below), and "is at least partly a response to concerns expressed by activists and civil society groups" (Sangmeswaran et al., 2008, p.65). The policy identifies the urban poor as those residing in houses measuring up to 600 square feet built-up area regardless of whether they live inside or outside slums. For such urban poor, the policy simplifies the procedure for new connections: it waives the one-time connection deposit for 24/7 pressurized piped service[70], and fixes a lifeline supply of 8,000 liters[71] per household per month at a concessional rate (to be decided by municipal corporations). The policy also mentions that water will be provided free of charge through public kiosks/cisterns/bore wells fitted with hand pumps to vulnerable sections such as nomads, the destitute, and the homeless (KUIDFC, no year).

Changes in Local Water Operations (Different Local Actors)

The Government Order

Until March 2003, HDMC operated and maintained the water distribution system. Reviewing the deteriorating water coverage and ineffective management of HDMC, GoK passed an Order in 2003 under which the O&M of the water system was transferred from the local HDMC over to the state KUWSDB in April 2003 to make improvements to the water service operations (discussed in further detail later in the chapter).

Different from HDMC, which operates different urban service departments, "it was considered important to have a single institutional set up and currently KUWSDB is responsible for the

[70] Excludes the cost of the meter.
[71] 8,000 liters = ~2,113 gallons per month or ~266 liters per day per household

management of water completely" (Raju et al., 2007, p.7). This study refers to KUWSDB as the water provider where the KUWSDB engineer has been leading the water service operations with assistance from HDMC administrative staff and valve men, where otherwise previously they were led by HDMC. HDMC retains the local water rights, participates in water-related decisions including the pilot project, and continues to hold other public works' related responsibilities such as stormwater drainage, solid waste, and sewerage. Around the same time that KUWSDB took over the O&M of water service operations in Hubli-Dharwad, in March 2003, according to the information provided by KUIDFC, the World Bank visited HDMC to discuss large-scale water investments. This was part of the state urban reform process. The Initial Project Information Document for the Karnataka Urban Water Supply Improvement Project (KUWASIP) was approved January 2004.

Karnataka Urban Water Supply Improvement Project

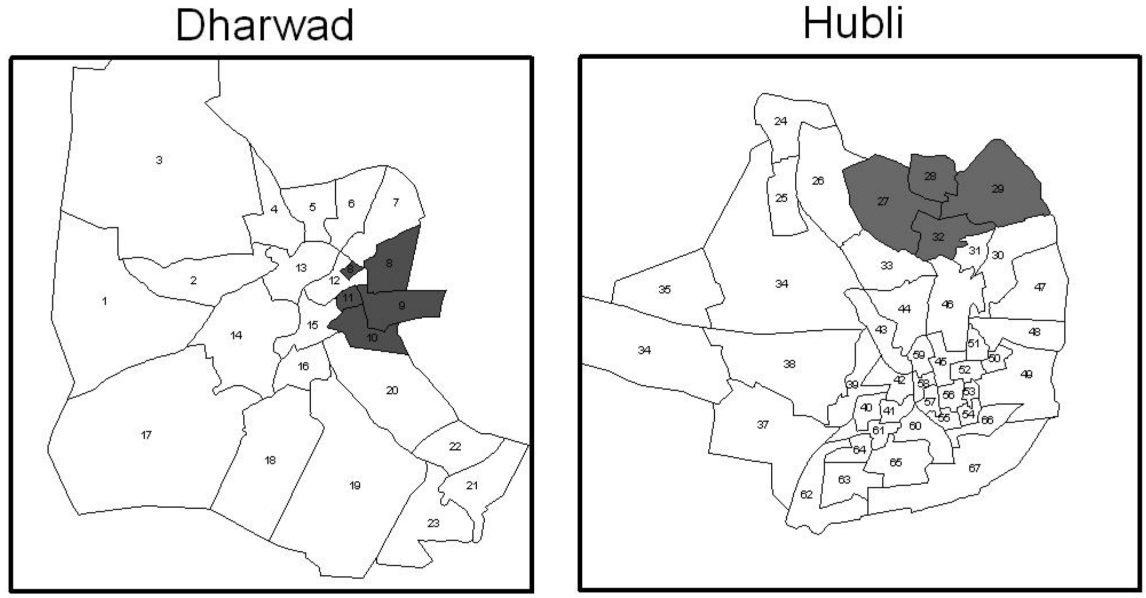
GoK initiated the KUWASIP to launch the urban water reform process based on "Urban Drinking Water And Sanitation Policy Statement of GoK" and to improve the urban water supply services and demonstrate that sustainable, efficient and commercially oriented service provision can be achieved (KUIDFC, 2014). In an environmental assessment of demonstration projects and priority investments (Wilbur Smith Associates Pvt. Ltd, 2003), KUWASIP was shown to include a sanitation component and was named as "Karnataka Urban Water and Sanitation Sector Improvement Project (KUWASSIP)". In the report, the KUWASSIP is defined as "a medium-term sectoral reform project" that envisages setting a policy, institutional and regulatory environment in [both] urban water and sanitation sectors that would enable service improvements, sustainable investments and coverage expansion gradually and incrementally through small-scale demonstration projects in three urban local bodies of Gulbarga, Belgaum and Hubli-Dharwad".

The projects were geared to supply 24/7 pressurized piped water in place of intermittent supply in demonstration zones, covering 5-10% of the population, in three cities of northern Karnataka: Gulbarga, Belgaum and Hubli-Dharwad. The more current KUWASIP is touted as a public-private-partnership (PPP), implemented in concert with the KUIDFC and the KUWSDB. Based on its competitive bid, Veolia Water, a division of Veolia Environement (France), was awarded the management and maintenance contract for two years (WSP, 2010). The KUWASIP would in essence then, as discussed further below, be reinstituting the 24/7 pressurized piped water service in portions of these select cities. Supplying pressurized water continuously through individual piped connections is not a new goal for Hubli-Dharwad (as discussed further below).

KUWASIP in Hubli-Dharwad

Under the KUWASIP, the pilot project covers selected demonstration zones in eight (out of 67) municipal wards, which were selected based on the ease with which they can be hydraulically isolated from the rest of the piped water network (Wilbur Smith Associates Pvt Ltd., 2003). The zones called pilot areas were set up in four contiguous wards each in Hubli and Dharwad. Figure 5-8 shows the municipal wards of Hubli and Dharwad including the pilot areas (shaded).

Figure 5-8 Municipal Wards in Hubli and Dharwad



Source: Burt and Ray, 2013
Note: Shaded wards denote the pilot areas that receive 24/7 continuous pressurized piped water service.

A major portion of the selected wards / zones in Dharwad is inhabited by lower middle class and lower-income population. Most of these wards exhibit narrow streets and row houses. In Hubli, the demonstration wards consists of a mix of well-laid out extension areas with middle class and upper middle class families and old areas with narrow streets and row houses (Wilbur Smith Associates Pvt Ltd., 2003).

The demonstration zones or the pilot area covered approximately 10% of the city population and spanned mostly residential users – ranging from extralegal settlements to legal low-income dwellings to middle- and high-income neighborhoods of apartment buildings and single-family homes. Based on my field visits and the interviews I conducted, there is a very small percentage of commercial/industrial users in the pilot area, and they have not been separately quantified[72].

According to the KUIDFC, these zones, when taken together, cut across all income groups (Wilbur Smith Associates Pvt., 2003), which is supported by the following observations made by Burt and Ray's (2014) team:

> *Our research team walked extensively in the 24/7 zone wards in order to create detailed maps of the areas to be sampled, and visually verified that low, middle and high-income neighbourhoods seemed to be well represented in the 24/7 zones.*
>
> *-Burt and Ray, 2014, p.160*

[72] This is based on my interviews of officials involved in the pilot project when I asked whether there is a count of commercial or industrial or other non-residential users or dwellings in the pilot area.

5.4 Delivering Water Service: From the Supply Source to The User

Piped water service in Hubli-Dharwad is delivered by the traditional approach of centralized infrastructure network that connects distant surface water supply sources to the urban dwellers. This section presents an overview of the piped water service delivery by discussing the scale of the physical infrastructure system connecting the centralized water supply source and the cities and the several influencing factors in the process, which affect the local water service operations, which do not seem to sustain the originally intended continuous supply of individualized piped water to all, now.

5.4.1 The Supply Source and The Different Influences on Water Service

Before 1956, there was little difference in water sources between the urban and rural areas; both relied on hand-dug wells and large water harvesting dams locally known as tanks.
- A Water Resource Study by Hollingham, 2011, p.1

Specifically for Hubli-Dharwad, only two such tanks served as sources of water supply, namely, Unkal Tank for Hubli and Kelageri Tank for Dharwad. As both cities grew the existing water supplies became inadequate, and newer sources had to be developed (Polisgowdar, 2001). Since 1956, Hubli-Dharwad have relied on piped reservoir sources, while the rural areas have increasingly relied on private boreholes, where water was drawn first by hand pumps and then motorized pumps, as electricity became available to the villages (Reddy, 2001).

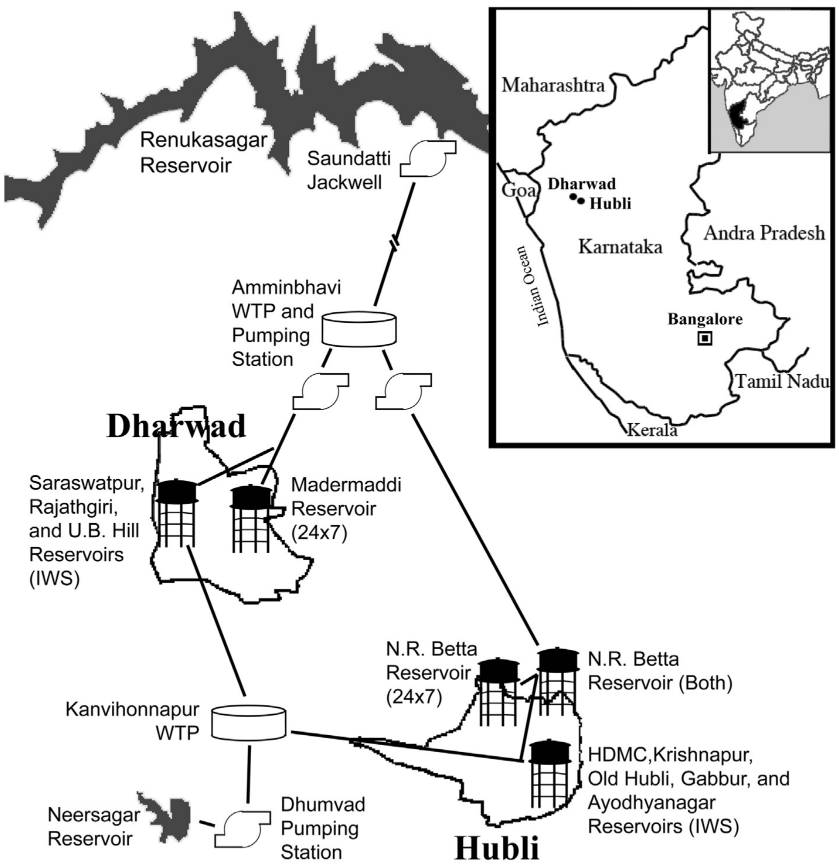
Today, the sources for piped water supply to the cities have converged into two sources: the Malaprabha and the rain-fed Neersagar reservoirs (Figure 5-9). The Malaprabha reservoir – located approximately 65 kilometers (km) or 40.4 miles northeast of Dharwad, was initially built by the State for irrigation, and now also is distributed for drinking purposes in both Dharwad and the rest of Hubli (KUWSDB, 2014). The Neersagar reservoir – 20 kilometers or 12.5 miles west of Hubli – was built in 1956 and still supplies drinking water to a part of Hubli. In 2001, an estimated 31.7 million cubic meters[73] per year was supplied to the local municipal water supply network (Reddy, 2001).

The Malaprabha Reservoir is built on the Malaprabha River, which is a tributary to Krishna River, one of the main rivers in India. The river serves as a water source for the entire Dharwad district along with the neighboring Belgaum district to the northwest and Uttar Kannada district to the west (shown in Figure 5-1 earlier in the chapter). Within Dharwad district, in addition to Hubli-Dharwad, the river is a water supply source for five other cities. Hubli-Dharwad is not the sole area that uses Malaprabha River as the source, which brings in additional variables associated with other cities and users between the otherwise "linear" connection between the source and the users in Hubli-Dharwad.

[73] 1 cubic meter = 1,000 liters or 264 gallons

Water is delivered to Hubli-Dharwad from the two central reservoir sources through a large physical infrastructure network of water transmission main pipelines[74] and distribution pipelines including storage reservoirs, pump stations, and associated appurtenances (Figure 5-9).

Figure 5-9 Hubli-Dharwad Water System Map



Source: Kumpel and Nelson, 2013; KUWSDB

As shown in the figure, surface water is drawn from the reservoirs and treated at the Aminbhavi and Kanvihonnapur water treatment plants (labeled WTP in the figure) using aeration, coagulation and flocculation with alum, clarification, rapid sand filtration, and chlorination with chlorine gas. Treated water intended for drinking and domestic purposes is transported via transmission/feeder mains (via pumping or gravity) to service reservoirs and then to the consumers in Hubli-Dharwad through a piped distribution network. The water however does not necessarily retain the water quality at the user end (Kumpel and Nelson, 2013) indicating other factors in play such as the vulnerabilities of the system to leaks and contamination or the aging distribution system within the cities.

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[74] Typically water mains are large in size and convey water from a distant natural water source to one or more central storage reservoirs or tanks in the city.

In terms of availability of water at the sourcee, as Table 5-6 indicates, surface water is one of the two water sources available to the cities with population close to a million, but is used as the only source to deliver piped service through the centralized pipeline network.

Table 5-6 Water Supply Quantities from Surface and Groundwater

Surface Water				
Sources/ Reservoir	**Total Capacity (MLD)**	**Dharwad**	**Hubli**	**Available Supply (MLD)**
		Actual Water Supply (Thousand Cubic Meters or Million Liters)		
Malaprabha	146	70	76	146
Neersagar	40	0	5	5
Total	186	70	81	151*
Groundwater: Capacity and Number of Wells and Public Hand Pumps				
Sources	**Total Supply (MLD)**	Approximate Water Supply in MLD (Total Number in parenthesis)		Total Number
Public Bore Wells	7.5	~2.5 MLD (321 wells)	~5 MLD (812 wells)	1,133 wells
Public Hand Pumps	10.5**	239 pumps	444 pumps	683 pumps
Total	18**			

Source: KUWSDB, 2013

Note: MLD = million liters per day, 1,000 cubic meters = 1 million liters
*This number is consistent with an estimate of 151.28 MLD of total water supply reported for Hubli-Dharwad by the Central Pollution Control Board (2009).
** Although the total quantity of the groundwater supply through hand pumps was not available, based on a total of 18 MLD groundwater supply reported by Wilbur Smith Associates Pvt. Ltd (2003), public hand pumps can be estimated to supply 10.5 MLD of water.

Historical documentation of the water resources may not be entirely reliable; nonetheless the available information from reports and interviews indicates a precarious situation of relying only on one surface water source for the entire city – not only due to the natural variability of water but capacity of the built structures. When I compared the data in Table 5-5 with the water design and capacity estimates from a report by Wilbur Smith Associates Pvt Ltd. (2003), I found that it reported the (storage) capacity of Neersagar reservoir as high as 42 MLD as compared to 40 MLD in Table 5-5; with time its capacity was reportedly reduced to as low as 11 MLD. Similarly, in the case of Malaprabha Reservoir, the capacity reduced from its design level of 68 MLD to 59 MLD. Reduction in the capacity of a reservoir can be typically attributed to siltation or build up of sediment that reduces the overall long-term water storage capacity. The reduced storage capacity means lesser water stored, which implies a water resource constraint. However, the report called this "capacity" reduction and attributed it to "scanty rains in the upstream catchment", indicating instead the maximum volume available, which would in essence affect the water quantity stored and available for supply.

While the water supply capacity seems to have diminished despite its design, in 2001, the water demand was projected to grow as the population grew at the rate of 2.35%[75] and reach 1 million by 2010 and the corresponding water demand to 54 million cubic meters (54 billion liters) per

[75] Population in the urban municipal area of Hubli-Dharwad increased from 525,000 in 1981 to 736,000 in 2001 (Kulkarni, 2001).

year. The higher demand would increase the water use per head, as modern plumbing fittings and water using machines are installed (Kulkarni, 2001). As the current water supplies stand, they would not be able to meet a demand of 150 liters per head per day (Kulkarni, 2001; Reddy 2001).

Reddy (2001) reports that the "a third stage of the Malaprabha reservoir has now been approved and is designed to supply a further 22.3 million cubic meters per year of water by 2010". The current water supplies (Table 5-5) do not include this additional capacity indicating it is not in operation yet.

The purpose of reservoir expansion, a part of larger capital works is to provide higher storage capacity at the single source with the intention of meeting the projected increasing water demands. This assumes that the water supplied from the reservoir, i.e., the quantity conveyed through the transmission and distribution network, gets delivered as is to the users. However, the following quote indicates otherwise:

> *From 1993 to 2001, about 3.7 million cubic meters per year [of water] was lost from the Malaprabha source, due to leakage and power failure, before reaching Hubli -Dharwad. The water main to the cities was constructed of concrete, which was easily damaged and readily broken by villagers along the pipeline trying to gain access to free water. Work started in 2001 and was completed in 2002, to replace the concrete pipe with a more robust bitumen lined steel pipe. From 2002 the total water supplied reached 35.4 million cubic meters per year.*
> *- Polisgowdar, 2001; Reddy, 2001 in Hollingam, 2011, p.4*

This is further supported by available historical data (till 2010) on water supplies and leakages from the water mains to Hubli-Dharwad (Table 5-7), which indicate approximately 40% of water losses due to leakages. The water lost here does not include water losses from leakages in the piped distribution system in the cities (discussed further below).

Table 5-7 Volumes of Water Supplied to the HDMC Area in Hubli-Dharwad and Volumes of Leakage from Water Mains

Year	Reservoir	Water Supplied (MLD)*		Leakage from Water Mains (MLD)	Percent Water Lost from Leakages
		Contribution	Total		
1956	Neersagar (unenhanced)	6.6	6.6	2.6	39.4
1967	Neersagar (enhanced)	13.1	13.1	5.2	39.7
1983	Malaprabha Stage 1	12.4	25.5	10.2	40.0
2002	Malaprabha Stage 2	6.2	31.7	12.7	40.1
2010	Malaprabha with Repaired Pipeline	3.7	35.4	14.2	40.1
2002	Malaprabha Stage 3	22.3	57.7	23.1	40.0

Note: The enhancements and the stages are stages of expansion and upgrades.
Source: Hollingam, 2011, *Source: Reddy, 2001

Despite such significant losses in transporting water into the cities, large capital infrastructure investments continue to be made with a goal of supplying continuously pressurized piped water.

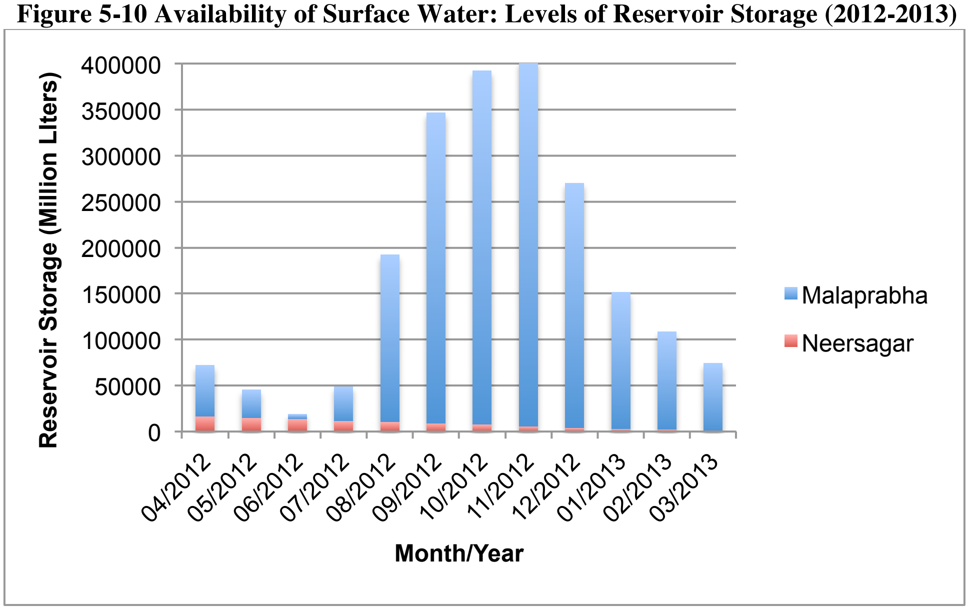
For Hubli-Dharwad, such water supply sources and the large infrastructure – a legacy of the centralized distribution system – assume continual availability of water at the source (Malaprabha and Neersagar Reservoirs that rely upon river water and precipitation. However, there are mixed messages. For example, in interviews and in published reports, water supply engineers project that water supplies for Hubli-Dharwad are "sufficient for the city even if the rains failed one year"; newspaper articles report a yet different story: they report water scarcity due to inadequate water at the reservoirs continually in 2005, 2009, and 2012 (The Hindu, 2005; 2012; TOI, 2009). The water scarcity reports were so rampant that an article in 2012 of "residents in the twin cities *not facing water scarcity*" made the news (The Hindu, 2012). Even after accounting for reduced water losses (10%) compared to the current losses or continuing rate of water losses (say 50%), the available reservoir capacity and the water supply is not estimated to last long (Table 5-8). The shaded cells in the table show the years for which water supply is anticipated to be available for.

Table 5-8 Estimated Increase in the Water Demand Over the Next 15 Years Compared To Available Storage Capacity

Current Reservoir Capacity*	Population	2011 1 million	2015 1.1 million	2021 1.28 million	2025 1.4 million	2031 1.6 million
186 MLD	Water Demand @135 LPCD	135,000,000	149,014,740	172,811,413	190,751,466	221,213,219
	Water Demand @ 150 LPCD	150,000,000	165,571,934	192,012,682	211,946,073	245,792,466
	Water Demand @ 200 LPCD	200,000,000	220,762,578	256,016,909	282,594,764	327,723,288

Further, more recent data of reservoir storage levels diminishing in the recent years show a volatile picture of the availability of water (Figure 5-10).

Figure 5-10 Availability of Surface Water: Levels of Reservoir Storage (2012-2013)



Source: KUWSDB, 2013

In addition, beyond the physical availability of water, access to the water in Malaprabha River may also be affected by the water conflict that Karnataka has with its neighboring states of Maharashtra and Tamil Nadu over the amount of water being extracted from the river (which reduces flows in the Krishna River on which the other states depend). It is not obvious whether and how this water conflict is accounted for in the planning and building of large physical infrastructure from the river into Hubli-Dharwad. Thus, using a single, surface water source and transporting water over long distances raises the vulnerability factor for the ~ 1 million population in Hubli-Dharwad.

5.4.2 Piped Water Service: A Function of Transmission and Distribution

Within the cities, the water transmission mains (Table 5-5) bring water to ground level and elevated storage reservoirs in Hubli-Dharwad, which then gets distributed to the users via the citywide pipe network. With around 302 km of distribution network (60% of the road network), "70% of the population is covered with water supply facilities" (Wilbur Smith Associates Pvt Ltd., 2003, p.1). The current piped water network in Hubli-Dharwad was initiated in 1956, and provided continuous water supply for the urban population (~786,000) of that time (Wilbur Smith Associates Pvt Ltd., 2003, p.1). As urbanization increased, the cities slowly outgrew their water system, resulting in intermittent water delivery (Burt and Ray, 2014, p.157). The water system has a design capacity of 130 MLD, but after leakages, supplies approximately 70 MLD to all the consumers (Wilbur Smith Associates Pvt., 2003, p.1). The water infrastructure therefore does not currently function to its intended levels and is in a deteriorating condition, mainly attributed to poor maintenance and upgrade (GoK, 2003).

New Water Infrastructure for the 10%

Post-2003, under the KUWASIP launched by GoK, the pilot project involved large capital investments both for improvements in bulk water supplies at the water supply sources and for water transmission and distribution. The pilot project consisted of priority investments and project activities within Hubli-Dharwad, which based on project reports and interviews, were contracted out to Veolia Water and involved several private contractors to construct and make the necessary repairs (Wilbur Smith Associates, Pvt. Ltd., 2003; World Bank, 2011).

Priority investments focused on improving bulk water supplies by replacing/ reinforcing the existing water transmission lines from the head works for the city and the feeder mains by cast iron pipes (18 kilometers in Hubli and 15 kilometers in Dharwad). These also included rehabilitation and replacement of pumps (Wilbur Smith Associates Pvt. Ltd., 2003, p.3).

The large-scale project activities in Hubli-Dharwad involved "construction of a new and exclusive 1,210-millimeter-diameter (or ~46.3-inch-diameter) and approximately 23-kilometer-long trunk (transmission) main from the Amminbhavi storage reservoir to the Nrupatungabetta ground level storage reservoir in Hubli. The entire stretch of this new alignment passes through private agricultural fields, village roads, and small streams" (Wilbur Smith Associates Pvt. Ltd., 2003, p.3). The alignment avoids the existing 900-millimeter-diameter (or ~ 35.4-inch-diameter) transmission main from Dharwad (shown in Figure 5-9). The activities also included "replacing, reinforcing and extending the feeder mains both in Hubli-Dharwad and installation of demonstration zones i.e., replacing the feeder mains, distribution mains changing of defective valves etc. in the select areas" (Wilbur Smith Associates, Pvt. Ltd., 2003, p.3). Based on my interviews with KUIDFC, the existing distribution network in the pilot area was abandoned in place and an entirely new network was installed.

Water Infrastructure for the 90%

There was a new distribution system built in the pilot area, whereas the old distribution system remains in operation in the remaining portions of the city. Capital works however continued such as construction of mini tanks and reservoirs, emergency improvements, pipeline works, pumps, and meters for water connections, as part of the O&M.

With the institutional and physical infrastructure background, the next section delves into the "outcome" or water service in Hubli-Dharwad especially about how the water service in the cities changed with the institutional changes and reforms.

5.4.3 Water Service and Service Operations

Based on the surveys by Wilbur Smith Associates Pvt. Ltd (2003), the following observations on Hubli-Dharwad characterize the water service in the cities:

> *About 70 MLD of water (as against the designed capacity of 130 MLD) is "supplied" [delivered] once in 5 to 7 days from two surface water bodies of Malaprabha and Neersagar and 70% of Hubli-Dharwad population is provided with water supply facilities (45% through house service connections and 25% through public taps or tanker supplies). The remaining population depends on own sources such as bore wells, open wells, etc.*
> *- Wilbur Smith Associates Pvt. Ltd., 2003, p.1*

Comparing the percentage of household connections with a World Bank report (2004), the number of house service connections quoted by Wilbur Smith Associates Pvt. Ltd does not include informal connections.

In the context of the new water service level benchmarks established by the Ministry of Urban Development (MoUD) and also as stated in the state Urban Development Policy, the following sections present the water service and how it is delivered under the KUWASIP in the pilot area as against that in the remaining portions of Hubli-Dharwad.

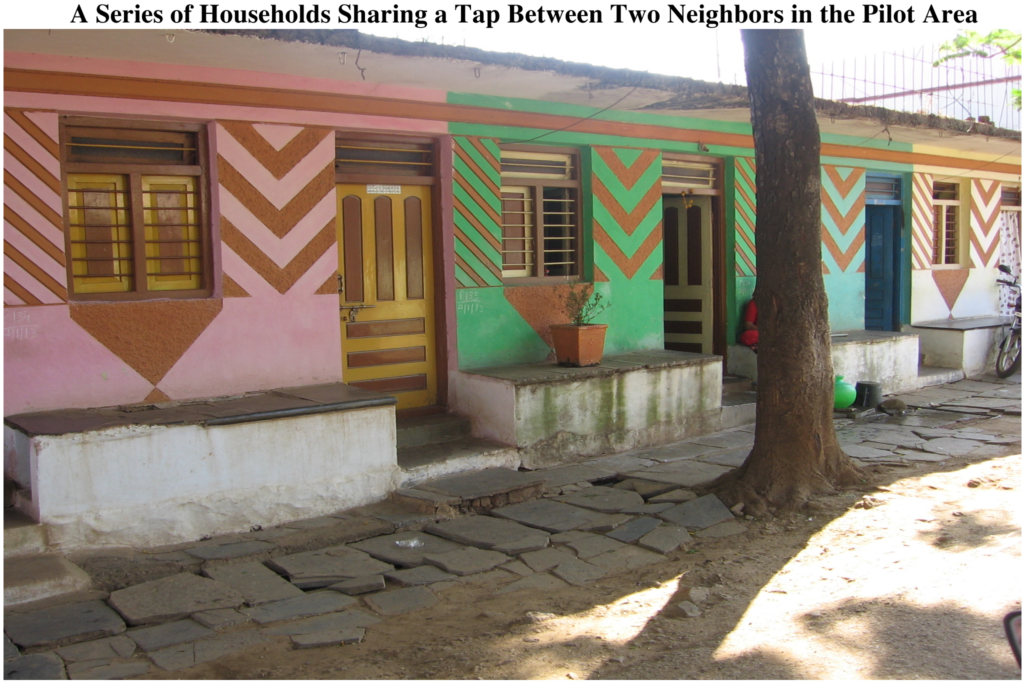
5.4.4 Centralized Piped Service for the 10%

Water Service

Under the KUWASIP, continuously supplied pressurized piped water service has been available to 10% of the city population since 2008. The system appears to be delivering high quality water on a continuous basis; a water quality study (Kumpel and Nelson, 2013) testing water samples collected in the pilot area indicates negligible risk when compared to the Bureau of Indian Standards for drinking water quality. For the most part, the users have the water service through individual piped connections, but I also observed piped connections that are located outside their homes and that they share with their neighbors (Figure 5-11).

Figure 5-11 A Tap Located Outside A Household in the Pilot Area

A Series of Households Sharing a Tap Between Two Neighbors in the Pilot Area



What was noteworthy was that the presence of informal settlements and the lack of tenure, which usually hinder the provision of legal water connections, were overcome in this case. Illegal and informal connections were regularized by implementing the pro-poor policy as part of the urban reform process – an institutional mechanism in play. Thus, 100% coverage was achieved in the pilot area. Yet, this coverage represents only 10% of the total population in Hubli-Dharwad that receives continuously supplied 24/7 pressurized piped water service. Since the inception of the project from around 2002-2003, after over 6 years of building large capital works, the urban reforms were specifically geared toward a small portion – 10% of the population. In the meantime, the remaining 90% continues to wait for the 24/7 pressurized piped service.

Water Service Operation

Following the initial phase of construction and building of physical infrastructure[76], the state KUWSDB along with KUIDFC and HDMC signed a contract with Compagnie Generale Des Eaux, a French multinational company, or Veolia Water (Veolia)[77] to operate and maintain the new water distribution system to deliver 24/7 pressurized piped water service in the pilot area. The other signatories on the contract include the Municipal Corporation of Belgaum and Municipal Corporation of Gulbarga – two other cities (not discussed here) in addition to Hubli-Dharwad that were included as part of the KUWASIP.

The new entrant in Hubli-Dharwad, Veolia has the responsibility of "operation and management" of the new water pipeline distribution system installed in the pilot area. The contract assigns Veolia to execute on-the-ground responsibilities including regular inspection, operation, and maintenance of the water distribution network in the pilot area to deliver 24/7 continuous pressurized piped water service. The tasks include providing pressurized continuous piped water service to all of the connected properties through metered connections; maintaining computerized records of the meter readings; and reading and recording all of the meters every month. At the end of every month, Veolia issues water bills to all the connected properties. Under the contract, "delivering the intended service" in the pilot area is the "performance target" for Veolia.

The intent of the pilot project was to "demonstrate the feasibility of change from intermittent to continuous supply of water" …and "commercially-oriented service provision" (World Bank, 2011). We see here, that through this project, GoK reinstituted the service goal, which was intended a few decades ago but did not sustain, this time with an added goal of making it commercially viable, i.e., making the service available to all through individual connections in the pilot area with cost recovery as a parallel goal. From my interviews with government officials, I find that cost recovery has typically and historically not been an objective as such in, and parallel to, supplying water. The focus on recovering the O&M costs (World Bank, 2011, p.10) is for improving the management of water service operations, which would include the financial health of the utility, which could include KUWSDB and Veolia, the case in point here. The pilot project has been hailed as a successful "public-private partnership (PPP) project" (ASCI, 2012). This signals an embedded goal of demonstrating the success of a PPP-contract in addition to delivering 24/7 continuously pressurized piped water in the pilot area.

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[76] A separate contract was signed with private corporations.

[77] A division of Veolia Environement, formed from Compagnie Generale Des Eaux.

Based on a review of available contracts and interviews with organizational staff and on-the-ground personnel, Table 5-9 summarizes the roles of the different organizations involved in the PPP related to the 24/7 pressurized piped water service in the pilot area. The table shows the various elements of water service delivery taken up by different organizations and that each form a part of the larger PPP arrangement.

Table 5-9 Broad Roles Related to Water Service in Pilot Area

Type of Organization →	Private Entity	Public Limited Company	Public Institutions		
Name of Organization →	Veolia	KUIDFC	GoK	KUWSDB	HDMC
Key Elements of Water Service Delivery*					
Provide and Ensure Availability of Bulk Water Supply	-	-	-	X	X
Provide water connections to all households	-	-	X	-	-
Operate and Maintain Water Distribution Network	X	-	-	X	-
Deliver 24/7 Pressured Piped Service	X	X	-	X	X
Key Elements of Cost Recovery*					
Install Meters and Maintain Them	X	-	-	-	X
Issuing Bills	X	X	-	-	-
Bill Collection	X	X	-	X	X

Note: The cells marked "X" indicates direct involvement in executing or assisting in executing the task on the ground related to the element in the left-most column.
* GoK issued pro-poor policy that provided a mechanism to regularize illegal connections.

With the separate roles tabulated above, the World Bank (2011) reports achieving "commercially viable 24/7 pressurized piped water service" in the pilot area. The report also shows 100% metering achieved in the pilot area with a recovery of 119% of O&M costs indicating successful accomplishment of the goal established at the beginning. An important finding here is that the 100% coverage and metering despite presence of informal housing developments would not have been possible if it were not for the public institutions, i.e., the KUWSDB and the GoK's policies and programs, which I discuss as part of the KUWSDB's operational practices.

Here, a closer look at the project success also reflects additional aspects of the PPP addressed by the public organizations: that KUWSDB is assuring the water supplies, which also is partially due to the large capital investment in the new water transmission line to Hubli; that KUWSDB along with HDMC staff is assisting Veolia in installing meters and maintaining them on the ground as well as in collecting the bills; and that Veolia is operating and maintaining the pipeline network in the pilot area such that non-revenue water (NRW) is reportedly as low as 14% (World Bank, 2011), while KUIDFC is ensuring that the contract responsibilities are fulfilled by all the parties. Maintaining low NRW aids in minimizing water losses, and hence minimizing lost revenues related to the water that cannot be billed. However, compared to more than 50% NRW reported in rest of the city, the significantly low NRW (~12%) in the pilot area can be attributed to the new distribution network installed for the pilot project. Whether the low NRW can be maintained as such will need to be monitored over time. It is key to note that a conductive environment with not only the physical infrastructure and clear responsibilities for the organizations involved, but also institutional mechanisms of monitoring along with political push, has enabled the provision of the 24/7 pressurized piped water service.

Through the pilot project as part of KUWASIP, GoK proposed to demonstrate that 24/7 pressurized piped high quality water can be delivered (in recent times). The pilot project involved both supplying 24/7 pressurized piped water on a continuous basis and executing a PPP, yet aspects such as “assurance” of water supply and serving informal housing with legal piped connections under the project are some of the aspects that are critical aspects addressed by the State (not by the PPP or private enterprise), which do not get equal attention in the government reports.

Based on the information provided by KUIDFC, the total cost of the pilot project is Rs. 237 crores (or $38 million), of which Rs. 182 crores (~$30 million) were a loan from the World Bank and Rs. 55 crores (~$9.1 million) was contribution from GoK. The entire loan will be passed on to the beneficiary cities as a GoK grant due to the pilot nature of the project. The project investments in Hubli-Dharwad are shown below in Table 5-10.

Table 5-10 Costs for the Pilot Project

Item	Cost (Rs. in million)	Cost (US $ in million)
Priority Investments	435.64	9.42
Demonstration zones	71.88	1.55
Total (Hubli-Dharwad)	**507.52**	**10.97**
Grand Total for KUWASIP (includes pilot areas in the cities of Belgaum and Gulbarga)	933.98	20.20
% Cost for Hubli-Dharwad of the total cost	54.3%	

Source: Wilbur Smith Associates, Pvt. Ltd., 2003

From a physical infrastructure and a management perspective, the pilot project has achieved its goal of water service delivery and recovery of O&M costs, which are also part of the national water service level benchmarks. However, the goal has been achieved only for 10% of the population. With an annual growth rate of at least over 2%, currently with ~10 years since the conception of the project, the proportion of the total population receiving 24/7 pressurized piped water service is fast reducing with time. This begs the question of whether there are other mechanisms in play or if water service delivery can only be viewed as an infrastructure and a management problem “optimally solved” through large centralized infrastructure systems and cost recovery.

Intrinsic in providing individualized piped connections to all is the provision of connections to informal settlements and poor alike, which may differ widely. For example, there may be residents that do have a title for the property they live on, or those that have a title for the property but have an illegal water connection, which is not recorded (e.g., by tapping into a water line by employing a plumber or by themselves). Different situations of informality may demand different responses. The World Bank (2011) reports achieving 100% of water connections in the pilot area. As noted earlier, the State pro-poor policy was instrumental in regularizing prior illegal connections or providing connections to those without tenure. This highlights the importance of an institutional mechanism, which does not form a part of the national policies in focus. However, Sangmeswaran et al. (2008) point out the downsides of the policy that have strong implications for the remaining 90% of the population, outside the realm of the pilot project. It remains to be seen how the situation in the pilot area can be replicated in the rest of the city:

> *HDMC has a policy of collecting a one-time connection charge (earlier Rs. 2,000, but now charged on a pro-rata basis), a policy independent of KUWASIP. But given that only households with legal connections are eligible for 24/7, what this means is that those with illegal connections who want to avail of 24/7 first need to regularise their connections by paying the connection charge to HDMC. However, not everyone may be able to afford this charge, which is additional to the Rs. 900 for the meter. For instance, in Hubli, in a declared slum that is part of the demonstration zone, slum-dwellers claimed that 70/450 households had not been given 24/7 (as of July 10, 2007) because they had failed to regularize their connections. What the pro-poor policy failed to anticipate is that 24/7 would be supplied via a new distribution network, which in turn meant that the old network in the distribution zone would be disconnected [KUIDFC 2006b], so that, in theory, the poor with illegal connections who failed to regularise their connections would not receive any water on operationalisation of the new scheme.*
>
> *- Sangmeswaran et al., 2008, p.65*

Appendix C provides the old and new water tariffs; which however do not reflect the connection fee that slum inhabitants have to pay to avail of the service from the new pipeline network.

Besides the critical role of the State's pro-poor policy at the time of the pilot project execution, it is worth noting that the pilot project in Hubli-Dharwad came into being the same time as that when the State KUWSDB took over the water supply service operations from the local HDMC. The replication of the pilot project would be a question if it were not for the strong contribution by the state toward the PPP and aggressive regulation through a management contract overseen and closely administered and monitored by KUIDFC. If HDMC, who had failed to deliver water service, had continued its operations, would the path of KUWASIP have been different than discussed here? For example, would bill collections have been at the reportedly high (95%) levels (World Bank, 2011)?

Similarly, would the 24/7 pressurized piped service have been delivered if it not were for the strong political leadership and support (Mitra, 2010) or if it were not a part of an impetus-driven urban reform process in the form of the larger KUWASIP with both water service, governance, and finance components (World Bank, 2011), with majority of the funds originating from an external source? A political analysis of the pilot project by Mitra (2010) supported by corroborations I got from my interviews with local and external organizations, that then current leadership by the Chief Minister Mr. Krishna provided a major support and push to the implementation of the project despite the several conflicts and oppositions that were raised against the project. At the same time, financial support was in no form trivial. The majority of the funds (77%) were provided by the World Bank as part of their social development loan to GoK for the KUWASIP (*Interview with KUIDFC)*.

Thus, a solid combination of the objective of delivering the service backed by political and financial support and other factors such as building of new physical infrastructure went into delivering 24/7 pressurized piped water service. The pilot project is now used as a poster child to showcase and perpetuate 24/7 pressurized piped service widely in India.

Based on current data available, the O&M costs are being recovered by user fees at the local level. However, the capital costs borne by the GoK would still be in the form of a long-term debt from the World Bank. Based on central government reports and interviews, acquiring loans from international financial institutions are and will serve as one of the key financing mechanisms for capital investments for infrastructure development (HPEC, 2011). Although it is anticipated that the local government would become more financially capable with time by generating their own revenue[78], the apportionment between the central and local governments of the debts and payments is unclear.

> *One…problem is that there is a significant vertical imbalance between expenditure and revenue, with consequent implications for autonomy, efficiency, and accountability. This, in turn, results in significant costs of administration and compliance as well as those arising from tax-induced inefficiencies in the allocation of scare resources.*
>
> *- HPEC, 2011, p.127*

Plus, with the current absence of HDMC and lack of clarity of its future role in water delivery, the sustenance of locally operated water service operations under the intended decentralization remains questionable. In such a context, given the current pace of delivering reliable water service through centralized infrastructure and relying on long-term debt repayment, how and when all of Hubli-Dharwad would receive pressurized piped water service is yet to be seen.

5.4.5 Centralized Piped Water Service for the 90%

Piped Water Service

Under the Government Order (2003), KUWSDB has been operating and maintaining the existing water distribution network for the 90% of the city population since 2003. Of the total city population, the centralized piped network supplying from the surface water reservoirs covers about 65% of the population (KUWSDB, 2011)[79], which means barring the 10% covered by the pilot project, 55% of the total city population receives piped service operated by KUWSDB (previously HDMC). The originally intended 24/7 pressurized piped water service from the 1950s has not sustained in Hubli-Dharwad. Water has been supplied through piped connections on an intermittent basis by HDMC/KUWSDB to the 55% of the total population for a few hours once in 3-5 days. Although the water is treated at drinking water levels and stored at central city reservoirs, the water quality[80] reaching the users has high variability, largely a function of aging infrastructure subject to leaks and breakdowns and contamination. The users boil or filter the water at home prior to drinking (Kumpel and Nelson, 2013).

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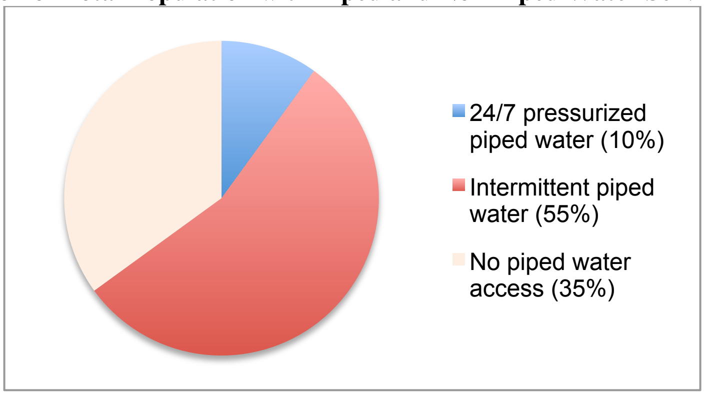
[78] Through a series of 'exclusive taxes' such as property tax, profession tax; revenue-shared taxes such as tax on goods and services, and non-tax revenue such as user charges (HPEC, 2011, p.130).

[79] Compared to the previous data of 70% piped coverage, the current available data shows a reduced coverage indicating that the growing population and a corresponding shrinking water coverage.

[80] The water quality study (Kumpel and Nelson, 2013) was conducted in the areas outside the pilot area (representative of the user conditions in the pilot area).

The remaining, substantial portion (35%) of the population lies outside the centralized piped network and does not have a water connection to the network. Water service for this portion of the population is discussed in the next section. Figure 5-12 shows the proportions of the city population that have and do not have piped water service.

Figure 5-12 Proportion of Total Population with Piped and Non-Piped Water Service in Hubli-Dharwad



Water Service Operation

Unlike the pilot area, the pipeline distribution network for the 55% of the population in Hubli-Dharwad is the same system that was first installed in 1956 (Wilbur Smith Associates Pvt. Ltd., 2003). However, constructing the system is not a "one-shot" operation (Rittel and Webber, 1973), rather, over time, the system has failed to deliver the intended 24/7 pressurized water service on a continuous basis for which it was designed. Two likely reasons based on the GoK Order (2003) are a near total lack of regular upkeep and expansion and extension of coverage and low revenues to support operations.

Since the KUWSDB took over the water service operations in 2003, its operations were specifically focused on and geared toward increasing the water coverage outside the pilot area, i.e., increase the number of water connections and improve cost recovery. I find this focus as a key driver in improving water service for the rest of the city population through these specific criteria similar to the focus of delivering 24/7 pressurized piped water service in the pilot area. KUWSDB operates and maintains the old pipeline network (previously done by HDMC) and continues to provide water connections to new users, both households and other, namely commercial and industrial users.

Similar to the pilot project, there were explicit goals established for KUWSDB's operations at the outset as it took over the water system operations. One key difference was the goals for the pilot area were to be achieved by the parties under the PPP (GoK, KUWSDB, HDMC, KUIDFC, and Veolia) for only 10% of the population, while the goals outside the pilot area were exclusively for KUWSDB while operating and maintaining the old, aging infrastructure for the remaining population. In this case, therefore, the NRW would be expected to be the same over time, if not higher, while balancing the growing burden of maintaining the malfunctioning piped infrastructure.

This section draws upon a recent article by Jayaramu et al., (forthcoming), which provides detailed information on the operations of KUWSDB. Several institutional mechanisms come into play as the following narrative unfolds. As discussed earlier in the chapter, the poor piped water service delivery, coupled with increase in water tariffs by HDMC, led to large distrust and defaulted payments of water bills by customers. This resulted in low revenues leading to inadequate resources necessary for maintaining the service.

Once in office, KUWSDB focused on improving customer service for the current customers and providing water connections to increase piped coverage. An excerpt from Jayaramu et al. (*forthcoming*) below describes some programs initiated by KUWSDB:

> *KUWSDB has adopted simplified and transparent rules and procedures centered around the users and the services that the users might need. KUWSDB makes available printed application forms with details on the documentation needed for new water connections to the residents free of cost at various locations including HDMC offices throughout Hubli-Dharwad. Once KUWSDB receives a completed application packet, the resident is sanctioned a new water connection within the specified period of 15 days under "SAKALA" - a GoK program that ensures effective customer services in all of the State departments as per the 2011 Karnataka Guarantee of Services to Citizens Bill (GoK, 2012a). The State Department of E-Governance has also established various Hubli-Dharwad One (HD-1) Centers established across the twin cities. The HD-1 Centers provide customer services such as issuing application forms; accepting completed forms and supplemental services including change in the name, size, usage, and the location of a water connection; and receiving payments of water bills. The HD-1 Centers operate daily between 8 a.m. and 8 p.m. The rules and procedures for water connections have been displayed at all of the HD-1 Centers along with the HDMC and KUWSDB offices. Once the completed application forms are received at the HD-1 centers, the applications are transferred based on the location to the respective offices for approval. The State departmental engineers at KUWSDB review the forms, conduct site inspection, and issue challans [or receipts] to the applicant indicating the connection fees that the applicant is required to pay. Once the applicant pays the connection fee at the HD-1 Center, the statement of fees is transferred to KUWSDB indicating that a KUWSDB engineer will install a water connection for the applicant.*
>
> *- Jayaramu et al., forthcoming, p.9-10*

The focus on providing water connections involved addressing the challenges associated with properties that had no tenure and where there were no mechanisms to install a formal connection. Lack of tenure previously was a barrier to a legal water connection; a new State policy changed that, allowing water connections to proceed for those who would acknowledge that the connection did not give them additional legal rights:

> *A water connection is typically installed for residents in a formal dwelling or a building... In south-Hubli, where there are vast stretches of unauthorized layouts and slums, the problem of insecure tenure is faced mostly by low-income or poor residents who as a result have no water connection. In this case, with a goal to provide water connection to these residents, KUWSDB adopted a mechanism to solve the problem of insecure land*

tenure. KUWSDB obtained a letter of undertaking from the residents confirming that they would not use the record of a water connection for purposes other than drinking or other claims. Using this as a basis, KUWSDB allowed the residents to file a new application for a water connection, based on which a water connection was provided following field verification by KUWSDB engineers of the lack of water access or absence of any water connection.

- Jayaramu et al., forthcoming, p.10

Jayaramu et al. (*forthcoming)* note that this significantly increased the water connections and the water access coverage in the city, for example by making the following improvements associated with providing new piped connections:

In the past, HDMC charged a uniform connection fee for all customers in Hubli-Dharwad regardless of their income levels. This changed in 2004 with the new State policies and with the KUWSDB taking over HDMC's operations. Post-2004, under the new connection policies, KUWSDB provides the urban poor with a subsidy on the connection fees ("a connection subsidy") and charges the higher income users a slightly higher connection fee (in effect, a cross subsidy). In addition to the reduced connection fee, the urban poor living in declared slums (notified by the GoK) receive a 50% discount. In the case of higher income residents, the higher connection fee is a development charge named as one-time 'pro-rata charge' commensurate with the plinth area of the building. For retail customers, KUWSDB charges Rs. 76 per square meter of the plinth area (i.e., Rs. 30 for source augmentation which includes headworks at the source, water treatment plant and transmission mains up to the City's first storage point; Rs. 30 for water storage and feeders; and Rs. 16 for service network). KUWSDB charges commercial and industrial customers at a 50% higher rate than the residential customers (HDMC, 2003). The maximum limit of pro-rata charge for domestic or residential customers opting for half-inch size connection[81] is Rs. 10,000 per kiloliter (kL) (HDMC, 2004). The urban poor customers with the plinth area of less than 600 square feet are excluded from payment of pro-rata charges (HDMC, 2012). A comparison of the connection fees applicable to different users and KUWSDB is shown in the table and figure below.

- Jayaramu et al., forthcoming, p.11-12

Domestic Half-Inch Water Connection Fees (in Rupees)

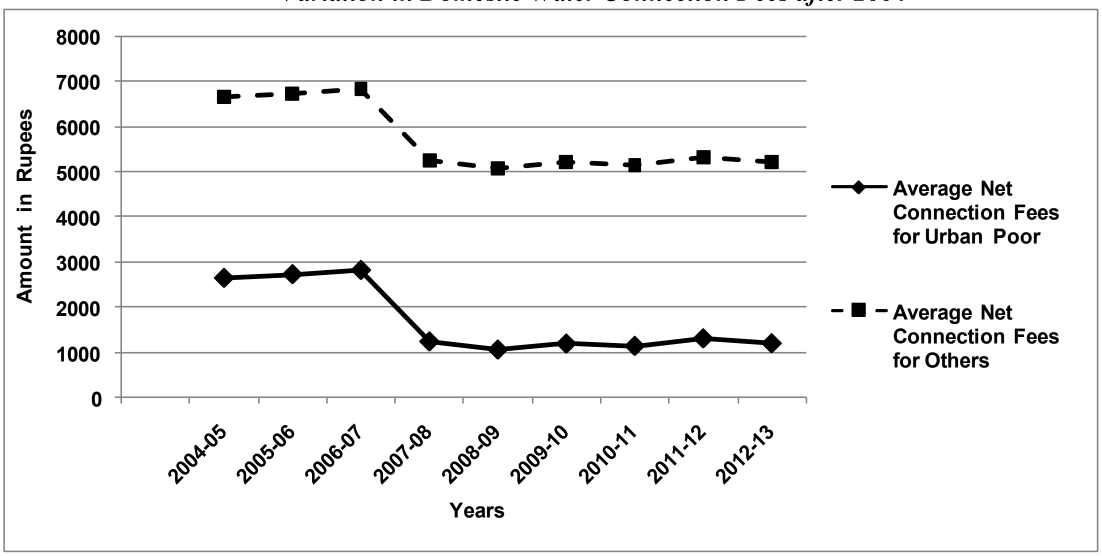
Year	Average Connection Fees for Urban Poor	Average Connection Fees for Others	Cost of Connection Work borne by KUWS&DB	Average Net Connection Fees for Urban Poor	Average Net Connection Fees for Others
2004-05	2,664	6,664	---	2,664	6,664
2005-06	2,747	6,747	---	2,747	6,747
2006-07	2,840	6,840	---	2,840	6,840
2007-08	2,945	6,945	1,700	1,245	5,245

[81] Normally connections are half-inch sized. For connections of higher size than half inch (e.g., for bulk consumers) the fee will be higher.

Year	Average Connection Fees for Urban Poor	Average Connection Fees for Others	Cost of Connection Work borne by KUWS&DB	Average Net Connection Fees for Urban Poor	Average Net Connection Fees for Others
2008-09	*3,063*	*7,063*	*2,000*	*1,063*	*5,063*
2009-10	*3,196*	*7,196*	*2,000*	*1,196*	*5,196*
2010-11	*3,346*	*7,346*	*2,200*	*1,146*	*5,146*
2011-12	*3,514*	*7,514*	*2,200*	*1,314*	*5,314*
2012-13	*3,703*	*7,703*	*2,500*	*1,203*	*5,203*

As shown in the table above and the figure below, the average net connection fees incurred by the urban poor has decreased since 2007. Further, there is substantial difference observed between the fees incurred by the urban poor (i.e., much lower fees) and the others (see figure below).

Variation in Domestic Water Connection Fees after 2004



There are several pro-poor connection subsidy schemes introduced by the GoK; e.g., a concession or a discount of Rs. 2,000 in the connection-fee for all the poor SC/ST families as per a GoK Order (2004). Under another GoK Scheme, 95% of the connection fees for poor SC/ST applicants is borne under 22.75% of State Finance Commission (SFC) Grant (GoK, 2011). The GoK also bears 95% of connection fees of the other urban poor under 7.25% of SFC Grant (GoK, 2012b). Apart from the subsidies, the low-income residents also qualify for an installment payment program where they can opt to pay the connection fee in four installments. Thus with a goal to provide affordable water access and connection, we find that there can be promising mechanisms that take into account the ability of the customer to pay the fees and provide a reprieve on the payments through discounts and subsidies or installments to low-income customers.*

** Scheduled Caste/Scheduled Tribe is Backward Classes of People category as identified by the Government of India and eligible for pro-poor considerations.*

- Jayaramu et al., forthcoming, p.13

The second component of providing piped water connections is about making the installation and maintenance of water connections efficient. KUWSDB mandated the use of more robust materials[82], capturing economies of scale in meter installation, and handling installation up to the point of the meter provided to all customers regardless of their income levels (Jayaramu et al., *forthcoming*).

One key caveat here, which Jayaramu et al., (*forthcoming, p.19*) also acknowledge is that this increase in water coverage is interpreted as increase in piped connections to households. While installations of new water connections have increased, in most of the city, due to the archaic piped system, serious problems persist with frequent occurrences of leaks, floods, and pipe bursts requiring emergency repairs. In the following discussion, I examine the operations of KUWSDB and how it "copes" with the existing deteriorating infrastructure network.

In my interviews with KUWSDB, the engineers conceded that they have to focus on resolving the numerous problems of the system rather than on improving the water service. Yet, the rationality in their operations focuses on efficiency and operating the system within the constraints. They have created a system to address the problems. A centralized complaint service routes the complaints or issues to different HDMC departments (including water leaks to the water department). Due to the high number and frequency of leaks, the complaints or issues are assigned priority levels and addressed accordingly within 24 hours, or 24-48 hours, or within a week (Table 5-11).

Table 5-11 System Breakdown and Priority of Actions

Nature of System Breakdown	Level of Priority	Timeline
Pipe Bursts	High Priority	Immediate Action, Within 24 hours
Minor Leaks	Prepare notice and repair after closing supply schedule	Within 24-48 hours
Bifurcating Leaks: Leaks at forks of pipelines due to failure of valves	Low priority	Within a week (to reduce disruption of water schedule)

Due to the poor quality of the infrastructure, responding and addressing the breakdowns may more often than not, conflict with delivering the water itself. KUWSDB engineers are stuck in a reactive "attending-to-firefights" mode more than a proactively planning mode, which can otherwise lead to more efficient approaches to deliver more reliable water. This can also be observed in how KUWSDB slides into becoming more of a reactive water provider for new users rather than being proactive in the water delivery planning and design for new communities and development. The process ideally could involve coordination and conference between the regional urban development agency (HDUDA) and KUWSDB over at least approving new development in advance of determining the infrastructure needs. However, in reality, KUWSDB receives a letter about approval of a development from HDUDA or it gets a call directly from the new users so that it can arrange for water transportation or installation of a piped water connection. There is a conceptual link between the operations of KUWSDB and HDUDA's

[82] High-density polyethylene instead of polyvinyl chloride.

activities that could improve access to reliable water, however limited coordination between the two institutions precludes efficient water service delivery.

Planning here does not have a vision. Implementation of roads happens before water lines or sewers. Engineers get a second priority here. Planning should be better/ [it should be] coordinated.
- Interview with KUWSDB

Through my field observations and interviews I conducted with KUWSDB, I find that the activity of providing a piped connection to a household that is not connected to the pipe network is not a straightforward or linear activity nor is it readily implementable or obvious. The process, which I call an "incremental planning process" involves creative thinking and problem solving on the go. As discussed below, the delivery process and the water delivery mechanisms selected are not uniform and are almost entirely demand-driven.

We determine how to deliver depending upon the notification of water demand or the call we get from the users.
- Interview with KUWSDB

Whether to provide a piped water connection to a user is not a given; it is also based on the users' location, which is a cost determinant for KUWSDB. If the user is located sufficiently close from the nearest water main pipeline distribution network (roughly up to 25 meters[83]), extending a pipeline (a tie-in) makes it more cost-effective for KUWSDB. The choice of installing a pipe extension is also driven by the number of users or households requesting a new connection. For example, for residents located at farther distances from the piped network, a "critical mass of users" or a group of households present a more cost-effective case than a single household. The costs of extending a pipeline thus hinges on the proverbial last mile reaching the user. Farther the users from the pipeline network, the more expensive it is to connect them to the network. KUWSDB enters into contractual agreements with private entrepreneurs for installing the pipes. In the case of piped connections, HDMC lists in the service contract, the areas and locations where the specific pipes should be laid, for example, "Providing & Laying of 110-millimeter diameter HDPE line from Shakthi colony to Akshaya colony 1st Phase." KUWSDB monitors the performance of the contractor by reviewing for completeness in the task within specified time and budget.

This working strategy, however much reactive than proactive, does seems to systematically account for several criteria such as the location, distance, cost, and time. However, efficiencies are lost in the ad hoc nature of the strategy. The water delivery process involves "resorting" to decisions on the cost and feasibility of the mechanism in a very short time rather than planning upfront. There may be poor execution on part of the contractor say, in failing to install the pipeline as designed or directed or restoring the site after construction is complete or having lax construction management practices. Some times it may be that the sheer urgency in providing piped conditions may overshadow the quality of work to be done. Finally, even if a pipe tie-in is installed and a piped connection provided to the users, the connection provides the same level of

[83] 1 meter = 3.2 feet, 25 meters = 80 feet.

water service associated with the existing piped network, i.e., mired with varying schedules of water availability and questionable water quality. Hence, the water service is not entirely adequate for the new users. Thus, this practice of increasing water coverage involves merely extending the pipeline to additional users without measures to maintain the water flows, which reduces the water pressure for all of the users, both current and new. Service that is not (or cannot be) provided through piped water flow is provided at times through tanker deliveries of bulk volumes of water (discussed in Section 5.4.6).

Based on my interviews, KUWSDB also has devised the concept of "group connection", which allows for newly authorized[84] user communities to approach KUWSDB and obtain water connections, where the service delivery and water connection fees are negotiated between the engineer and the group. For example, KUWSDB extends the pipeline to the community to provide a main water "group" connection at a lower rate; the group in return installs the individual tie-ins and offers to inspect and maintain the main connection. This reduces the maintenance costs for KUWSDB where it intervenes only if there is a complicated problem, which the group cannot solve; and also provides the connection at a low cost to the group in a shorter time frame.

A noteworthy point in KUWSDB's operations is how the institutional performance changed and had a direct bearing upon the water service operations, particularly cost recovery. The new connection policies with the intent to providing water access are geared toward internal revenue generation while accounting for different abilities-to-pay of the users. GoK introduced pro-rata charges for new connections that are in proportion to the household building size, which in turn affects water usage. Urban poor are exempted from pro-rata charges, whereas the higher income households are charged based on their larger house sizes (Jayaramu et al., *forthcoming*). This practice enabled KUWSDB to provide piped connections and also helped the users avoid coping with private plumbers. KUWSDB utilized the enhanced revenue from the pro-rata charges to cover the cost of water connection installations for the poor (cross subsidy).

> *The new connection policy also created a mechanism for installing and maintaining individual water connections with a long-term warranty on materials quality and workmanship. The table below shows the steady increase in connection fees mainly due to pro-rata charges creating surplus funds, which is used to meet the costs of installing water connections for low-income customers.*
>
> *- Jayaramu et al., forthcoming, p.17*

Fees and Expenditure on Water Connections

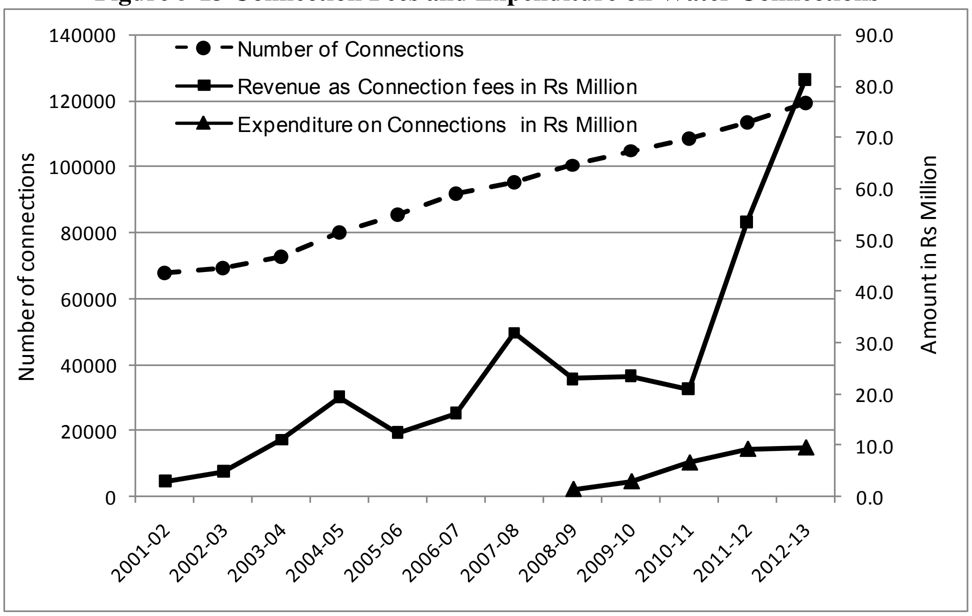
Year	**Number of Connections**	**Revenue as Connection fees (Rs. Million)**	**Expenditure on Connections (Rs. Million)**
2001-02	*67,729*	*2.9*	-
2002-03	*68,997*	*4.8*	-
2003-04	*72,851*	*11.0*	-
2004-05	*80,108*	*19.3*	-
2005-06	*85,645*	*12.5*	-
2006-07	*91,994*	*16.2*	-

[84] Approved by the government.

Year	Number of Connections	Revenue as Connection fees (Rs. Million)	Expenditure on Connections (Rs. Million)
2007-08	*95,499*	*31.9*	*-*
2008-09	*100,588*	*23.0*	*1.4*
2009-10	*105,018*	*23.5*	*2.9*
2010-11	*108,935*	*20.9*	*6.6*
2011-12	*113,586*	*53.6*	*9.3*
2012-13	*119,608*	*81.4*	*9.5*

Figure 5-13 below shows the revenue from connection fees and a drastic increase in that revenue post-2010-2011. Both the aspects of KUWSDB's operations (set as original intent of taking over HDMC's operations): water service coverage and cost recovery are shown in the figure. An increase in water connections is shown in comparison to the costs.

Figure 5-13 Connection Fees and Expenditure on Water Connections



Source: Jayaramu et al., forthcoming

With the new connection policy, there was a drastic reduction observed in the number of illegal connections from 30% in 2002 to 2.5% in 2012 (table below).
- Jayaramu et al., forthcoming, p.18

Status of Unauthorized Connections

Year	Number of Total Connections	Number of Illegal Connections	Percentage of Illegal Connection s
August 2002 (Water Service Under HDMC)	*68,997*	*21,072*	*30.5*
March 2013 (Water Service Under KUWSDB)	*119,661*	*3,260*	*2.7*

Implementation of the policy accounted for the means to pay for lower income households and increased water access through piped connections in urban poor areas (Table 5-12).

Table 5-12 Water Access to the Urban Poor

Year	Total Urban Poor Population	Urban Poor Covered with Piped Water Supply	
		Population	Percentage
March 2003	175,000	90,000	50
March 2013	250,000	200,000	80

Thus far, KUWSDB's service operations have improved the recovery of O&M costs to 73%, with metering of 67% of the water connections (KUWSDB, 2013) while operating and maintaining the existing deteriorating infrastructure.

Institutional Capacity

As part of my fieldwork on the water service operations, I further investigated how the outcomes mentioned above were in fact achieved. Taking the example of improved cost recovery, KUWSDB played a substantial role in bill collection, which contributed toward cost recovery for the entire city – including the pilot area (World Bank, 2011). Here the State Engineer took measures to improve institutional capacity within the department that helped improve staff performance. Collection of water bill payments had been a large component that had lagged behind and affected the revenues. Prior to 2003, there was a considerable gap between expenditure and revenues with losses of up to 85%; low priority to customer needs; and general apathy in the staff toward making any operational improvements.

One critical component of recovering costs was improving bill collections especially with thousands of rupees of arrears from before 2003. For achieving cost recovery as part of the pilot project, the important task of bill collection was assigned to HDMC. With the takeover of the local water service operations by KUWSDB, it was KUWSDB that was instrumental in collecting the bills. However, in the rest of the city, cost recovery, which was a goal of the incoming State Executive Engineer, involved more than bill collection – i.e., increasing the piped connections for improving access, improving customer service through complaint redressal and providing additional centers conveniently located for bill payments. The improvement in cost recovery, used as a metric of operational performance, can be seen in the improved staff performance, which helped increase operational efficiency.

Prior to 2004, HDMC's responsibilities of water service operations were combined with other urban services; the following quote signals the likely lack of focus in the broader administration and revenue-heads for different service departments affecting their performance in terms of service. At the same time, within the same water service department, separating the revenue and legal aspects from the actual water delivery operations also signals creating of silos namely, say of O&M of infrastructure and billing and collecting revenues:

The head of the corporation (HDMC) heads the different departments from traffic, sewer, roads, to solid waste. XXX is the head for water alone, which helps him stay focused in the sector. Plus, he is the technical, administerial, and revenue head, which has helped him connect the dots and strengthen and improve the ties in between the three (staff efficiency, cost recovery adding to revenues, application of technology like e-governance). The previous Superintendent at HDMC was the head of water service (maintenance and administerial) and there was a different head for revenue (separate officer). Assistant Commissioner for administrative and legal head for legal issues.

- Interview with KUWSDB

KUWSDB took over the responsibility of operating only the water infrastructure and delivering water service, while the other urban service delivery departments remained with HDMC. Under HDMC's operations, staff promotion was only loosely connected to their performance and at the same time better performance was rarely rewarded.

In the government departments, due to the legal and labor laws, employees file suits in the court of law. HR is weak. There is no division of responsibilities, the roles of staff are not clear, there is no monitoring of performance. There was a lack of clear job description.

- Interview with KUWSDB

By taking over of the local operations and staff, KUWSDB's functions also involved assessing the staff performance and planning for execution of certain tasks to meet the objectives set forth by GoK. As the KUWSDB engineer put it:

...80 to 85% staff is good ... The remaining 15-20% of the staff are low performers … With the motivating measures, this situation can be improved.

- Interview with KUWSDB

Institutional capacity was improved by administering performance measures for staff, which included not only on how much bill arrears were collected but also by the number of water customers the staff worked with. Salary raises were offered for improved performance. Recognition in the form of promotions, awards, and rewards such as membership to a special gymnasium or a swimming pool proved to be effective motivators. Participation of high performers at the office award ceremony/ party was a confidence booster for the staff; there was high rate of bill collection observed, which increased revenues and thus cost recovery. Some excerpts from my interviews with the local officials provide supporting information:

Salary range also is now comparable to private sector… I know this woman who left a private company to join HDMC (a public organization)!

The institutional mechanisms and practices that the KUWSDB engineer adopted reflect a constant emphasis on learning where "effective institutions maintain staff through providing sufficient incentives, compensation, employee benefits, and promotion opportunities so there is a minimum of unwanted turnover. Institutions that develop and maintain staff feel that people are their most important asset" (Cullivan, et. al., 1988, p.56).

The autonomy of the utility (in this case KUWSDB operating only water deliveries) essentially relates to the degree to "which the management of the utility is able to make decisions regarding the provision of water services". What I observe in its operations so far, also provides information regarding the degree to which it can be seen as being apolitical or not, the permanence and stability of the organization." KUWSDB took over operations under the specific GoK order with specific goals that made it accountable; accountability, relates to the degree to which the management of the utility is held accountable for the decisions they make (Schwartz, 2006, p.85), which applies to the KUWSDB engineer who was instrumental in making the sweeping changes in not just achieving the goal but instilling the institutional mechanisms that have a higher likelihood to continue in his absence.

I observe the KUWSDB engineer's ability to exercise control and that of being insulated from political interference (likely conferred by the GoK) that could otherwise adversely affect the regular operations and water delivery efficiencies. The following quote provides supporting insights into the capability and possibility of effective operations by the KUWSDB engineer:

> *Control is the means through which accountability and autonomy are simultaneously defined and ensured. One important function of control is to define who is accountable to whom, for what and for which period, and what are the consequences in terms of rewards and sanctions. Defining the responsibilities of people is just the beginning of control. To be effective, a control system must develop a performance measurement mechanism to verify results. The third element in control is to define the limits of authority and responsibility of each party/actor concerned, thus providing operational autonomy to the actor, subject to control within the established limits. The control needs to be exercised only when limits or boundaries are crossed. Subordinate individuals or organizations have freedom to act within the boundaries. Thus accountability, control and autonomy are inextricably linked together and can work only as an inter-dependent system.*
>
> *- Islam, 1993, p.134*

Institutional capacity is not only improved within the organization (in this case, a public organization) but I observe capacity augmentation in the form of PPPs that KUWSDB engages in. KUWSDB partners with private entities as a more cost-effective strategy or devises innovative new solutions to meet users' needs.

In addition to installing new water connections and improving customer service, how KUWSDB makes efforts to improve upon the existing piped water service (intermittent) and the service for those who have no access to piped connections (35% of the population is expensive to provide them connections) is worth an examination. The following discussion delves into the some of the water delivery mechanisms that KUWSDB uses to provide water in the city both for users with and without piped connections.

5.4.6 The "Other" Water Delivery Mechanisms

KUWSDB operates the piped water infrastructure as the primary delivery mechanism for a majority of the population. However, the piped service is inadequate for the current customers. Further, at least 35% of the population does not have piped connections. In the process of O&M

of the aging and deteriorating infrastructure system, responding to continual breakdowns, and providing piped connections, KUWSDB has its own "coping" strategies and adopts "other" mechanisms as alternatives or back up options to deliver water to all users and makes up for the inadequacies in the current system while working with the resources it has. These strategies are made up of a combination of water supply sources, different transportation and delivery mechanisms KUWSDB, and the different organizations involved with KUWSDB.

Water Supply Source: Groundwater

A second water supply source (besides surface water) for Hubli-Dharwad reported by KUWSDB and the Central Groundwater Board (Southwest Region; 2008) is groundwater, which could serve as an active source with attention to monitoring and treatment.
As shown in Table 5-5 above and also from interviews with the water engineers, I find that KUWSDB uses groundwater as a secondary source, and it is drawn from public bore wells operated by the municipal corporation and distributed via tankers. Groundwater is also drawn using hand pumps available for public use. The main known source of groundwater in the Dharwad district is recharge by annual precipitation (CGWB, 2008). The water levels are found to be shallower in Dharwad ranging from 6 to 9 meters (19 to 29.5 feet) below ground surface with deeper levels at 10 to 20 meters (32.8 to 65.6 feet) below ground surface in areas bordering Hubli and Dharwad (CGWB, 2008). The groundwater levels are reported as "safe", although there is only limited monitoring and no regulation (Central Groundwater Board, 2008).

Based on interviews with water engineers at KUWSDB, surface water is used for higher uses such as drinking while groundwater is supplied for uses other than drinking, including commercial and industrial processes. This is because, in terms of water quality, surface water is considered superior to groundwater (see following excerpt from a report on artificial recharge and water quality).

> *The water quality survey results [for groundwater in peri-urban areas of Hubli-Dharwad were compared against the Indian water quality standards]. It was found that the majority of hand pumps, 14 out of 17 (82%) were non-potable according to the Maximum Permissible Limit in Absence of Another Source (MPLAAS). When compared to the Highest Desirable Limits (HDL) …for parameters such as total dissolved solids and bacteria, none of the water samples passed.*
> *- Hollingham, 2010, p.8-9*

Besides the public bore wells operated by HDMC/KUWSDB, a field survey by Raju et al. (2007, p.8) report that people "have made huge investments to have their own source by drilling bore wells and open wells. In all the newly upcoming areas, drilling bore wells is a common feature" (see Table 5-13).

Table 5-13 Estimated Number of Private Bore Wells

Sectors	Hubli	Dharwad
Households	5,900	2,050
HDMC-owned wells	1,200	501
Commercial establishments	1,867	165
Total	**8,967**	**2,716**

Source: Adapted from Raju et al., 2007, p.8

Different from the CWGB report, a report commissioned by KUIDFC (Raju et al., 2007) cites a study conducted by the Department of Mines and Geology in Hubli and Dharwad during 2000 to 2004, which indicates that groundwater depletion is evident through the declining water levels from 3.42 meters to 47 meters in Hubli and from 3.31 meters to 35.14 meters in Dharwad. The possible causes highlighted by the department are drought conditions and excessive drilling of bore wells. Further, the following quote highlights the woes of the private dwellers and users:

> *…The bore well drillers also support this view [of declining groundwater levels]. The private water tankers have also added to the problem in certain areas. Increased tanker business with high extraction levels has aggravated depletion, for instance, in Keshwapur in Hubli where the highest number of tankers are found, the water table level has gone [down] to [a depth of] 800 feet.*
>
> *- Raju et al., 2007, p.10*

Despite the water supply struggles, other water supply sources or regulation and better management of current resources is rarely observed. At the same time, innovative approaches such as rainwater harvesting, although are highlighted as a better alternative and made mandatory by the Karnataka Housing Board for all new layouts and housing (Times of India, 2012), "nothing significant has been done to promote it nor concerted efforts has been undertaken" (Raju, et al., 2007, p.10). This is also despite its "emphasis since the 2002 National Water Policy" (Raju et al., 2007, p.10). Based on my interactions with officials and my field observations, I see this lack of efforts – regulation or exploring new approaches – more as a symptom of limited or a lack of impetus. These approaches or mechanisms are undermined as being an "alternative" compared to larger capital-intensive initiatives propelled by the central and state governments.

Water Transportation and Delivery: PPP In Action

As I briefly mentioned above, KUWSDB contracts with private contractors for work related to water resource development such as drilling wells. KUWSDB also engages with the private sector to operate different mechanisms to improve upon the current piped water service. Tankers are used to transport and deliver not only groundwater from bore wells but also surface water stored in the local city reservoirs in some instances.

Tankers and Tractors

Providing a water connection (or a piped connection) for users is not the only way KUWSDB provides water service. Where piped connections are not feasible, KUWSDB uses other mechanisms for transporting and delivering water such as tankers or tractors and recruits private vendors and tanker operators to deliver water to urban households – an improvement in a short time frame over the situation of no piped service or no water access at all.

A common situation is as follows: Users (households or communities of several households) call KUWSDB and request for water service. Following this request application, KUWSDB's approach involves recruiting private vendors that operate tankers and tractors to deliver treated water to the users. As directed by the KUWSDB engineer, the tanker- or tractor-operator collects the treated water in the vehicle-tank from an assigned storage reservoir for the city zone in which the users are located or are close to, and delivers the water to the users.

Both the tankers and the tractors are used to serve an area of 5- to 6-kilometer (km)[85] radius. Distance is a factor considered due to the cost; greater the traveling distance, higher is the cost incurred by the vehicle operator, and thus KUWSDB. KUWSDB recruits an appropriate vehicle depending on the water demand and their local knowledge of the roads. For example, depending on the width and the condition of the road in the neighborhood, HDMC opts between using a large (6,000-liter) tanker or a smaller (3,000-liter) tractor.

In some instances, KUWSDB also accounts for the local weather conditions in determining the physical mode of water delivery. For example in the monsoon season, when the road conditions deteriorate and affect road transportation, tractors with their smaller size and maneuverability operate more effectively on narrower mud roads than tankers (see Figure 5-14 below).

Figure 5-14 Some Examples of Tankers and Tractors Used to Deliver Water

Tankers | **Tractors**

KUWSDB typically uses surface water storage supplies as a drinking water source, which is relayed to the users.

> *I have made it clear and announced to the users that the [KUWSDB-dispatched] tankers will provide water only for drinking purposes.*
> *- Interview with KUWSDB Engineer*

Sometimes, if KUWSDB receives calls for water demand for purposes other than drinking such as washing and cleaning or for a domestic event such as a wedding, KUWSDB uses public bore wells as a water source. Here, however there is no measure to know if the water is indeed used by the users for drinking or not, except for the understanding between the users and KUWSDB discussing the water need and determining the source of water supply.

Private tankers operating independently are infamous for charging exorbitant rates for water deliveries (Davis, 2005; Ranganathan et al., 2009). There is no explicit regulation of the tanker deliveries, yet in this case, KUWSDB has introduced novel approaches to address these

[85] 1 kilometer = 0.6 miles

problems through monitoring the tankers that it recruits and adopting different institutional mechanisms as discussed here: First, to ensure that the water collected by the tankers is delivered to the users as planned, KUWSDB assigns the tanker- or tractor-operators to the task of collecting a specified quantity of water from a storage reservoir and deliver the specified quantity to a particular community in a city. Second, the contract provides clear instructions on the timing and duration of the operation of the vehicle, and the expected vehicle conditions (clean and well maintained) and subject to inspection by KUWSDB. A security deposit is collected from the contractors prior to starting the work and they are then paid after the conclusion of the task as specified.

KUWSDB has recently begun using Geographic Information System (GIS) and Geographic Positioning System (GPS) technologies in spatially tracking the tractor- and tanker-operators.

> *We pay tankers to deliver water in peri-urban areas (19 tankers equipped with sensors) so (I) can track them via GPS. An IT firm administers billing of tankers.*
> *- Interview with KUWSDB Engineer*

The KUWSDB Engineer is able to monitor the travel routes of the vehicle so that the operator provides a true estimate of distance traveled in collecting and delivering the water. When the water is delivered as assigned to the user community, the tanker operator obtains a sheet signed by the user to confirm that the specified water quantity has been delivered to the user. The user pays for the delivered water at the local KUWSDB service center. The user does not pay the tanker, which avoids any service compromises or overcharging the customers.

Operators are required to travel with a logbook (provided by KUWSDB) to ascertain quantities of water transported. The tankers/tractors collect water in the quantity required from the reservoir, enter a time in the log book at the source, deliver water with a receipt, and get signature from at least two users in the community at the delivery point. The operators log their time of return when they return to the HDMC office. A contract with an operator for daily tanker delivery service typically runs on a monthly basis. This provides an incentive to the tanker operator to maintain and improve their performance so that the contract continues to get renewed.

The payment to the KUWSDB-dispatched tanker operator is held back or retained until the entire work is completed. The contract is executed for a specific work task for a particular duration. Because KUWSDB is the primary public institution, providing equitable service – to the urban poor in particular – is one of its objectives. The water is delivered free of charge to the urban poor. The tariff for other users is Rs.1 Per 10 kL and for special/ private functions and Rs. 23.20 per kL for private functions (hotel), commercial use.

Water Kiosks

In areas with no piped connections or where no clean water supply source exists nearby, KUWSDB recruits private vendors who design, install, and operate kiosks that dispense ultraviolet (UV)-treated[86] water. KUWSDB delivers water drawn from groundwater well for drinking through kiosks or booths that treat water through processes that remove particulates and total dissolved solids and ultraviolet treatment. The kiosks are stationed within neighborhoods especially the ones outside the piped service area that have no ready access to water (Figure 5-15).

Figure 5-15 Examples of Water Kiosks

Source: Courtesy Mr. Jayaram

The operators also design and build the UV-treatment units that are portable and can be easily installed at a particular location designated in a community. These kiosks serve as a timely improvement in a desperate situation of no access to safe drinking water.

[86] Ultraviolet (UV) is a type of energy found in the electromagnetic spectrum, lying between x-rays and visible light. UV treatment is a method that destroys bacteria without adding chemicals.

NextDrop for Piped Service

In areas with intermittent piped water service, KUWSDB operates a water supply schedule to provide water in one or more neighborhoods in the city at a time. This is to manage the water quantities available at the city reservoirs and to guide a controlled distribution of water to all the connected consumers, akin to a water rationing practice. Water utilities in countries like the U.S. identify water rationing as a water supply strategy during emergency conditions such as a drought or water scarcity or unanticipated infrastructure system breakdowns. In this case, water rationing is not an advanced planned strategy; rather it is a rational approach to work within the constraints of a malfunctioning infrastructure system and resources available and delivering water service at the same time.

Water rationing is practiced more so due to the inadequate and varying quantity of water stored in the city reservoir. The service schedule may vary. As a result, water is delivered approximately 2 to 3 hours a day for 3 or 5 pre-scheduled days in a week in a neighborhood. The availability of the water to the user depends on the user being at home when the water is on and for the duration the water is on.[87] This is for households obtaining water not only from communal taps but also from individual taps due to inadequate piping or pumping within the household to allow for automatic filling and storage. Depending on how long the water is on for and its pressure, the user may or may not have collected adequate water during that time. The users cope with this inadequacy by purchasing a tank to store water whenever the water service is on and for using it later, thus having the water available 24/7. Depending on the dwelling, the water storage tank is typically within or outside (on the rooftop or in the vicinity; Figure 5-16).

Figure 5-16 Water Storage Tanks Built or Purchased by Households

Tanks on a Two-Story Building Top

Communal Tank

This approach can be undertaken only if the tank and its installation are affordable to the users and if their dwelling structure has sufficient space and capacity to hold the tank. The urban poor households at times invest in communal tanks (Figure 5-16 above) where they share the costs of

[87] There can be instances where users could leave home by attaching a hose from the pipe to the tank so that the tank would automatically fill up when the water is on. However, most of such systems are manually operated by the household members and unattended filling of the tank may lead to overflows.

the tank, its installation, and maintenance. The intermittent piped water service in combination with such storage provides water to majority of the users when they need it.

The intermittent water service is intended to deliver water on a schedule, but schedule adherence is weak. The time and the duration of the water service changes if KUWSDB faces emergency situations such as water leaks, network breakdowns, or pipe bursts that KUWSDB has to attend to. Emergency situations are more frequent than rare. Such situations cause water losses and raise the need for urgent repairs, which result in forced changes in the water service schedules. KUWSDB posts public notices and messages relaying the water service schedule or any changes to it in advance. However, the notices or messages do not necessarily reach the user in advance or on time. For the user then, the water service becomes arbitrary.

The changing water supply schedules in the intermittent piped service makes the service uncertain for the users. However, through the daily firefights associated with the system breakdowns, KUWSDB has been able to provide a factor of certainty to the intermittent water supply schedule for many households by working with a private organization, NextDrop. NextDrop is a private nonprofit organization that was founded to apply innovative mobile technology. NextDrop identified the market and the need for addressing the uncertainty in the water supply schedule and made a proposal to work with KUWSDB in resolving the issue. KUWSDB entered into an agreement with NextDrop different from a service contract with other private entities discussed. Operating under a license to operate in Hubli, NextDrop provides a service of relaying in advance, the water schedule and duration of when the tap water would be available in the form of a text message on cellular phones.

NextDrop partners with KUWSDB, where it works with the KUWSDB engineers and valve men, who operate the valves of the water distribution network and are instrumental in scheduling and supplying the water as per the schedule. NextDrop obtains direct information from the valve men and KUWSDB staff concerning reservoir levels that affect the water supply schedule and sends text messages over the phone to subscribed customers. NextDrop serves as a conduit of information, between KUWSDB and the users, bringing certainty to the service, where the users receive information on the water schedule in advance that enables them to plan their day more productively than to rely on the vagaries of the changing water schedule.

NextDrop retains the autonomous nature of decisionmaking related to its operations, and works collaboratively with the KUWSDB staff toward a common goal of bringing certainty to the changing intermittent water service. The partnership of KUWSDB and NextDrop entails an agreement of operation of NextDrop in the neighborhoods with intermittent water service and where the users can get the information and have certainty in the piped water service at a nominal fee. NextDrop provides this service for a fee of Rs. 10 per month to its subscribing customers and based on my interviews currently has over 10,000 subscribers[88].

Water service delivered through these other mechanisms is not entirely desirable; water service delivered by tankers or kiosks is still dependent on the user being at home to receive water and may be an access point of inconvenience compared to piped water. KUWSDB recruits tankers

[88] In Hubli-Dharwad and Bangalore.

and other private vendors in response to the demand within and outside the piped networked area; however, adopting such mechanisms (besides installing pipeline tie-ins and piped connections), is viewed as a stop-gap measure, thus the mechanisms receive a resigned approach where the same measures continue to be operated with poorer results, whereas a more proactive, comprehensive approach and planning for and incorporating regulatory mechanisms could improve the outcome, such as not having to call KUWSDB every time the users need water or avoid the externalities of traffic or other delay factors and nuisance by multiple tanker visits.

Other Water Providers

As the preceding sections show, the government agency provides water using different PPP arrangements[89], either through management contract (e.g., Veolia as the system operator) or through service contracts (e.g., tankers or other vendors). Self-provision of water by users is also common but it is practiced more in response to the poor municipal water service, which Raju et al. (2007) refer to as "flourishing water markets" that are tapped by the private vendors. The following quote shows the extent of private, unregulated, water markets thriving in Hubli-Dharwad.

> *Packaged drinking water has captured a large market relatively over the years. Demand for packaged drinking water has been definitely on the increase as opined by the packaged water distributors of Hubli and Dharwad. …Tankers constitute another important actor in the trade. Around 100 tankers* thrive in the cities. The market is also characterized by some malfunctioning related to lack of regulation and control, while the companies are not registered, regulations on quality control are nil.*
> ** the tanker count includes tankers in the city of Belgaum*
> *- Raju et al., 2007, p.19*

The markets respond to the water demand, rising not only related to inadequate water service but also natural water scarcity:

> *Higher the water scarcity, higher [is] the business for bore well drilling companies. All over the state [of Karnataka], a large number of bore well drilling companies have been established in recent years. Sadly, none of the bore well drilling companies is made accountable on the number of bore wells drilled, the extent of drilling or any rules. However, the city corporation makes it compulsory for any customer to take the permission before drilling a bore well which is an appreciative effort taken to regulate these bore well companies in the cities but [is] not religiously followed. Migratory drillers, mostly from Tamil Nadu [neighboring state] make roaring business as they drill for less cost comparatively.*
> *- Raju et al., 2007, p.20*

5.5 Delivering Water Service to All: The "Pilot" Way or The "Other" Way?

The study of the two water delivery processes in Hubli-Dharwad allowed me to evaluate if the approaches account for time, scale, and cost considerations, and deliver or have a potential to

[89] Recall the broad definition of PPP that I have adopted, as discussed earlier, considering the wide range of arrangements.

deliver reliable water to all of the city dwellers, now and sustain over time. Table 5-14 summarizes the assessment of the two processes, following which I discuss the potential of each process to deliver water to the entire city.

Table 5-14 A Brief Comparative Summary of Approaches to Water Delivery in Hubli-Dharwad

Area in City	Pilot Area	Remaining Area
Water Service	**Continuously Supplied 24/7 Pressurized Piped Water Through Individual Connections**	**Non-24/7 Continuously Supplied Pressurized Piped Water**
Water Delivery Mechanism	Centralized water infrastructure system delivering water from a distant central surface source and treatment through a network of pipes	Source: Centralized water source (surface water) or multiple groundwater wells Mode of Delivery: Pipeline extensions, Tankers, Water Kiosks, etc. Last Mile Connection: Individual or communal pipes, bring water home from a few tens of feet from home (distance may vary)
Time Taken to Deliver Water	6 years from concept to begin operation, now in practice	Now, has been in practice over the years
Scale of Coverage (Percent of the City Covered)	10	90
How Cost is Factored In	Cost developed for the single approach	Cost considered for different alternatives prior to determining the final approach
Source Consideration	Assumes water is available at the supply source, i.e., at the Malaprabha and Neersagar Reservoirs	Assumes water is available, and adapts the working operations based on the availability of water at the city storage reservoirs and the groundwater wells.

5.5.1 The "Pilot" Way

While the pilot project in Hubli-Dharwad has demonstrated the implementation of the reinstated 24/7 pressurized piped water service goal, it has done so only for the 10% of the population. While planning of the scaling up the service for the remaining parts of the city continues to remain in progress, it is important to understand the feasibility of achieving the service for a heterogeneous population and development in short order.

Firstly, the actual service objective of achieving continuous supply of pressurized piped water seems to be questioned by many, not as much as a solution in itself (which is attractive to achieve) but more in terms of its feasibility and implementation in the context of scale and time and the equity concerns it raises through the conflation of its execution under a PPP.

Some quotes from my interviews with practitioners and researchers follow:

24/7 is a desirable objective but how it can be best implemented is the question.

How can transparency and accountability be built in with public interests? …Need to work on performance. …Right now, there is limited focus with more interest in financial sustainability and cost recovery – to make it more attractive for the private sector.

24/7 also assumes / or makes people use water only for piped water. This makes their [large-scale] investment risk-free.

24/7 service is a 'red herring' – a goal the government t is chasing for its own good.

Secondly, I see the scalability of the pilot project to the remaining portions of the city or its replicability to other cities, in the enabling environment that brought together some essential attributes, which I describe above. However, the pilot project exhibits some unique features that questions its replicability or the scalability elsewhere. One is the assurance of availability of water provided by the KUWSDB. In the cases of any service failures (including, owing to nonperformance of Veolia), it was KUWSDB / GoK who retained the responsibility of delivering water to the public. As discussed in Chapters 2 and 4, water supplies can be vulnerable due to the risk of adequate water availability at the source. In the case of Hubli-Dharwad, water availability at the Malaprabha River and Neersagar Reservoir is prone to risks, mostly unpredictable risks such as a dry year or a drought. Anthropogenic risks involve the possibility of water conflicts, in this case the inter-state dispute of the Krishna River, of which Malaprabha River is a tributary. The uncertainty of water availability threatens the delivery of water service. Such a risk "turns into responsibilities" for KUWSDB, which then faces the task of providing water to the users in the event of water scarcity. The PPP arrangement in this case dissolves and the water delivery task (not necessarily continuously supplied 24/7 pressurized piped water) is zeroed on the government.

Cost recovery, the prime component of the pilot project was achieved from efficient collections of the water bills, which can be attributed to KUWSDB's operations, including the internal management and operational processes combined with insulation from political interference, which improved its institutional capacity. Autonomous operation of water service, i.e., separating it from other local responsibilities such as sewage, drainage or other infrastructure services, and presence of a competent KUWSDB engineer, who initiated mechanisms to improve organizational performance, may not necessarily be replicated elsewhere merely through a PPP contract; rather would need execution of specific institutional mechanisms perpetuated by the KUWSDB engineer.

Finally, the presence of KUIDFC as not only an independent monitor of performance and manager of the contract with Veolia but also as a coordinator amongst the involved parties from HDMC to KUWSDB and Veolia helped keep all the parties and their responsibilities in check with the goal of supplying 24/7 pressurized piped water on a continuous basis to the 10% of the population. The intrinsic purpose of KUIDFC is that of being a facilitator and a coordinator, concentrating on development of urban infrastructure financial market. In line with this objective, KUIDFC is also planned to initially concentrate on developing urban local body capacities and identification and development of bankable projects (KUIDFC, 2013). For the pilot project, KUIDFC oversees the process, coordinates between the different institutions involved, and ensures that the service is delivered as stated in the contract. Thus, having a separate entity devoted to these tasks and to monitor that project goals are achieved is a great advantage to the pilot project. Whether the "pilot" way is scalable or replicable and if it can meet the water needs of all the users in Hubli-Dharwad and other Indian cities in a short order remains a question.

5.5.2 The "Other" Way

Aligning with my hypothesis in Chapter 1, in this chapter I find that there can be indeed another approach of examination of the water delivery problem, which can lead to other ways to provide water that meet users' needs, and offer physical delivery approaches that are faster and likely cheaper and institutional approaches that can ensure service delivery now, and over time. In Hubli-Dharwad, I have examined how KUWSDB, being a public entity, has been effective in improving water service operations by increasing the number of water connections and enhancing cost recovery. I have also shown how KUWSDB operates different kinds of water delivery mechanisms through a combination of water supply sources, delivery options, and institutional mechanisms (including engaging with private entities) in providing water to the majority of the city population. I call this a "hybrid approach" due to the combinations of different water sources, distribution facilities, and institutional mechanisms.

The hybrid approach is being actively used in delivering water to 90% of the population (a large section, compared to the 10% in the pilot area) and has been in operation for years. The hybrid approach also takes both time and financial constraints into account, and offers a tremendous potential of delivering water to a large scale of population, fast. The institutional mechanisms that I provided a detailed account of make the approach a strong candidate to replicate in another context. However, the water service currently is inadequate and does not achieve the water service levels of water access, availability, and quality. I observe that these missed opportunities result from incremental and ad hoc planning and due to a reactive, rather than a proactive stance. In the next chapter, I take a step forward by considering the water delivery problem as a "wicked planning problem" and delve deeper into the this hybrid approach and how its benefits can be leveraged and how it can be improved upon by adding levers of efficiency.

Chapter 6 Delivering "Water When You Need It": Using A Broader Approach

24/7 will happen when it will happen. But interim solutions need to be implemented till it comes in place.

- Interview with Water Engineer

6.1 Introduction

In discussing plans for water service delivery, water engineers in Hubli-Dharwad recognize that supplying 24/7 pressurized piped water to all on a continuous basis will take years, and so other solutions must be implemented until such time as continuous pressurized piped water service reaches everyone. Even if pressurized piped water is the most desirable of the options in the long term, the wicked planning problem line of planning theory suggests that complex planning problems such as water service delivery are not necessarily solvable by optimization or a "one-size-fits-all" approach, especially in the dynamic context of rapidly urbanizing and heterogeneous demand conditions and lack of basic water access and suggest that when there are differences in values, priorities, and preferences, providing a wider range of choices can be a robust way forward.

In this chapter, I use the framework of the wicked planning problem in characterizing the water service delivery problem in Hubli-Dharwad and then delve deeper into these other ways or "interim" water delivery options stated in the quote above, in particular, those which the state and local government organizations have adopted for serving entire cities and which have been in practice over time. The "hybrid approach" that I see on the ground requires improvements in the service and incorporation of further efficiencies, as well as institutional mechanisms to ensure that water is delivered as intended and over time accounting for equity concerns. I analyze the possibilities for offering a wider range of acceptable options and improvements by adding levers of efficiency and environmental and land considerations that meet access, availability, and quality standards but may offer more flexibility and faster improvement in quality of water service for the populace of Hubli-Dharwad.

Drawing upon field visits, participant observation, and interviews, I show that there are several alternate, faster, and likely cheaper ways in which urban users can have 24/7 water service or "when they need it": means delivering water to the user such that the user has water available in the quantity and quality when needed for the purpose of use, regardless of the delivery mechanism. These alternate ways acknowledge and respond to the heterogeneous and dynamic user conditions, and provide "water when you need it" now, but they need parallel and equal attention from and a formal recognition by the government to do so effectively, supported by appropriate resources to create an "enabling environment" similar in concept to the one I discuss for the pilot project, to ensure their success or effectiveness. Such improvements to the current hybrid approach[90], which I call the "enhanced hybrid approach," could be done faster than it is

[90] In parallel to the implementation of the centralized piped service through PPP or as a transitional strategy while the 24/7 pressurized piped water service is made available to all urban households.

likely to be possible to provide continuously pressurized piped water to all, and in some situations may also be less expensive.

6.2 Approaching The Water Service Delivery Problem in Hubli-Dharwad

In Table 6-2 below, I outline how the water service delivery problem in Hubli-Dharwad exhibit the the characteristics of Rittel and Webber's (1973) wicked planning problem.

Table 6-2 Water Service Delivery in Hubli-Dharwad: A Wicked Planning Problem

Characteristics of Wicked Planning Problem listed by Rittel and Webber (1973)	Associated Characteristic of Water Service Delivery in Hubli-Dharwad
No definitive formulation of problem	It is viewed as an infrastructure-failure problem (e.g., leaking pipes), a water resource problem (e.g., inadequate or changing water levels in the city reservoir), a management problem (e.g., low cost recovery by Hubli-Dharwad Municipal Corporation or HDMC), or an equity problem (e.g., unaffordable water fees).
Solutions are not true-or-false, but good-or-bad	New infrastructure is one solution, but building it in the pilot area does not guarantee reliable water service to all of the city population. Although the infrastructure by itself may be capable of delivering pressurized piped water service, there are several tradeoffs that can keep the service from reaching all of Hubli-Dharwad[91] making it good or bad, such as the time required to scale up the service to all; uncertainty of the water available at the source; and presence of large scale and diverse urban development that would create severe environmental and community disruption impacts. In the meantime, water service continues to remain poor for 90% of the population.
No immediate and no ultimate test of a solution	Implementing the pilot project is considered to be a "test case" for delivering 24/7 pressurized piped water service. However, to the extent that the problem is seen by some as the ability to maintain the infrastructure system and water services over time, the short-term results are not as good a test of the solution. There may not be an ultimate test of the solution if the issue is being able to deliver safe water and at a reasonable price to the entire city population over time as this is a moving target and the test criteria are debatable.

[91] Even the current piped water infrastructure system does not reach all of the city residents.

Characteristics of Wicked Planning Problem listed by Rittel and Webber (1973)	Associated Characteristic of Water Service Delivery in Hubli-Dharwad
Every solution is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly	Building a new water distribution system amounts to a commitment to deliver water by pressurized pipes for decades to come. However, the effectiveness of the system can be gauged only over time, as the O&M of the infrastructure ensues, and if the service is delivered and sustained as intended. Having made the investment, there is no simple reversibility.
No enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan	Water can and is delivered in a variety of ways, Water service delivery remains a "moving target" for the municipal engineer for varied reasons from the location of a user, whether it is a new or an existing user, the conditions the user is located in so that the engineer can weigh the available water delivery options accordingly. There is no particular set of solutions available that can address the problem; rather the nature of the problem itself continues to change.
Every wicked planning problem is unique	Delivering water service in Hubli-Dharwad is about delivering water to households living in diverse conditions from dwelling structures; different living conditions (formal versus informal or planned versus not planned); their location with respect to the distribution network; as well as socioeconomic aspects such as low- to high-income and their existing water provision mechanisms, which vary widely.
Problem is considered a symptom of another problem	Poor water service is a symptom of different problems. One example is lack of urban planning processes such as limited or no linkage between urban development and delivering water. This is visible through limited coordination between approval and implementation of new urban development and water service delivery. Providing a water connection for new households has taken over 2 years in the past where the urban development agency still continues to approve new development while KUWSDB continues to look for different ways to deliver water to these new developments once they get notified.

Note: The table is developed based on the water service delivery discussion in Chapter 5.

6.3 Framework to Developing the "Enhanced Hybrid Approach"

6.3.1 Characterization of the Diversity of Users

In order to plan for water delivery under the "enhanced hybrid approach", I developed a typology to characterize the diversity of the population that KUWSDB needs to deliver water to instead of homogenizing the water service for everyone. The typology is based on using proportions of populations that have been served by a predominant water infrastructure system for years and the presence of the newly built pilot project. I also account for the scale of the population, including the population that is not reached by either of these systems. Further, this typology accounts for the "last mile" connection of the water delivery mode to the user. Because centralized piped infrastructure covers over 65% of the city population[92], I use that as a main feature of reference

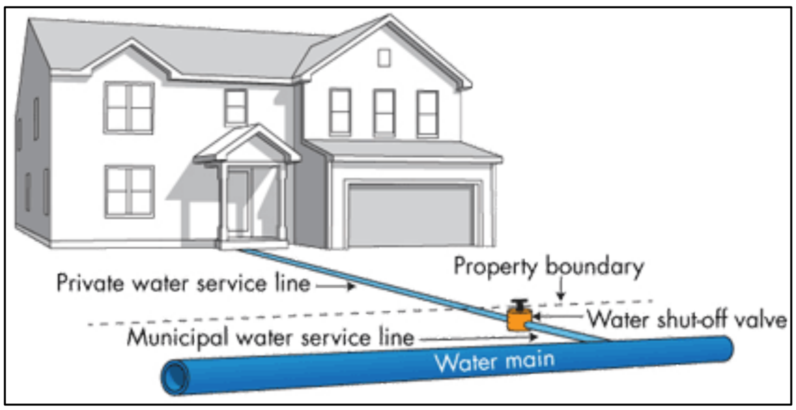
[92] 10% of this population lives in the pilot area and is served by the new piped infrastructure system built as part of the pilot project.

and of connectivity, and characterize the diversity of the users depending on the following features[93]:

- The presence or absence of a bulk water pipeline or a water main and the presence or absence of a tie-in with the bulk pipeline or a connector, and
- The presence and absence of internal plumbing, which is present within a dwelling or a building and that serves the individual households or units of the building.

For the purpose of this analysis I define the water main as a water pipeline transporting water from a "bulk water supply source" such as a surface water storage reservoir within the city or a groundwater well or another facility to a tie-in pipeline. I define a connector as a pipeline that connects the bulk pipeline to multiple dwellings or buildings. Figure 6-2 shows a schematic of the connection between the bulk ("water main" in the figure) and the tie-in ("water service line" in the figure). Internal plumbing is the piping system built within the building and the individual units to convey water from the tie-in to the units. For this analysis, I assume that a tie-in or a connector is present only when a water main is present and is absent when the bulk line is absent.

Figure 6-2 A Schematic of a Water Main and A Connector for Water Service



Source: HealthCanada

The typology could be adapted to or developed differently in varied contexts using different sets of features as a reference. I use connectivity and bulk and water tie-ins as one way to characterize the users.

Following the typology and drilling further into the 55%- and 35%-portions of the population, Table 6-3 presents five categories of users based on the presence and absence of the water main, the connector, and internal plumbing.

[93] There may be other ways in which the users can be classified depending on the context, such as only in terms of income levels or only formal versus informal developments, or combinations of those, etc.

Table 6-3 An Example of a Typology: Five Categories of Users

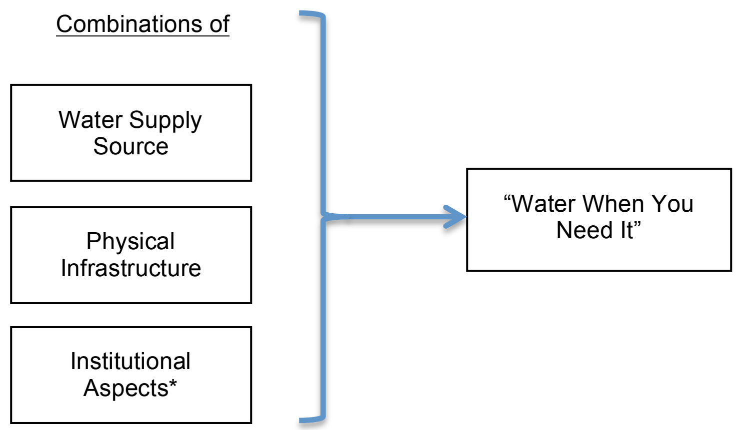
User Type	Presence/ Absence of Water Main and Connector, and Internal Plumbing	Some Examples	Approximate Portion of Population in Hubli-Dharwad
A1 (All Piped)	Water main and connector present, Internal plumbing present	Existing buildings (single-family bungalows, 2-3-story or larger multi-family apartment buildings) and some new development	10% present in the pilot area plus ~45% of those that are covered by the old pipeline network
A2 (No Connector)	Water main present and connector absent, Internal plumbing present	New development where a tie-in to the network (bulk line) has not reached but has internal plumbing	Within the 55% that are located inside the old pipeline network but are not yet connected
B (No Internal Plumbing)	Water main and connector present, Internal plumbing absent	Old development such as chawls, which may perhaps be demolished for new development. Informal settlements.	Within the 55% that are covered by the old pipeline network and rely on public stand posts
C (Not Piped)	Water main (and connector) absent, Internal plumbing present	New development where there is no bulk line in the vicinity (hence no tie-in) but has internal plumbing	Within the remaining 35% that are outside the pipeline network
D (Not Piped, informal)	Water main (and connector) absent, Internal plumbing absent	Slums or informal settlements	

Note: I assume that a tie-in or a connector is present only when a water main is present and is absent when the bulk line is absent.

6.3.2 The "Enhanced Hybrid Approach"

As I explain below, the "enhanced hybrid approach" builds upon the hybrid approach adopted at the local level by KUWSDB (Chapter 5) and capitalizes on its benefits of providing water to a large population in a short time and takes costs into consideration. The "enhanced hybrid approach" also improves upon the disadvantages of the hybrid approach due to the view afforded by a more comprehensive look, which is otherwise lost in the inevitable incremental planning process on the ground. The approach (Figure 6-3) is geared toward achieving the goal – the service of "water when you need it" through a combination of physical infrastructure and institutional aspects and involves different available water supply sources, physical infrastructure or facilities or processes to deliver water, and institutional mechanisms to ensure sustenance of the service. This approach mainly takes time and diversity of users into consideration, including the low-income users being sensitive to the costs.

Figure 6-3 Enhanced Hybrid Approach



*Institutional aspects include institutional arrangements and institutional mechanisms such as monitoring, regulation, and others.

The first two boxes in Figure 6-3 – *water supply source/s* and *physical infrastructure* – involve centralized, decentralized, or other combinations of water sources and facilities and structures that can be used to deliver water to the users in the quantity and quality of water needed for the purpose of use. This also incorporates the varied multiple household uses of water from drinking, bathing, cleaning to washing that demand different water qualities, which then drives the physical modes that can be used, for e.g., local rainwater harvesting options, smaller satellite storage tanks for a community with more efficient (fewer and certain) water deliveries by tankers. I devise mechanisms that deliver water from a water supply source to the users through different transportation modes and storage facilities, and that employ different water treatment options including centralized water treatment to point-of-use household treatment options.

The proposed *institutional aspects* form the third box of the enhanced hybrid approach. Drawing from the previous chapter, these form not only the institutions such as the local and regional or public and private organizations but also the mechanisms and features that ensure the delivery of water as needed. The institutional aspects allow for more flexible and resilient institutions, perhaps with new designs, which in turn allow for more creative, diverse goals and adaptive mechanisms to deliver water. To meet increased future urban demand, planning and providing in larger numbers can be implemented by organizations, which are responsible for collective behavior of actors and for achieving goals beyond the reach of an individual (Scott, 2003) and institutions, in particular public organizations with the appropriate mechanisms, can play a key role in the distribution and allocation of the water production and delivery costs in a way that is equitable and also respond to the demands of a large number of users, i.e., it is not necessary to replace them with private sector providers in all cases. This concept can also involve communities and be used to study mechanisms such as building community storage tanks operated and maintained by the local residents.

I look at who may be involved in the various aspects of delivering water, e.g., the State or local engineer, the users or a household), or a private company providing certain water delivery-related services such as operating tankers or water kiosks and how they are involved, including O&M of the facilities, or regulation and monitoring certain activities. I also identify any additional considerations outside water delivery, i.e., any coordination of water and urban planning and development elements that may be necessary. The institutional aspects would also include mechanisms such as monitoring of operations or coordination in between the local engineer (either KUWSDB or HDMC) and the local planning organization such as the Hubli-Dharwad Urban Regional Development Authority (HDUDA) and the HDMC planning department for planning for new users and sustaining the service for current users.

6.4 Delivering Water to All, Now: Planning Some Scenarios under The Enhanced Hybrid Approach

I develop scenarios of water service delivery mechanisms that strive to deliver "water when you need it" to all users in Hubli-Dharwad. The scenarios are not necessarily my propositions, in fact there are disadvantages to some; rather I provide these as an array of examples or options. The scenarios are context-specific and the application of these scenarios would depend on various factors such as water demand and water availability and would vary based on the type of neighborhoods (density, topography, etc.). The scenarios may also vary from city to city depending on the urban development and water use. In essence, the scenarios help demonstrate how the approach can be used to adapt to the diverse conditions. The scenarios may be implemented by KUWSDB or HDMC utilizing the institutional mechanisms that help enforce and monitor the delivery of water as intended.

If we were to look at a water delivery mechanism, it typically consists of a water supply source and facilities or processes to treat, store, and distribute water (and pump, if necessary). Use of a particular natural water supply source such as a river or a lake, a particular set of water transportation, storage, and treatment facilities, and use of particular distribution facilities would deliver a particular type of water service. Ensuring whether the service is indeed delivered over time or considering equity concerns would form the institutional aspects. If we use the three service metrics of access, water availability (time and water quantity), and water quality, different components of a water delivery mechanism can achieve the service metrics. For achieving "water when you need it", the service needs to meet all the metrics. As a starting point, I use 135-LPCD-standard of minimum water that covers basic needs and that would be available when the users would need in the quality they need for the purpose of their use. Here, the objective is to deliver, and not just supply, 135 LPCD. For a household of four, for example, the water service objective would be to deliver 540 liters per day. If I consider this as the basic service for subsistence, it would help derive a lifeline rate where lifeline is supposed to reflect subsistence needs[94].

I provide some scenarios of the enhanced hybrid approach, which is a combination of technical solutions and institutional arrangements that deliver water when the users need it. A wider set of

[94] For example, in South Africa, the lifeline is set at 25 liters per person per day, and provided as 6,000 liters per household per month (regardless of income). This is being enforced despite practical difficulties and opposition from multilateral financial institutions and private operators. For instance, one operator initially argued that its contract did not include the provision of free water, and continued its policy of disconnection for non-paying households (Budds and McGranhan, 2003).

such mechanisms and their combinations thereof can provide a broader menu of options to select based on time and budget constraints as well as the local context.
The scenarios are developed based on field observations, literature including reports on cases of different water delivery mechanisms, and interviews with water practitioners, and other anonymous sources cited as such for conditions of anonymity. I start with proposing water delivery to the 35% of the users that experience the lowest level of water service in terms of no bulk pipeline present or internal plumbing, i.e., Category D (Not Piped, Informal) and then move my way to Category A (All Piped) users who have both bulk (water main) and internal plumbing but lack certainty or water quality in some instances. I point out some advantages and disadvantages as I develop the scenarios, which allows weighing different options based on the context. Depending on the users, the water service provided by the proposed mechanisms is compared with their baseline or their current water service level so as to provide an improvement over current situation as well as achieving "water when you need it" in a sustained manner.

Users D (Not Piped, Informal)

Water delivery in this case, will necessarily entail consideration of all the three physical service metrics: water access point, water availability, and water quality. In this category, there may be users living in informal settlements that are not located within close proximity of a water main, hence they may not have direct or close water access point or they may have to rely on private vendors trucking in water for an exorbitant price.

Informal settlements, by nature, may lie in a vacant space or on a land parcel that is identified for future development, or based on their location in the city they may be in existence for some time and continue to remain so over time. Depending on the anticipated plans and as allowed for in the political context, the water deliveries may vary. Given the density and close vicinity of dwellings in informal settlements and lack of roads or limited connected or continual stretches of roads, obtaining a linear right-of-way for providing a water main and a connector to each dwelling can be a challenge. Another barrier could be tenure, without which a legal connection cannot be provided to the dwellings. In Karnataka, the pro-poor policy enabled regularization of connections and provision of water connections to informal developments. One caveat here is that high connection fees may preclude low-income households from obtaining a connection to the new network installed in the pilot area and this needs to be accounted for institutionally, regardless of whether the local utility is KUWSDB or HDMC, say by introducing a "pay-by-installment" program. The situation may vary depending on the size of the settlement, the planned use of the land parcel where the settlement lies, and how far it is from the city storage reservoir, and the following water delivery options may be considered.

Existing Source – Tanker Delivery – Point-of-use Water Treatment

For settlements of say 50 households of 4 members each, with 135-LPCD as a starting point, the water service objective would be to deliver 27,000 liters on a daily basis. Assuming a 6,000-liter tanker (the current capacity available to and used by KUWSDB) at the rate of Rs. 300 per trip plus Rs. 23 per kilometer, depending upon the distance of the settlement from the nearest storage reservoir (say, 15 kilometers), the cost of delivering the water (6,000 liters) would be Rs. 645 or ~$11 per trip. With the requirement of 27,000 liters, the cost for a maximum of 5 daily tanker trips of a total of 30 kilometers would cost Rs. 2,190 or $36 (Rs. 65,700 or ~$1,086 per month) for 50 households. Use of a tanker of larger capacity would help reduce the trips. The last mile connection here would in the form of users hauling water in closed-top containers from the point of distribution to their homes, which may be up to 50 feet. Here, if KUWSDB is assumed to recruit a privately operated tanker and continue to incorporate institutional mechanisms of regulation and monitoring of the tanker operations, say when the tanker operator fills the tanker at the assigned storage reservoir and delivers water as assigned to the neighborhood. Water is available for free to the urban poor living in 600 square-foot dwellings, which is assumed for this informal settlement.

A supplemental mechanism of storage can help in reducing the frequency of tanker trips and relying on one tanker trip at a time. This can involve building a communal storage tank for the 50 households. With an estimated need of at least 30,000-liter (~7,925-gallon) tank (greater than 27,000 liters of daily demand), which may cost up to Rs. 10 per liter to build, the capital expenditure for building or installing one or more tanks with that capacity would be a total of Rs. 3,00,000 ($4,961) or Rs. 6,000 ($99) per household. KUWSDB can utilize its operating budget for water service deliveries to make a partial or an entire investment. In this case, yet, the communal storage tank may still require 4 daily tanker trips to store water, however, one advantage could be that the users may not have to wait for the tanker to arrive every day. Rather the tankers could arrive say, in the night to avoid traffic delays, this option could provide stored water whenever the users would need it close by. The storage tank will need an initial study of a site where the tank can be built (any vacant lots or parcels not slated for future development or underground/ aboveground tank possibilities) and specific cost development for building the tank and maintaining it (either by KUWSDB or community-managed).

The last mile-connection here is in the form of people collecting the water from the communal tank in containers. The tank can enable water access to the users when they need it. Carts that can carry at least 4 containers at a time could be used to deliver water between the communal tanks to different homes. The O&M cost may involve at least a quarterly cleaning of the tank and maintaining its integrity. This responsibility can be shared in between the community with KUWSDB through a mutual agreement, which can bring in commitment from both sides to sustain long-term operation of the tank.

Delivering drinking water by tankers can be supplemented by a tanker delivery of water for nondrinking purposes where the water is drawn from public groundwater wells operated by KUWSDB. This does not guarantee how the users would use this water and there is a possibility that the water may be used for drinking. For safety purposes, KUWSDB could provide water filters for free to all the households that would provide basic treatment to the water such as alum to settle out any particles or remove solids and make it safe (and palatable) to consume or also recruit a private vendor to operate water treatment plant (discussed further later as an option).

Delivering water by tankers over a long time however may not be a sustainable option given the number of daily trips the tankers have to make in between the reservoir or the well to the users (if there is no communal storage option available and /or it is not possible to use large tankers) as well as the time taken for each tanker trip, which may vary with traffic, distance, and the weather, to name a few factors. Further, this delivery option still assumes availability of an existing centralized surface water source.

If there is a change in my primary assumption of the settlements being informal, meaning, if there is political motivation for providing piped connections to the informal settlements, the water delivery option would change. Below I discuss another water delivery mode; that of providing formalized piped connections to the 50 households. The connections would receive water through a connector into the neighborhood from a distant (existing) water main or involve installing a water main from the current water supply source (the city reservoir).

Existing Source – Existing Pipeline Network – New Formalized Piped Connections – Point-of-Use Treatment

If providing piped connections to the informal settlements is an option, using the existing infrastructure and extending a tie-in connection to individual households from the bulk line (which, in this case (Users D), would be farther than 15 kilometers) would mean spending between Rs. 300 and Rs. 600 per meter of pipe[95] to provide connection to the current unpredictable intermittent service (not a sustainable long term option, discussed further below).

The costs for installing the pipeline would be way too high for the service the users obtain. There may be additional supplemental mechanisms necessary to provide more regularity in the service or provide additional water in the pipes, or even a separate bulk pipeline. A new bulk pipeline or a water main would be a larger investment, which typically caters for larger developments and which might be advantageous if new development and growth is foreseen in the future. Here, a conference between the water department and the urban development agency (KUWSDB and HDUDA) may provide insights into the future development and its density and thus the water demand and its distribution. This could help devise and plan delivery options for current and future users.

Under both the delivery options (tanker and piped connections) above, water treatment may be needed depending on the source, delivery, and the use. To maximize the benefit from water treatment and minimize the contamination and lost benefits through transporting the water, I propose water treatment at or closest to the point-of-use. There are studies (Ercumen et al., 2014) that show that in settings of water system network malfunction, consumers of tap water are prone to gastrointestinal illnesses higher than those using point-of-use treated water. The study by Ercumen et al. also concluded that tap water consumption is associated with gastrointestinal illness in malfunctioning distribution networks. System deficiencies such as water outages also are associated with increased gastrointestinal illness, suggesting a potential health risk for consumers served by piped water networks. The quicker point-of-use treatment methods can also accelerate the health gains associated with improved water until the longer-term goal of universal access to pressurized piped water is achieved (Parker et al., 2006). In Table 6-4 below, I show a range of household water treatment options that can be used by to treat at various levels adapted from a report by the Woodrow Wilson Center for Scholars (2006) on *Expanding Opportunities in Small-Scale Water and Sanitation Projects*. The table provides performance criteria for some examples of the treatment options based on how effective they are inactivating in microorganisms such as viruses, bacteria, protozoa (which would depend on the source water

[95] The cost of pipes varies with the type of pipe; Rs. 300-400 per meter for polyvinyl chloride (PVC) pipe and Rs. 400-630 per meter for high-density polyethylene (HDPE) pipe. The cost includes labor.

quality) including having residual chlorine, which is chlorine levels following treatment that effectively inactivates bacteria and some viruses.

Table 6-4 A Range of Household Water Treatment Options: Some Performance Criteria

Household Water Treatment System Option	Effectiveness of Removal				Acceptable to Users?	Scale of Operation
	Virus	Bacteria	Protozoa	Residual Protection?		
Chlorination	Medium	High	Low	Chlorine	Yes	Operates at village and national scale
Biosand filtration	Unknown	Medium-high	High	No	Yes	Operates at village and national scale
Ceramic filtration	Unknown	Medium-high	High	No	Yes	
Solar disinfection	High	High	High	Safe Storage	Yes	
Filtration and chlorination	Medium	High	Unknown	Chlorine	Yes	
Flocculation and chlorination	High	High	High	Chlorine	Yes	Operates at village and national scale

Note: One or more of these options can be made available by KUWSDB to the households with assurance and monitoring of quality.
Source: Parker, et al., 2006

One drawback of providing piped connections would be that they would serve to continue the poor water service through the currently deteriorating water distribution system. The service could be considered an improvement over the current absolute lack of water service, however it would be ridden with uncertainty and inadequate availability of water, which would need to be supplemented by additional mechanisms (also discussed further below for Users A, All Piped). In this case, with the lower-income households in the informal settlement, the most cost-effective approach may be tanker deliveries, albeit on a temporary basis, and supplemented by a communal storage tank.

In this case, a second drawback of providing piped connections and which would also apply to delivering water by tankers is that both the delivery options would still rely on the centralized distant, single water source (possible use of different water sources are discussed under additional scenarios below). Both the long distance to the source and heavy reliance on the single source pose greater risks of cost of delivery as well as inadequate water availability for the growing population. In both these cases, a more promising solution in terms of lower localized, decentralized piped network as delivery investments with higher levels of service can use a different water supply source, which is local to the community.

Users D (Not Piped, Informal), C (Not Piped), B (No Internal Plumbing)

Local Water Source – Treatment – Delivery

This approach may apply to users in the different categories in addition to Users D (Not Piped, Informal), especially Category C (Not Piped) and B (No Internal Plumbing). Here, a local groundwater well system may be developed where the well water can be drawn using mechanical pumps or a local water body such as a lake could be used to draw water. In both these cases, water would need to be first tested for water yield and water quality. Here, KUWSDB (along with HDMC and the community of the households) can pass a resolution to work with and provide legal authority for a private entrepreneur or an organization to construct and operate a water treatment and delivery center for drinking water and use the local water source (whether surface or groundwater). I use a case of an organization that has developed a commercially viable decentralized model of water treatment and delivery with a rapid reach of 10,000 to over 1.5 million users from 2005 to 2011.

First, the water at the source would need to be screened or tested before determining the level of treatment. If the water at the local source is found to be fit for consumption (with treatment), the organization would build an 800- to 1,000-square foot, two-story building that would house the water treatment process units. The water treatment involves removal of bacteria and Ascaris[96], and turbidity followed by UV treatment. The business model for this approach involves building a treatment facility and center located at the water source (whether a well or a lake or another water body) that can treat and produce 60,000 liters per day, which can be expanded to up to 2% larger capacity. This would serve as a satellite center with at least five other delivery centers; where any two centers are located within ten kilometers of each other to address any emergency situations. The initial start-up process – from screening of the water, assessing of the water demand in the area, setting up of the treatment facility center, and making water available for users can take up to 10 weeks. The estimated cost for establishing the treatment and delivery center is a total of $50,000 (or Rs. 30,00,000)[97] of which KUWSDB would contribute 30% (i.e., $15,000 or Rs. 900,000) with the remaining 70% (i.e., $35,000 or Rs. 21,00,000) would be incurred by the organization. Besides the capital costs, the organization would operate and maintain the facility center by employing two part-time workers and one supervisor for every five plants. The resolution consenting the organization to operate the plant would also allow for using electricity at lower rates than the standard commercial and industrial users to keep the costs low. The employees are recruited from the local population and trained by the technical staff at the organization prior to starting work.

The last-mile connection in this case largely involves the local population walking a few feet to the closest center to pick up high-quality water, which is safe and available at ease compared to the their current water situation. Figure 6-4 below shows the water access point for users before and after this mechanism is implemented.

[96] A parasitic worm that affects humans and causes the disease Ascarsis.
[97] Using current 2014 conversion rate of $1=Rs. 60

Figure 6-4 Last-Mile Connections (An Example of a Baseline and Improvement from Enhanced Hybrid Approach)

Baseline

Water Obtained At a Nearby Water Center

Source: Wordpress.org. Compiled from different sources.

Home-delivery options can also be set up. Water is delivered in a 10-liter pre-washed polythene can that is available for sale at the facility. A cart that can carry multiple containers at a time can be used to reduce the delivery trips. Drinking water is available for users at the rate of Rs. 1 per 10 liters (subject to adjust for inflation) as against the baseline of no service available. There is no direct cash transaction; rather a booklet of ten coupons, each of Rs.1 is available for sale at the facility. Users buy coupons from the operator and exchange coupons for water on a regular basis. A moderate salary package for maintaining the water service, as well as a respectable employment opportunity help avoid any foul play. Further, KUWSDB, as the local public agency can regular audit the operations to ensure water service is delivered as planned.

To maintain a commercially viable model, the water treatment design capacity is set at 60,000 liter per day with an operational period of at least 8 years. Thus, the model requires water demand for say, a community of at least 115 households, which is much greater than the 50-household community that I started to assume in Category D users. In a growing community however, especially larger communities at the city peripheries, which are fairly far from a centralized water source, and where immediate and sustained water service options are minimal, this model offers a solid approach of water service. Since the water source is located at the treatment facility, its protection as a water supply source is assured by the organization. The modular design of the facility also offers expansion of water treatment and delivery if needed.

This can be achieved by KUWSDB recruiting private entrepreneurs to design and build or design, build and operate such plants where the KUWSDB would provide access to the supply source accompanied with regular audit and monitoring of the quantity of water drawn and delivered. There could be a State-approved list of certified or licensed engineers and contractors with quality performance standards where the work quality could be regulated through specific mechanisms of monitoring and enforcement of those standards. There could be an arrangement made with the community where local human resources could be utilized in operating the plant. The operations of the plant in some cases have involved home delivery of water cans similar to the commercial water providers for offices in countries such as the U.S. The water is of drinking water quality and no additional water treatment is necessary. This mechanism would need to be combined with regular groundwater monitoring of both its level and water quality to inform of the usage as well as any changes in treatment that may be necessary.

In addition, under this business model, the private organization also invests up to $8,000 and partners with local nongovernment organizations for local development such as on basic education in the community through schools or employing teachers. This model has proven successful in various parts of local communities in India especially in the states of Andhra Pradesh and Gujarat. Here, the role of KUWSDB would remain as a steward of the local water supply source. The assurance of water delivery rests with the incentive of continuing to grow the water service and meet the growing demand.

A publication on urban poverty (Searchlight on India, Bangladesh, and Pakistan) states the following about the role of private sector solutions in delivering water to informal settlements and slums:

> *Private sector solutions to mitigating challenges such as access, safety and affordability are emerging in India. By mobilizing the poor, using appropriate user friendly technologies and collecting essential data, these organizations are not only improving access to water but also are generating employment opportunities in the slum areas*
>
> *- Desai, 2013*

The design and operation of the water delivery mechanisms above are driven by a larger water demand, which is not always possible to garner, therefore in such cases, KUWSDB can consider another option; that of using a local water source. This option involves harvesting rainwater for long-term use, which involves collecting the rainwater (in a catchment area), and routing rainwater to a storage area, followed by a conveyance system. The catchment area may be a natural surface allocated for this specific use (for Users D [Not Piped, Informal]) or it may be rooftop and paved surfaces in the community (in the case of Users B [No Internal Plumbing] and C [Not Piped), where the water would flow through pipes and storm drains into wells that get recharged. In the case of natural surfaces, the impermeable top clayey soil may need to be cleared to allow for water infiltration. In the case of the rooftop, periodic inspection of any leakages would be necessary. The water can then be drawn through strategically located wells and delivered to the users in the community. Initially the drains need to be cleaned thoroughly say, using a one-foot baffle wall, that also helps in arresting the heavy silt. The system design may change based on the local rainfall distribution over the year, the intensity of the rainfall, the water need, and the runoff coefficient of the particular surface of the catchment area. The wells are also filled up with layers of boulders, pebbles and coarse sand to ensure efficient filtration. It may take a few days to a few weeks to install a system. The use of the water depends on the level of treatment provided, which in turn is also sometimes governed by the intended use. There could be a first-flush arrangement followed by treatment through a rapid sand-filter and using various kinds of storage options can determine the level of treatment necessary for the use intended (Ragade, 2005). Using the case of 50 households, a catchment area for collecting say 27,000 liters, i.e., a 0.02 acre-foot area means approximately 871 cubic feet of area. A case involving this capacity cost Rs. 2,50,000 ($4,129) in Delhi. The costs will vary with the city, and the local context from the water demand, the site and the acreage of land used, the soil, and the piping options used. KUWSDB could develop a comparative analysis and adapt the water service delivery mechanism for Hubli-Dharwad and for specific areas and communities. Private townships emerging particular in city outskirts can also use this model in areas with higher precipitation.

The rainwater harvesting option would also be consistent with the mandatory rule by the Karnataka Housing Board (TOI, 2012) and furthering local resource harvesting.

Hubli-Dharwad receives 973 mm [millimeter] annual rainfall. For calculation purpose, in a 100 square meter space, we can conserve nearly 58,422 liters of rainwater. At the household level, the expenditure for adapting rainwater harvesting would be around Rs. 4,000 to Rs, 5,000…
- The Hindu, 2011

KUWSDB can pursue local rainwater harvesting options in different neighborhoods. These options can utilize funds that are earmarked for water service improvements and capital infrastructure, which involves smaller community-level decentralized piped systems connecting to locally harnessed water sources such as rain-fed reservoirs (Hooda and Desai, no year). Under the Jawaharlal Nehru National Urban Renewal Mission, the central government provides funds for structural and other improvements, which may involve the treatment technologies and delivery options discussed above.

Users A2 (No Connector) and B (No Internal Plumbing)

For this category of users located within the piped network that are not yet connected to the pipeline network but are connected with stand posts may have to rely on tanker deliveries described above. However, there is a risk of proliferation of unregulated tankers, which are entirely independent and privately operated that charge much higher rate (over Rs. 1,500 per tanker) versus the Rs. 200-300 per tanker trip charged to KUWSDB. Especially in water scarce regions or during droughts, with increasing peak demand and the "scarcity value" may increase the public's willingness to pay for water deliveries. This therefore creates a condition where there is unequal supply to meet demand resulting in a market distortion. Media reports (TOI, 2014; Indian Express, 2011; 2012) indicate the growing fury of the people around the advantage taken by the unregulated private tankers and demand regulation of the tanker operation to provide services as basic as water. Under the enhanced hybrid approach, KUWSDB (or a local agency such as HDMC if present or another agency in another context) would incorporate regulation to address such market distortions. KUWSDB would (does currently) contract with the tankers with strict monitoring and enforcement provisions. It could also allow operation of licensed- or registered-only private tankers and regulate their operations including the price they charge and monitoring the water withdrawals from a water supply source such as a groundwater well. Local contexts may vary widely and can be improved upon with local information and creative improvements.

Users A1 (All Piped) and A2 (No Connector)

In this category, there is one set of users (A1) that have developments such as bungalows or multi-family apartment buildings connected with the bulk pipeline and tie-in and have individual piped connections but experience intermittent service with unpredictable changes in the schedule and another set of users (A2) that are not connected to the bulk pipeline yet. This category of users also has storage tanks installed within or on the top of their dwellings. To supplement the water delivery options, the water service may be improved in one or more ways: by improving certainty in the water service schedule. This can be achieved by scaling up NextDrop's operations where NextDrop, a local nongovernment private entity works with the local valve men employed by KUWSDB and identifies the water delivery schedules in advance. The certainty in the water service provides reliability as the users continue to wait for pressurized piped water service. The costs incurred by NextDrop involve those related to human resources and software management costs. NextDrop charges each household a fee of Rs. 10 per month. However from the physical infrastructure perspective, the continual turning on and off of the valves and only intermittent use of the piped system for transporting high flows, where the system has been originally designed for continuous use and water flow, does not relieve it from further deterioration and the wear and tear. The sustainability of the current system is therefore a question. Hence, NextDrop may after all be an interim solution to provide a degree of reliability.

Based on my field observations, water is supplied to one or more neighborhoods in a city at one time for a specific duration and then to others. Water is supplied through the same infrastructure network built with the intent to deliver continuously pressured water to all. If the infrastructure then is designed for a certain uniform pressure, the intermittent use of pipes for delivering large quantities of water at high pressures can lead to deterioration of the system (Vairavamoorthy et al., 2007). A longer-term solution may be to retrofit the existing system to operate at intermittent levels (Vairavamoorthy et al., 2007), however this will need to be tested in a real case, nonetheless, there can be multiple options that could be considered to investigate and improve the efficiencies of the current systems. For example, Vairavamoorthy et al. (2007) outline an approach to design urban water distribution systems for developing countries to maintain adequate and equitable supplies under the common conditions of water resource shortage. The guidelines are novel in that they recognize the reality of intermittent supply and hence provide new methods of analysis and design, appropriate for such systems. These objectives are expressed in terms of equity in supply. The water system is designed to maintain a certain lower pressure and equitable flows including adequate pressure at water connections and duration or time of supply that are convenient to the consumers; which also help sustain the integrity of the system longer. The design guidelines are driven by a modified set of design objectives to be met at least cost. An example is reinforcing the existing system with additional pipes and flow reduction valves, strategically placed to minimize the deviation in pressure (Vairavamoorthy et al., 2007).

Through these scenarios, I sketch the multiplicity of options that the wider set of considerations open KUWSDB to and show that there are and can be acceptable reasonable quality alternatives to pipes that are cheaper and faster and which would need to be examined further in terms of their benefits and disadvantages for the context. These scenarios can be modified and adapted to more diverse scenarios, which may vary widely with different cities and regions. Planning for institutional changes and local regulatory mechanisms and making modest investments towards these other options could produce benefits in short term (even if they were to eventually be replaced with pressurized pipes). It may be that only institutional mechanisms would bring drastic improvements in certain situations than making large physical infrastructure changes.

Table 6-5 below summarizes the water delivery mechanisms under the enhanced hybrid approach, which leads to a “portfolio” of options for each of the components listed. KUWSDB or a local municipality for example, can proactively plan such a portfolio and use the most applicable mechanisms to deliver “water when you need it” to all, fast.

Table 6-5 Summary of Scenarios of Water Delivery Mechanisms Discussed under the Enhanced Hybrid Approach

User Category	Source	Transport/ Delivery	Last Mile Connection (Access Point)	Water Treatment (Water Quality)	Examples of Institutional Mechanisms
A1 (All Piped) *Baseline: Piped arbitrary service*	Local Water Source	Existing Piped Network	Existing connection	Optional In-house Treatment	Provide certainty in schedule (e.g., engage with NextDrop, regulation of operations of local valve men), Install meters with volumetric tariffs
	New Communal Tank	Connect to existing network	Existing connection		Group mechanism (cost-sharing) to build and maintain tank to provide and maintain greater water availability
A2 (No Connector) *Baseline: Communal tap, private tanker*	Existing Surface Water Source	Connect to existing network	Existing connection	Optional In-house Treatment	
	Groundwater	Pump directly into a local network or Haul container	Individual connection	Point-of-Use Water Treatment	Measure, monitor, record groundwater levels and quality; modular treatment and delivery plan
B (No Internal Plumbing) *Baseline: Communal tap, private tanker*	New communal tank	Connect to existing network	Existing connection	Point-of-Use Water Treatment	build and maintain tank to provide and maintain greater water availability
C (Not Piped) *Baseline: No Service or Expensive Service*	Local Water Source (Rainwater Harvesting Tank or in-Ground)	Existing Piped Network (if adequate pressure)	Formal piped connection	Point-of-Use Water Treatment	Group mechanism, subject to site suitability, monitor water quality
	Local Natural Source or Storage Tank	Decentralized piped network designed for intermittent service for the community	Formal piped connection with certain water availability		
D (Not Piped, Informal) *Baseline: No Service or Expensive Service*	Local Water Source (Groundwater Well)	Pump directly into a local network or Haul container	Individual connection	Point-of-Use Water Treatment	Measure, monitor, record groundwater levels and quality; modular treatment and delivery plan
	Local Water Source (e.g., groundwater) - Decentralized Treatment Units/Facilities	Haul containers or Use carts that can carry multiple containers from a nearby satellite center		Point-of-Use Water Treatment	Monitor water quantity and quality, practice reduction in impervious surfaces and retaining pervious surfaces for infiltration (for groundwater recharge)
	Existing Source	Tanker	Haul containers, Use carts that can carry multiple containers	Point-of-Use Water Treatment	Monitor tankers, regularly renewable contracts with tanker operators for enforceable

User Category	Source	Transport/ Delivery	Last Mile Connection (Access Point)	Water Treatment (Water Quality)	Examples of Institutional Mechanisms
					standards
	Existing Source	Existing Pipeline Network	Formalize piped connections	Point-of-Use Water Treatment	Regularize connections, rebates on water treatment methods, regulate private vendor practices
	New Source (Groundwater Well)	Local Pickup	Haul containers, Use carts that can carry multiple containers	Point-of-Use Water Treatment	Measure, monitor, record groundwater levels and quality; modular treatment and delivery plan

6.4.1 The Benefits of an Enhanced Hybrid Approach

I have shown that there are a number of ways that water can be provided with acceptable quality and 24/7 availability. By considering a broader set of possibilities we open up opportunities to multiple ways of serving individual needs, fast and reducing costs. I show that making small investments in and improvements to the currently widely practiced hybrid approach can produce benefits in the short-term and also sustain the service in the long term by incorporating institutional mechanisms, even if eventually pressurized pipes would be built.

The enhanced hybrid approach, incorporated as a policy design, could drastically increase the chances of implementing cost-effective and fast approaches that would help in achieving water when you need it. Incorporating the different values, perceptions, and considerations for delivering water would make for robust policy design conductive to achieving "water when you need it". Enforcement can be driven by various factors, importantly by the strong and endured leadership backed by financial support, which is seen in the conducive or enabling environment created in the case of the pilot project in Hubli-Dharwad. I posit that such an endured support and further productive research and planning of wider set of consideration of water deliveries can deliver "water when you need it" faster and cheaper and can also serve as an effective transitional strategy until the 24/7 pressurized piped water is continuously supplied to all.

I also see the enhanced hybrid approach offering the following benefits:

Adaptive Mechanisms for Specific Conditions with Multiple Benefits: The user conditions in Indian cities can be widely heterogeneous, whether it is the dwelling they reside in (informal settlements, apartment buildings, or single-family homes) or their income (urban poor[98], low-income, middle-income, and high-income), or their location (within or outside the piped network) or the water service they experience (piped or not; intermittent, inadequate water quantity or uncertain times or 24/7; poor or good water quality). Meeting such demands and augmenting the particular inadequacies in the service level may involve making changes to existing physical facilities and planning and maintenance functions or creating new institutions and this can be known by studying the specific user needs carefully. Due to the widely prevalent poor water service, its reliability has already been externalized to private efforts by the users where they have to resort to coping mechanisms and incur costs. Since there is no one particular test of the solution, opening up to wider considerations for different mechanisms can provide for a learning process. Rather than presuming a certain solution upfront, the benefit from any new approach perceived by the user needs to be understood such as if the approach would meet the unmet water needs in a timely manner and/or reduce any additional or new coping costs for the user; and if the benefit would be perceived differently by a current user and a future user (who has no direct or coping costs in achieving the desired water service). The benefits of the hybrid approach stem not only from its adaptability to the user conditions but also from its accountability to time.

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[98] Urban poor is defined as the population that resides in a 600-square foot dwelling (Government of Karnataka Policy).

Diversification of Risk: The hybridity of the approach opens up possibilities of investing in a diverse portfolio of water sources, physical facilities, and institutional aspects reducing the risk that a central and only a single approach would be subject to – whether it is one water source shared by many users, or a main pipeline that could break down, or one institution, which could be say, subject to bankruptcy. Identifying the risk factors or vulnerabilities of the mechanisms, meaning the failure points, can help account for such risks. For example, harnessing local water supplies with community participation may be a cheaper alternative to transporting water from miles away and also exposing the transportation system to the risk of breakdown. Planning and developing local, and at times, multiple options can diversify risk.

Sustenance of Service and Scalability: The enhanced hybrid approach does not only consider, but it accounts for the local water needs and user conditions and incorporates institutional mechanisms to sustain the water service, which can be placed in different political contexts. Enforcement, regulation, monitoring, and other such mechanisms can help maintain the operations of water delivery along with any context-specific unique characteristics that may drive the process. Planning for such mechanisms can allow for considerations to improve other basic urban services. The approach can also utilize local energy options, such as integrating a decentralized version of piped water system in a community (Hooda and Desai, no year) with a waste-to-energy unit that can be scaled to a neighborhood, to minimize costs as well as vulnerability to power failures. The adaptability of the approach along with its hybridity of the approach can help sustain the service in the long term.

> *With the growth in urbanization, planning means, integrating existing centralized systems with new sources of decentralized water management systems, and continuing to push the traditional boundaries of water management with other infrastructure services such as stormwater and sewage management into the areas of water use efficiency and urban design. From the perspective of spatial planning and institutional reform, the key to realizing the aspiration of where everyone gets reliable water service will be the expansion of collaboration of the water sector to include those responsible for all facets of city planning, infrastructure and service delivery*
>
> *- Binney et al., 2010*

Equity: Equity concerns may arise from inequitable water service, i.e., when users incur higher costs for inadequate or inequitable service compared to higher-income users. By introducing the "water when you need it" service objective, the enhanced hybrid approach establishes a baseline of addressing the basic water needs (lifeline) beyond which the water use would depend on the demand[99], and hence the use and fee structure would depend upon the values and perceptions of a community. Within the enhanced hybrid approach, the small investments in themselves reduce the cost burden of the enhanced hybrid approach. A combination of different institutional arrangements involves inclusion of the public or the community. This may also involve sharing the costs by the community itself, which may be one-time or be distributed over time.

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[99] Need for water is a subjective term, but typically it refers to the minimum amount of water required to satisfy a particular purpose or requirement. It also sometimes refers to the desire for water on the part of a water user. Demand for water is an economic concept often used to describe the amount of water requested or required by a user (Gleick, 2003).

6.5 Planning for Water Service Delivery as a Wicked Planning Problem

Acknowledging and understanding water service delivery as a wicked planning problem is an important initial step. An essential following step is taking a broader approach to address the problem.

Delivering 24/7 pressurized piped water service through centralized infrastructure is one approach in wealthier nations such as the U.S. This has received the center-spot in the Indian government policies. However, besides the centralized approach there are several other approaches that water utilities in the wealthier nations adopt, which are rarely incorporated in the planning exercises. For example, water utilities proactively include and plan for diverse water sources from surface water, groundwater, to stormwater reuse and recycled water, and strategies such as demand management as part of their water portfolio (EBMUD, 2010). A water portfolio for a local body can involve diverse supply sources, emergency mechanisms as contingency plans, flexibility to adapt to local conditions, and adopting performance standards coupled with mechanisms of enforcement.

Another example that could but has not received attention is direct regulation of private water utilities such that they deliver clean, safe, reliable water to their customers at affordable rates (CPUC, 2014).

Although there is a mention of "other" water sources and delivery mechanisms in the central government documents, the process stops at acknowledgment.

> *In urban and industrial areas, rainwater harvesting and de-salinization, wherever techno-economically feasible, should be encouraged to increase availability of utilizable water. Implementation of rainwater harvesting should include scientific monitoring of parameters like hydrogeology, groundwater contamination, pollution and spring discharges.*
> *- Section 11.4, National Water Policy*

The large infrastructure investment and development scheme of Jawarharlal Nehru National Urban Renewal Program claims to have "41% of its investments in the water supply sector" (HPEC, 2011), however there is a pale reckoning of a wider set of considerations in the investments and monitoring of the outcomes. For example rainwater harvesting, although acknowledged in the National Water Policy, is recommended only as one of the optional reforms rather than mandatory reforms for the urban local bodies as part of JNNURM (HPEC, 2011), which is the large-scale implementation vehicle of infrastructure service.

To realize the effectiveness of the enhanced hybrid approach to deliver water to meet users' needs at scale and in time, it would need an enabling environment, which can promote actively planning for and designing different scenarios to improve current efficiencies and reduce barriers. One way the enabling environment may be created is through institutionalization (legitimization) of the "enhanced hybrid approach" (with resource allocation) with an objective of meeting users' needs; this would enable not just rapid proliferation of the approach through its implementation but would also create a market for new and adaptive technologies in a more collected than a fragmented manner.

Water resources projects, though multi-disciplinary with multiple stakeholders, are being planned and implemented in a fragmented manner without giving due consideration to optimum utilization, environment sustainability and holistic benefit to the people.
- *Section 1.2 (vii), National Water Policy*

I see implementation as an implicit component of planning. Planning for water service delivery as a wicked planning problem acknowledges that the problem can be formulated differently and can be addressed in different ways. Planning for it accounts for multiple sets of possibilities and a richer menu of options to address the water service delivery problem.

Chapter 7 Recommendations and Future Research

7.1 Overview

In this concluding chapter, I summarize the main contributions this dissertation makes and discuss insights looking forward into future research.

7.2 Water Service Delivery: A "Wicked Planning Problem"

My main argument in this research is that the water service delivery problem in urban India is a wicked planning problem, for which there is neither agreement on the problem nor consensus on the ways to solve it. Some see the problem as a failure by the government to properly design, build, and operate pressurized piped water systems similar to those in operation in other countries. Others see it as an unwillingness to price water so that a sufficient revenue stream is generated to fund the needed systems. Still others see it as the result of the unplanned and weakly regulated growth in Indian cities, which is creating unprecedented demand for urban infrastructure and led to an emphasis on extending services to new development rather than maintaining a state of good repair for the already built up areas. And still others see the problem as rooted in the poverty afflicting a quarter to a third of the urban population, resulting in difficulties in paying even for basic needs such as water.

From the perspective of the central government, the problem has been diagnosed as local water agencies lacking the technical capacity and financial wherewithal to implement 24/7 pressurized piped water services; the prescribed solution is to remove the responsibility for delivery from government, instead tapping private sector expertise, desire to succeed, and distance from local politics to deliver services. The prescribed solution further includes a technical specification of centralized water delivered through pressurized pipes to individual taps, implemented by contracting with private engineering and management through design-build-operate and management contracts. However, I show that the urban water service delivery is more nuanced and more complex, involving all the elements the various critics have raised in their interpretation of the problem – political courage, technical capacity, government finances, rapid, weakly regulated urban growth, poverty and more – extending the very availability of sufficient water from conventional sources given growth pressures, drought, and climate change. This leads to continued political debate about the strategy going forward and doubts about its long-term sustainability.

Having shown that water service delivery is not only far more complex technological and managerial problem than can be resolved by a private-sector-led building and operations program, but one involving substantial uncertainties, debates over the technologies that can be used, and conflicts over values that include organizational, financial, and political dimensions, I argue that the water delivery problem has many of the elements of Rittel and Webber's (1973) classic planning theory of a "wicked planning problem". Viewing it as a wicked planning problem allows us to acknowledge that there is not likely to be a single right answer, and that acknowledgment allows us to open up thinking about a broader approach to address water service delivery by laying a water service objective that opens up considerations of different technical and institutional approaches while considering scale, time, and budget.

A study of the current water service delivery process in a growing urbanizing region in India provides an understanding of the current hybrid approach, which is considered a "last resort" or a "fall back option" to deliver water fast, cheap, and to a large population size. Water service however suffers. I argue and find that a broader approach widens up the considerations to different ways that water needs can be met. The different ways that I observe in the field under a "hybrid approach" can be improved upon for better water service provision in the form of an "enhanced hybrid approach" that proactively combines technological options and institutional arrangements and provides ways to eliminate or minimize barriers to water service delivery and the inefficiencies in a more systematic way. This approach has a tremendous potential to provide "water when you need it" faster, and in likely cheaper ways to all, and in a much shorter time frame - which is the need of the hour.

7.3 Looking Forward

Considering the enhanced hybrid approach as one way to meeting users' water needs faster and at the much needed large scale, I see legitimizing the approach as a start toward a movement in improving the water service situation on a large-scale in India. This has implications for other urbanizing regions in the world. Capitalizing on some of the interconnections within and outside urban water delivery as a planning problem that are discussed in this dissertation, I discuss some insights for future research below.

A starting point of research can be a study on direct application of the enhanced hybrid approach, where I would examine the feasibility, including the local land conditions, costs, time of select water service delivery mechanisms in say, a community in a city that suffers from poor water service. This would involve understanding the factors that drive the poor service levels, e.g., uncertain time schedules or poor water quality, devising any technical measures and adopting institutional measures such as working with the local municipal engineer or water operators or involving the community to share costs or responsibilities, in making improvements to the service.

Besides the interconnectedness between different water delivery mechanisms and the institutions, I show the interconnection of land and water service delivery in this study. One line of future research can be to study how land affects water service delivery, which in turn also affects land use and development. The State of California for example requires that the local water suppliers prepare urban water management plans (UWMP)[100] for their service area and the plans incorporate the growing urban demands and approaches on how to meet them. Any new developments resulting in new water demand are required to prepare a water supply assessment and that be incorporated into the UWMP. A comparative study can be developed in India on how the local municipal codes and their implementation affect water service and what other parameters are in play and that conflict water service delivery. This study can also be expanded to other infrastructure services such as sewage collection and treatment.

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[100] California Urban Water Management Planning Act (Water Code sections 10610 et seq.)

I see another line of research through an examination of the operations and workings of different institutional arrangements for local and specific water service delivery mechanism in an entire city or a town. An expanded version of the study of institutional mechanisms in this dissertation can help identify the different components of the institutional framework, regulatory setup, or other mechanisms, and other variables that may play a role and which can help make improvements in efficiencies, in not just water service but also the wider planning arena. Some examples to study are:

- An all-public endeavor of delivering 24/7 pressurized piped water in a town, Malkapur (pop. 35,000) in India by the state organization, Maharashtra Jeevan Pradhikaran;
- Conduct a comparative institutional study of water deliveries - for example, the role of regulation and other institutional mechanisms in water service delivery by one of the few private water utilities in India such as Jamshedpur Utilities and Services Company (JUSCO) in Jamshedpur (pop. 570,000) in India can be studied with that of a private company serving a comparable population size in a different setting, say, California American Company in Monterey County (pop. 450,000) in the U.S.
- A continuation of this study (Chapter 6) to evaluate the workings of a local municipal corporation on implementing the "enhanced hybrid approach", especially where the State plays a limited role in the local implementation except for through providing financial and policy support.

A fourth line of research can delve into multiple sectors of infrastructure and services. The enhanced hybrid approach for water delivery provides pathways to connect with other infrastructure service streams. While water is but just one of the basic infrastructure services, other infrastructure services such as power[101] and sanitation in India[102] are in need of major improvements. Studying the enabling conditions for the success of some projects[103] that cross the different infrastructure sectors and have multiple benefits; a conducive environment can be identified for application of technical and institutional aspects for faster reprieve from poor urban services. An example is to employ small-scale wastewater treatment technology in a community to generate gray water that can be piped back for washing and cleaning purposes. Biosolids generated from the wastewater treatment can be used for generating energy. The research, with a planning frame to study such infrastructure service development and accounting for the context can create new areas of innovation in the field. Understanding how such a system can sustain through exploring the institutional arrangements would be an intrinsic part of the research.

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[101] Over 75% of India's population has access to electricity (World Bank, 2011).

[102] 62.3 percent and 16.7 percent of households in rural India and urban India respectively did not have any bathroom facility and 59.4 percent and 8.8 percent households in rural India and urban India respectively had no latrine facilities (Ministry of Statistics, 2013). The sewage treatment capacity is approximately 51% of the sewage generated (CPCB, 2009).

[103] Projects in California such as the East Bay Municipal Utility District's Waste to Energy Project (2014a), Food Waste Project (2014b), San Francisco Public Utilities Commission's Living Machine (2012), and OCWD's groundwater replenishment project to general potable water from advanced treatment of recycled water (2004) with several parallel benefits of water, wastewater treatment, and solid waste management, and energy generation.

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Appendix A: Interview Guide

[To update with additional details if necessary]

1. Sample Questions for Water Providers (City Engineers, Planners, Other Agency Representatives involved in Water Planning and Provision, Water Vendors/Contractors, Technical Experts)

- What is [your agency/company]'s role in water service provision (e.g., provide water in Hubli and Dharwad, build, operate, and maintain infrastructure facilities, etc.)?
- What other infrastructure/public services does [your agency/company] provide (e.g., wastewater)?
- In which geographic areas does [your agency/company] provide water service (e.g., cities of Hubli and Dharwad, other)?
- What are the tasks involved in providing water from the source to the user; in terms of
    - Physical facilities
    - Costs of the tasks
    - Actors/ Who is responsible?
- Are there some areas (e.g., physical location (hilly)) or types of users (informal settlements, taller apartment buildings) more challenging than others to deliver water (e.g., in terms of cost of delivery, physical topography, informal settlements with no formal mechanism to pay the tariffs, etc.)? Why?
- How do you manage the challenges? *[Discuss any specific ones raised]*
- How has the 24/7 pilot project affected the conditions?
- How is the service and its delivery different in the non-24/7 areas compared to the 24/7 pilot area (e.g., discuss how you deliver water? How do you decide when to recruit tankers? What other options do you have? Who incurs costs and who pays?)
- Do you work with the local planning agency? How?

2. Sample Questions for Staff/Agencies involved in urban planning and development (City Planners, Other Agency Representatives involved in urban planning, zoning, and development and relevant such areas, Technical Experts)

- What is [your agency/company]'s role in urban planning and development? What does it comprise of?
- How is it related to water (other infrastructure) service provision (e.g., provide water in Hubli and Dharwad, build, operate, and maintain infrastructure facilities, etc.)?
- Do you coordinate or work with the local water department or municipality? How?

3. Sample Questions for NGOs and Technical Experts?:

- Water supply is a State responsibility in India. However, now with growing population and the increasing water demands, there have been more local and regional (independent entities like the KUIDFC) involved in planning, coordinating or building water infrastructure and providing water service to the users. How do you think have the roles and functions of central, state, regional, and local agencies in the field of water service provision in Hubli-Dharwad evolved and where do they stand today? Any comments in general for the water service in India are welcome.
- What in your opinion is reliable water service? Is it the same as individualized connection to continuous 24/7 water service or how is it different?
- In your opinion, considering the rapid urbanization and the institutional changes (new water policy on 24/7 and increasing focus on public-private partnerships), what approaches or steps or strategies can help maintain reliable water service to users in Hubli-Dharwad?

Appendix B: Brief Discussion of Costs Charged By the Utility

I do not find any one standard cost that a household pays or should pay, or a utility charges or should charge for water service. The cost for a household for municipal piped water service can vary widely. If we were to look at the cost components that a utility charges, there is a one-time fee component, which may be a connection fee charged for a new user prior to getting an approval for a new connection or for providing the physical pipe connection, and a regularly charged tariff for water consumption through that connection. There is a wide variation in the costs that a utility charges a household in the specific urban context and an examination of these costs show a different picture with further differentiation by income and consumption levels.

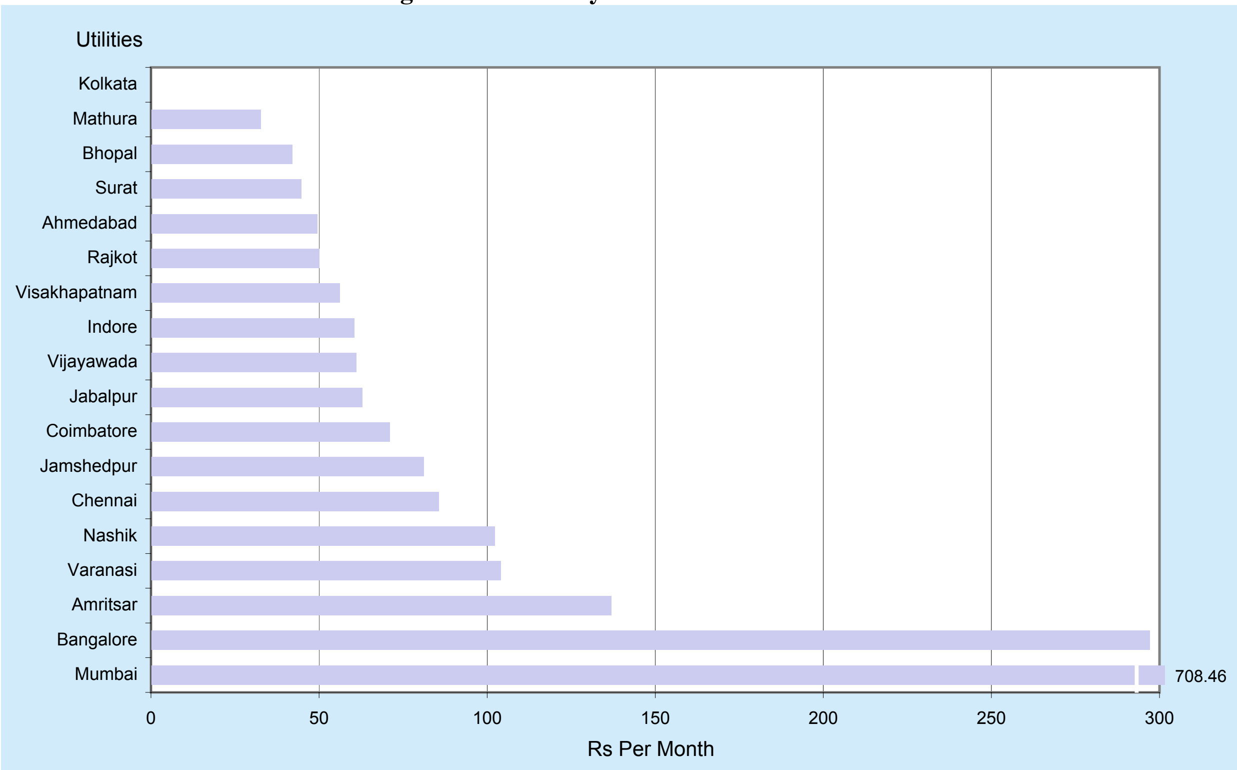
One component, the connection fee varies widely with the utilities; it can range from Rs. 100 (Ahmedabad) and Rs. 300 (Jamshedpur) to Rs. 3,000 (Coimbatore) and Rs. 5,500 (Vijayawada) i.e., between $1.64 and $90.45 (GOI&ADB, 2007). What also varied in this case was collection of the payments. Only two utilities allowed payment by installment over 12 months while the rest required payment prior to providing the water connection (ADB&GOI, 2007). The payment-by-installment may have a bearing on low-income households, who might find it more affordable than making a one-time payment and still availing of the service. It is then helpful to understand the local context, where allowing payments by installment can assist lower-income households to gain access to a water connection.

Another component of the fee for the household is the regular tariff for the water service. Tariffs per cubic meter (or per 264 gallons) vary widely from Rs. 20.55 ($0.34) in Bangalore to Rs. 5.04 ($0.08) in Chandigarh to as low as Rs. 0.62 ($0.01), to no charges in Kolkata (ADB&GOI, 2007). The definition of tariff below (ADB&GOI, 2007) shows a unitary perspective of the utility where it is derived from "water consumed" versus "total amount billed". The average tariff, a rough measure of cost per cubic meter (or 1,000 liters) of water, is calculated in the utility survey as follows::

Average tariff (Rs. per cubic meter) = [total annual billing (Rs.)] / [total annual consumption (cubic meter)]
…where, the consumption assumes functional metered connections and consumption is considered equivalent to water supplied.

Another measure of cost charged by the utility is the average monthly bill for a household. Similar to the water charges per cubic meter, a household monthly bill reported by the utilities has a wide range between Rs. 40 ($.66) to over Rs. 700 ($11.58) per month (Figure 3-28 below). The monthly bill amount does not necessarily represent the water consumed by each household because the tariff structure may not charge based on the volume of water used. In addition, the water consumption varies with income levels, which is not reflected in this data.

Figure B-1 Monthly Household Bill



Source: GOI&ADB, 2007

The monthly water bill estimates are but a generic measure of the service at best (in this case, Rs. 4.91 per cubic meter [GOI&ADB, 2007]) because the basic tariff structure may itself vary – whether it is a flat fee or is charged based on volume of water consumed. But then, as we saw earlier, water consumption recorded is not necessarily equal to, and may be much lower than the water supplied.

Appendix C: Water Tariffs in Hubli-Dharwad

The tariff structure for the piped water service in Hubli-Dharwad has historically been flat and recently has transitioned to a block tariff system. Unlike the pilot area, the tariff system for the remaining portions of the city establishes different rates for different types of users. HDMC's tariff system covers domestic, commercial, and industrial users where the tariffs are higher for commercial and industrial users, which can be considered as a cross-subsidy for the domestic users. The urban poor, characterized by the users who live in less than 600 square foot premises, are provided water free of charge.

Water Tariff System for Piped Water for Varied Users (Intermittent)

	Domestic Users		Commercial		Industrial	
	Before 1996	**After 1996**	**Before 1996**	**After 1996**	**Before 1996**	**After 1996**
Minimum Charge/Month (Flat charge)	Rs. 4	Rs. 45	Rs. 20	Rs. 90	Rs. 25	Rs. 180
Volume of Water Consumed (liters)	**Charges (Rs. Per kL)**		**Charges (Rs. Per kL)**			
0 – 50,000	0.25 – 0.70	1.26 – 2.66	Flat Rs. 6	3.32 – 4.32	Flat Rs. 8 – 12	Flat Rs. 8.64
5,001 – Above 1,00,000	0.90 – 4.00	1.66 – 6.16		5.32 – 7.32		

Note: 1 liter = 0.26 gallons; Rs. 1= $0.016

Water Tariff System in the Pilot Area

Domestic Users	**Prior to Pilot Project**		**Under the Pilot Project**	
Access to Connection	Connection Fee	Rs. 55 – 175*	Minimum Connection Fee	Rs. 48
-	Monthly Charge	Rs. 45	Monthly Charge Toward Capital Cost	Rs. 30
Water Consumption/ Use	**Volume of Water Consumed (kiloliters)**		**Volume of Water Consumed (kiloliters)****	**Price per kiloliter (kL)**
	0 - 50	1.26 – 2.66	0 – 8	Rs. 6
	50 – 100<	1.66 – 6.16	8 – 25 *(up from 8-15 kL)*	Rs. 8
	-	-	25 – 40 *(up from 15-25 kL)*	Rs. 12 *(down from Rs.15)*
	-	-	For above 40 kL *(up from 25 kL)*	Rs. 20

* The connection fee prior to the pilot project includes a refundable deposit of Rs. 50. The fee varied widely and reached an amount of over Rs. 2,000, and is shown here only for informational purposes for basic comparison with that under the pilot project.
** The text in *italics* indicates the change (reduction) in the water tariffs from the proposed tariff system.