4 Poor provision of household water in India: How entrepreneurs respond to artificial scarcity

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Though water is not strictly a 'public good', in most countries it has been a convention that water supply and provision is the government's realm. In India too this is the case.

India is blessed with some of the best natural water resources in the world. It has perennial rivers that are spread fairly evenly across the country, a large coastline, and (generally) high rainfall levels. The country's large population centers also tend to be spread out according to the availability of water. However, many urban Indian households do not have adequate water available for their daily requirements.

This chapter analyses problems with urban water supply in Delhi and other urban regions of India. (At least 700 million of India's people live in rural areas and similarly lack reliable and affordable water. This topic deserves consideration, but elsewhere.) It examines the negative human and environmental impacts of unpriced water which is supplied inefficiently (and in some cases not at all) by the public sector. We argue that good policy is about allowing and promoting private initiative, not preventing or controlling it. By suitably structuring the conditions for private sector involvement in water provision, governments would enable more widespread access to water across India, while simultaneously achieving environmental goals. The conditions for private sector water provision do not require micro-management or micro-regulation of the water supply economy, but would be facilitated by simple, broad policy measures.

Human water requirements

International organizations such as the U.S. Agency for International Development, the World Bank and the World Health Organization recommend between 20 and 40 liters of water per capita daily (LPCD) for the average human being. This estimate excludes water for cooking, bathing, and basic cleaning. These figures are similar to standards recommended by the UN's International Drinking Water Supply and Sanitation Decade and Agenda 21 of the Earth Summit.

Table 4.1 shows the estimates of per capita water requirements for a region with an average (moderate) climatic condition. However, for hot countries such as India, somewhat larger amounts are required – both for cleaning (better hygiene) and for consumption. The National Capital Territory of Delhi with its extreme climate provides a perfect example. The 2001 'Master Plan of Delhi' (MPD) recommends 70 gallons per capita daily (GPCD) (equivalent to 265 LPCD), while a manual on water supply and treatment produced by the Central Public Health Engineering and Environmental Organization's (CPHEEO) recommends 60 GPCD (227 LPCD) as a minimum.

According to these estimates, Delhi's daily water requirement in 2001–2002 was 827 or 965 million gallons (MGD), in contrast to the Delhi Jal Board's capacity to supply only 650 MGD. As discussed below, even this amount does not fully reach the household consumers.

India has adequate water resources to meet the daily needs of its inhabitants. There is also a water supply mechanism (by way of municipal supply or local water boards) which processes and supplies large quantities of water. However, our per capita water

Table 4.1 **Basic water requirements for human domestic needs**

Purpose	*LPCD*
Drinking Water*	5
Sanitation Services	20
Bathing	15
Food Preparation	10

Source: Gleik (2000).
*This is a true minimum to sustain life in moderate climatic conditions and average activity levels. In warm and hot climates the requirements would be somewhat higher.

requirement is extremely high – far higher than in most other countries. For instance, most European cities supply in the region of 120 to 130 LPCD. Even countries with a similar climate and per capita incomes as India – such as Senegal and Ivory Coast – supply in the region of 70 to 110 LPCD.[2] Most Indian cities do manage to process water at that level, and even beyond.

So where is the problem? Consider Delhi, India's capital: the city has relatively better water supply infrastructure than most Indian cities. Water is processed in the northern end of Delhi, from where it *flows* to the rest of the city. Unlike most of the world, urban water supply is not pressurized in much of South Asia, so water flows are a function of gravity and gradient. Though this system is less costly to operate, it also has serious environmental consequences.

Water requirements reach a peak during certain times, typically mornings. During this time, households draw the largest proportion of their daily requirements. But gravity-backed water flows are not adequate to service the needs during this peak time. Consequently, many households do not receive water and need to obtain supplementary water supplies (discussed below).

This problem is not limited to peak hour scarcity. Much of the water is not priced or is priced very low.[3] Municipal governments would actually receive negative net revenues if they established water-saving mechanisms (such as water meters), so little is done to

encourage more efficient use of water. As a result, municipal governments have made few investments in improving water supply infrastructure. Theft and pilferage are rarely monitored and leakages are endemic. As a natural consequence, a large percentage of water is 'lost'. Estimates of these losses range from 40 to 60 per cent of the total water processed in Delhi. Almost all other South Asian cities face a similar situation.[4]

An associated problem is that of un-priced water in urban slums. These areas receive water at a common source, where it is collected by each household. In many places, this source is not even tapped, so water flows and drains away freely whenever it is supplied and regardless of whether it is collected.

While much of Delhi's water is wasted, most households do not receive adequate water and they resort to withdrawing sub-surface water. Many others find other ways to access it – such as illegally using pressurized pumps to draw water from the municipal pipes. These second-best solutions have many hidden costs:

- First, they involve large-scale withdrawals of sub-surface water. This causes unobserved and irreversible harm to the environment.
- Second, they are highly energy-inefficient, since many households have to draw water using their own motorized pumps. Typically, many large pumps drawing water require more energy than if water was adequately pressurized at a single point.
- Third, this requires households to store their own water. When water is priced artificially low or at zero, there is inadequate incentive for households to prevent waste.
- Fourth, poorer households purchase water from private or publicly subcontracted vendors. These vendors transport water tankers to neighborhoods which face water scarcity. This especially affects the poor, leading to a high unit cost of water, plus hidden costs in terms of additional effort and inconvenience.

Water supply in India differs from the rest of the world in another way: no Indian city supplies water for 24 hours a day. Almost all neighborhoods obtain water once or twice a day. Consequently they are forced to draw and store water for their *expected daily* requirements. During this drawing and storing, water is lost. Moreover, users are likely to draw more water than they actually need.

Leaking pipes, water storage and the slow movement of water during transmission and distribution contribute to health problems, especially for the poor. In India's tropical climate, parasites multiply rapidly. When water moves slowly, or is stored, this process accelerates. When pipes leak, impurities enter the water. Consequently, households are forced to filter and/or boil their water to make it fit for human consumption, a process that requires use of electricity and cooking gas (or LPG). Households that are unable to do so have negative health consequences – in the form of water-borne diseases such as diarrhea, typhoid and many others.

In the long term, better supply and usage of water will require it to be priced appropriately. Much water simply does not carry a price. Where prices do exist, in most Indian cities these are in the range of Rs. 0.5 to Rs. 5 (US $0.01–$0.12) per kilolitre.[5] Experts tend to believe that if water is priced at Rs. 15 (US $0.30) per kilolitre, even poor households have the ability to pay for water, and also have an incentive to use it more efficiently. At these levels, even local governments would have sufficient revenue to overhaul the water supply infrastructure and to implement water efficiency measures.

Many claim that the poor cannot pay for water, and use this argument to imply that water should not be priced. But this argument is not based on reality. India's relatively poorer population *does* pay for water, both in a monetary sense and in terms of the effort required to obtain clean water. Poorer households in a slum in Delhi pay Rs. 200 (US $4.50) per month for about 500 litres of piped water supplied twice a day (case study discussed in detail below). In a 30-day month, this works out to be Rs. 13.33 (US $0.30) per kilolitre. Add the convenience of 24-hour water, the cost of having storage devices and extra energy expenditures, and the price of Rs. 15 per kilolitre is well within reach of poor households. In any event, if the issue is increasing access for the poor, this is not an argument against pricing water per se, as there are many preferable alternatives to subsidize water. This, however, is not the main focus of this chapter.[6]

If household consumers can pay for water, it is possible to engage the private sector in supplying water. Private initiative in water supply has not been encouraged in the past (and even currently) in India. Environmental considerations have perhaps been the key factors behind opposition to the private sector. Consequently, many private water supply activities are illegal. In many cases even if these activities are allowed, government functionaries require bribery for the 'privilege' of allowing the activity to continue. Despite artificial barriers imposed to prevent private water supply, private sector initiative is growing. This is simply the result of demand which is unmet by public sector or government initiative, and likewise the speed and flexibility with which entrepreneurs can respond to changing conditions.

We show that private initiative, even when *not supported by public policy*, does not harm the environment any more than the government's inaction. In fact, private sector action may prevent existing problems from getting worse, and often leads to improvements in environmental quality. Perhaps more importantly, the private sector is able to service poorer neighborhoods much better than the public sector. Finally, when compared to their public sector counterparts, private sector entrepreneurs are far better at finding economically efficient ways to supply water in an affordable, efficient manner.

The public provision of water and existing scarcity

Water is under-supplied in India. The fact that water supply is almost wholly in the realm of the public sector verifies that governments are unable to provide adequate water supplies.

Table 4.2 **Main sources of water in urban India**

Source	*No. of households (millions)*	*Percent*
Tap	33.3	70.1
Tube-wells	10.2	21.4
Wells	3.2	6.7
Tank/ pond reserved for drinking	0.1	0.2
Other tanks/ ponds	0.0	0.1
River, canal, lake	0.1	0.2
Spring	0.0	0.1
Tanker	0.5	1.0
Others	0.1	0.2
Not available	0.1	0.1
Total	47.6	100.0

Numbers rounded to nearest decimal place.
Source: Data from NSSO (1999)[8] cited in Bajpai and Bhandari (2001).

Urban India is characterized by poor water supply infrastructure. Services are generally poor for all sectors of society, but for poorer sectors, conditions are worse because of their perceived inability to pay.[7] The government supplies water either by way of water boards or municipalities whose revenues are extremely low; a direct impact is a low level of investments and expenditures on urban services in general. Problems in water supply are especially severe.

This section reports the general conditions of water access by urban Indian households.

The figures in Table 4.2 pertain only to urban India. Approximately 70 percent of the urban households have tapped municipal water as their main source of water. The rest must rely on other sources.

Given that water processing centers must be located close to the main source of surface water, processed water travels a long distance before reaching many areas. Proper flow of available water is therefore crucial in determining water supply to the population. While the processing centres may have the capacity to process enough water to cater to the entire city, they may not be able to do

so. Water is unavailable to many due to (1) lack of adequate supply infrastructure, (2) leakage and (3) illegal access from existing water lines during transportation. Some consumers break into the water pipe and draw water free of charge; the municipal employees (and sometimes the police) are paid regular bribes for allowing this to continue.

Consider the case of Delhi. In 1998–99, the total water processed and pumped by the Delhi Jal Board (DJB) was 2,475 MLD (million litres per day). Of this, at least 1,082 MLD – approximately 44 per cent of water supplied by the DJB – cannot be accounted for, which implies that the water is lost during distribution (Economic Survey of Delhi, 2001–2002). Water is lost mainly due to leakage in water mains, communication and service pipes and leaking valves (Suresh V. 1998). According to one estimate, about 82 percent of leakages occur in the house service connections, through service pipes and taps. The remaining 18 percent is due to leakage in the main pipelines. Moreover, water supply is un-metered in many urban areas. In lower-income neighborhoods, a significant proportion of water is supplied through stand posts, which also results in large, unaccounted for losses.[9]

Whether losses are due to leakage in ill-maintained pipes or due to pilferage by households and other entities, they impose two important costs. One cost is borne by the municipality, in terms of lower revenue; the other is borne by households that are forced to use alternative water sources to fulfill their daily water requirement or must make do with very small amounts of water.

Approximately 7 million households (20.5 percent) which receive municipal tap water must supplement their water supply with other sources (Table 4.3). Loss of water during transportation reduces the amount received by the households who are paying for the water that they use.

Given that water supply from the municipality is already priced at a very low level, and the cost of using alternative sources is very high, the tendency for households to supplement their water sources indicates that they receive an insufficient amount of water.

Table 4.3 **Supplementary water sources in urban India**

Supplementary source	*Number of households with principal source of drinking water as tap water and supplementing*	*Percent distribution of households with principal source as tap and supplementing*
Tap	614,564	1.8
Tube Wells/ hand pumps	3,992,515	12.0
Wells	1,521,794	4.6
Tank/ pond reserved for drinking	47,425	0.1
Other tanks/ ponds	40,074	0.1
River, canal, lake	209,466	0.6
Spring	68,572	0.2
Tanker	295,128	0.9
Others	79,876	0.2
No supplementary source	26,396,988	79.3
Missing	1,779	0.0
Total	33,268,180	100
No tapped water	14,172,772	

Source: NSSO (1999), authors' calculations

Approximately 4 million households (12 percent) which have municipal water as the main source use tube wells and hand pumps as a supplementary source. Of all the sources of water, installation of tube wells and hand pumps is the most expensive, requiring an initial lump sum expense (Rs. 100,000; US $22,727) for machine bore-wells and Rs. 90,000 (US $2,045) for hand boring (including pumps) in addition to maintenance expenses. Another 1.5 million households rely on wells to supplement municipal water supply.

The uncovered 30 percent

Thirty percent of India's urban population does not have access to municipal water and is forced to obtain water from other sources

(Table 4.2). Underground water – accessed through wells, tube wells and hand pumps – is the next most widely used principal source, accounting for more than 27 per cent of households' main water supply. A small percentage of urban households depend on water tankers rather than piped municipal water supply. Other sources such as tanks, ponds, springs, rivers, canals, etc. are also used, although insignificantly.

Good water supply

The true cost of water to the household depends on the ease with which it is accessed as well as the pricing system imposed by the water provider. Shared access and limited supply impose costs in the form of time spent in long queues. Access to water can be considered 'good' if processed tap water is available for 24 hours a day, is available inside the house and is intended for sole access. In contrast, many of the 70 per cent of 'tapped' households must share water from a main source. Of the 33 million households which do receive municipal water, only 15 million (46 percent) have exclusive access (Table 4.4), while 18 million (54 percent) require some sharing. Sharing essentially implies a single source – such as a public tap in a certain area – which is the main source of water for those living in the vicinity. Inevitably, this kind of access is characterized by queues and waiting, not to mention the inability to price such water.

As mentioned, the amount of water used by each household is measurable if the household has sole access. Not only does this

Table 4.4 **Tap water right of use in urban India**

Right of access	*Number of households (millions)*	*Percent*
Sole	15.2	45.6
Shared	8.7	26.1
Community	8.4	25.2
Others	1.0	3.1
Total	33.3	100

Source: NSSO (1999), authors' calculations

Table 4.5 **Relative distance from principal source of drinking water: Households with taps in urban India**

	No. of households (millions)	*Percent*
Within dwelling	15.3	45.8
Outside dwelling but within boundary (premises)	8.4	25.3
Others	9.6	28.8
Total	33.3	100.0

Source: NSSO (1999), authors' calculations

make it possible to charge for water use, it also facilitates differential pricing. If the responsible user can be traced, any overuse and misuse of water can also be easily identified and penalized. While punishment may help, incentives are a superior way to solve the problem amicably. A metered water supply would mean that more efficient use of water would be rewarded, since less use implies a lower charge. It also makes possible the management of water supplies at different times of the day – i.e. charging a higher price for peak times and a lower price for off-peak times. A metered water supply also makes detection of leakages is easier. Also, planning is easier if gaps in requirement and provision are precisely identified. However, shared access to water means that additional costs accrue, since it is difficult to measure usage by individual households and charge appropriately.

Much of the public discussion on water supply and user charges is based on the presumption that the households have *sole* access. However, this is not the case for the bulk of urban Indian households. A related problem is the distance between the dwelling and the source of water. That is, many households incur great effort to obtain water from the main source.

Only 46 percent of households have the luxury of having the tap within their dwelling; the rest must go outside their house to fetch water. Another 25 percent manage to have access within the boundary surrounding their dwelling. But 30 percent still must go

Table 4.6 **Water right of use in urban India**

Right of access	*Number of households (millions)*	*Percent*
Sole	19.6	41.3
Shared	12.7	26.6
Community	13.6	28.6
Others	1.6	3.5
Total	47.6	100.0

Source: NSSO (1999), authors' calculations

beyond the boundary of their dwelling. Even in urban India, almost 10 million households travel some distance to access tap water (Table 4.5).

Of approximately 20 million households who have sole access to tap water as their principal source (Table 4.6), only 11.3 million households have no supplementary source. We could conclude that these households are served the most efficiently. However they may lack a supplementary source of water, and as noted previously, 24-hour water is not supplied anywhere in the country.

In sum, not only is the penetration of municipal water supply low (about 70 percent of total households), it is also quite poor in terms of access. Most households that depend on tap water either share it with their neighbors, or transport it themselves to their dwelling, or both.

The poor in urban India

Of all the households that are not being serviced efficiently, the worst affected are those of fewer economic means. Many justifications for the prevalence of public provision of water are given, such as the idea that privatizing an 'essential good' like water could lead to high prices that would prevent the poor from having access to water. However, the existing public sector system imposes an additional burden on taxpayers, while the poor still do not have good access to tap water.

To assess the situation of the poor, a simple index was created to

Table 4.7 **Distribution of economic status as per principal source of water – urban India**

Source	*Economic status of household*			*Missing*	*Total*
	Low	*Medium*	*High*		
Tap	66	74	80	66	70
Others	34	26	20	34	30
Missing	0.2	0.0	0.1	0.1	0.1
Total	100	100	100	100	100

Source: NSSO (1999), authors' calculations

represent the economic status of the households. The index used ownership of certain amenities and certain lifestyle characteristics of the households (see Bajpai and Bhandari 2001). On the basis of this index, the households were classified as belonging to the 'low', 'medium' or 'high' economic strata. Approximately 41 percent of the total households belonged to the low economic stratum. Another 13 percent belonged to the medium economic stratum and 23 percent to the high economic stratum. The remaining 23 percent could not be characterized into these categories since not enough information was available on their asset ownership/use (Table 4.7).

Looking across various economic sectors of society, Table 4.7 shows that a high percentage of households receive tap water. Looking across the figures for all households, the distribution between tapped and untapped is 70:30. In case of the low economic class, the ratio is 66:35. In the case of households with medium and high economic status, the ratio is 74:26 and 80:20 respectively.

The absolute numbers are more alarming than the distribution suggests. Approximately 7 million households (14 percent) in urban India that belong to the lower economic stratum do not have access to tap water. Public provision of water has not managed to make tap water accessible to the urban poor. The public sector hasn't even managed to provide good water supply to relatively wealthier households which do possess the ability to pay for tap water.

Environmental impact of poor water supply: Overuse of sub-surface water[10]

Of 47.6 million urban households, 20 million extract water from underground sources. Of these, 13.4 million rely on sub-surface water as their principal source. The pressure on groundwater use is not reduced by public provision of water. Even among those who use municipal tap water as their main source, there are many who supplement it with other sources. A direct impact of the insufficient public sector provision of water is that wealthier people can afford to access alternative sources. In urban areas, this tends to be sub-surface water resources.

Groundwater can be an efficient source of water supply only if it is not *over-extracted*. As is well known, groundwater is over-extracted if it is extracted in excess of the groundwater recharge. Groundwater replenishment (recharge) stems from rainwater infiltration. An underground aquifer can become extinct if water is extracted at a faster rate than the recharge rate.

Over-exploitation of groundwater has the following environmental effects which may not be taken into account when establishing the economic cost of depletion:

- It causes water tables to recede to such low levels that the aquifer cannot replenish naturally. This causes the source of water to become extinct over time.
- Pollution of fresh water increases. Groundwater is available at shallow as well as deep levels. Deep groundwater constitutes the fresh water system. Recharge from rainwater results in replenishment of the shallow aquifer by means of upward leakage from the deeper aquifer. The decline in groundwater levels due to overexploitation changes the hydraulic gradient, thereby triggering the speedy movement of pollutants from above to the deeper groundwater system.
- Land subsidence (the lowering of the land surface) results from changes which occur underground. Subsidence is generally permanent, because even if the aquifer is recharged

to original levels, this would not cause the land surface to elevate (Leake 1997). Land subsidence causes many problems:

(1) Slope of streams, canals and drains become altered.
(2) Bridges, roads, railroads, storm drains, sanitary sewers, canals, and levees as well as public and private buildings may be damaged.
(3) Forces generated by compaction of fine-grained materials in aquifer systems may cause failure of well casings.
(4) In some coastal areas, subsidence may cause tides to move into low-lying areas that were previously above high-tide levels.
(5) Earth fissures are also associated with land subsidence. When groundwater is pumped, it causes horizontal movement in the sediments. This leads to narrow cracks of an inch or less in width. Over time, these cracks can expand and develop into large fissures, tens of feet in width. This is due to erosion, as the fissures intercept surface drainage.

Groundwater is a mineral resource and has a dynamic character, with both stock and flow aspects. If only the flow of the resource is utilized, then it is possible to sustain the use of groundwater over time. If, however, we also utilize the stock, then the resource tends to diminish over time, causing environmental damage along the way. Generally if the subsurface water table is falling, it indicates over-extraction of groundwater.

A constant monitoring and control of groundwater utilization is required to ensure environmentally sustainable use of groundwater. This requires knowledge of the situation regarding the existing groundwater resources. However adequate assessment of groundwater use for non-irrigation purposes is still lacking (Dhawan 1995).

As a reply to a question raised in the Indian Parliament in 2000 (Lok Sabha 2000), a State-wide list of over-exploited and dark blocks was obtained from the Ministry of Water Resources. A dark block is on the verge of being over-exploited; over-exploitation is defined as extraction in excess of recharge. According to these figures, of the

5711 blocks, *taluks*, *mandals* (administrative units) and watersheds, 310 were categorized as dark and 160 were marked as over-exploited.

In India, the largest environmental impact of receding groundwater levels is the increased scarcity of potable water. Evidence specifically pertaining to urban areas is not well documented. However, the impact of over-extraction of groundwater is obvious from various rural areas of India where groundwater is drawn by hand-pumps and recently by means of tube-wells.

The Center for Science and Environment has also noted that over-pumping, lack of groundwater recharge and a gradual destruction of the local traditional systems of water harvesting have contributed to water shortages (CSE 1999).

For instance, in Chennai the overexploitation of groundwater caused water tables to fall, and regions around the sea experienced ingress of seawater which then led to extreme soil salinity. The same is true of Junagarh district in Gujarat, and many other areas of India.

Over the years, groundwater contamination has caused many deaths in India. The fact remains that most areas which currently have contaminated water previously depended exclusively on groundwater. As these areas were already rich in certain metals or compounds, falling groundwater levels meant increasing contamination. In Madhya Pradesh, the district of Mandla is one example where consumption of groundwater leads to Fluorosis. Approximately 94 per cent of people in the 157 villages in the Dungarpur district of Rajasthan suffer from dental Fluorosis, and an abnormally high 32.5 per cent have skeletal Fluorosis, which affects about 100,000 people in the state.

Arsenic pollution has also been noted, particularly in West Bengal where groundwater in many of the State's small towns and villages is now contaminated. When arsenic is naturally present, overuse tends to concentrate its levels. In Bichhri, a village in Rajasthan, the water pouring out of the bore-wells is brown in colour. More than 90 wells which were once used for irrigation and domestic water now lie unused (CSE 1999).

Table 4.8 **Delhi's groundwater decline during the 1990s**

Blocks in Delhi	*Decline (meters)*
Mehrauli	4–10
City	4–8
Njafgarh	4–7
Kanjhawala	4–5
Alipur	4–5

Source: Lok Sabha (2000)

Groundwater use has increased as urban India's population grows and public water provision becomes relatively more scarce, and the effects are beginning to show. Long-term observations about Delhi's water supply made by the Central Ground Water Board (CGWB) have shown that, in many parts of the city, groundwater levels declined drastically during the 1990s.

The maximum range of decline is 4 to 10 meters in Delhi during the last ten years. The situation is similar for other cities that do not have good access to processed tap water. The inability of the local governments to provide water (a duty of the local government by law) and the need for more water has led to the emergence of alternative means to obtain water, which generally utilize groundwater. The inability of the governments to enforce poorly-defined groundwater laws is visible from the emergence of private water suppliers.

Private sector responses

Poor provision of water by the public sector has meant that low quality water has been delivered in an extremely inefficient manner. This means poor coverage of households and the denial of a basic necessity, creating an unmet demand for water.

To get around problems caused by the public sector, wealthier urban residents have constructed their own tube wells – an activity that is not strictly illegal. However, the poor are unable to afford this alternative. Part of their water requirements are being met by

informal entrepreneurs operating in the private sector. This activity occurs in two ways:

1. Tankers operated by private individuals and companies supply the water either from surface water sources (legal) or from subsurface sources (illegal). Water is priced according to the volume drawn from each water tanker; and
2. Water is supplied from sub-surface sources and transported by way of pipes to within the household premises. This activity is considered illegal by the government.

Private water tankers

The Delhi Jal Board (DJB) is the government's water supply arm. The DJB has its own fleet of tankers for water distribution. However, these tankers are only used in the following cases:

- When water is not available because of leakages or bursts in water lines, or any other faults in the system. In such a case the water tanker is to be supplied within three hours of complaint, subject to availability. This service is provided at no cost to the users.
- For private functions such as marriages and religious functions. The water tanker can be supplied on any working day, if a booking is made 15 days in advance. The price depends on the distance of the house from the DJB water storage area (Table 9).

It is not possible to buy water from the DJB on short notice; an advance booking is essential. This leaves many people, who may or may not have a municipal water connection, without any recourse from the government when they are stranded with no water supply.

To solve temporary water shortages, communities or households may request the services of private tankers. Private tankers are contracted by municipalities to supply water. This water is accessed either from a surface or sub-surface water source, and this involves little (if any) processing. However, there is no difference in the price

Table 4.9 **Tanker rates from Delhi Jal Board**

Distance	*Stationary (Rs./US $)*	*Filling (Rs./US $)*
Up to 5 kms.	Rs.400/$6.82	Rs.225/$5.11
5–10 kms.	Rs.600/$13.64	Rs.325/$7.39
Beyond 10 kms.	Rs.1000/$22.73	
Upto 15 kms.	Rs.425/$9.66	
Beyond 15 kms.	Rs.450/$10.23	

Source: Delhi Jal Board (2002).
Approximate prices based on exchange rate of Rs.48/US $1.

level for the different sources of water. Some private suppliers supply processed (DJB) water; they are subcontracted by the DJB to do so.

Private water tankers transport water and fill it into the household's storage tank. They charge a standard fee according to the quantity of water supplied, and do not require an advance booking. The water tankers generally have a capacity of 3,000 or 6,000 liters. The charge is Rs. 300 (US $7) for 3,000 liters and Rs. 500 (US $11) for 6,000 liters. Since these private suppliers are present in almost all neighborhoods, the prices generally do not relate to the distance the tanker must travel.

Often, groups of people in the same neighborhood collectively call for a tanker. These are generally low-income or lower-middle class households which may not be able to accommodate 6,000 or even 3,000 liters (either because their storage tanks are smaller, or they don't possess a storage tank). These households share the cost of water by paying for the quantity that they individually consume.

Private piped water supply: A case study from Delhi

The case study is from an illegal (squatter) settlement (slum or *basti*) situated in South Delhi which faces acute water shortages, especially in the hot and parched summer months. All four of Delhi's municipal water processing centers are located in the northern part of the city; by the time the water reaches the southern part of the city, much of it is lost.

The residents of this *basti* and many similar *bastis* in Delhi form a major portion of the labor force for the city's service industry. While the government is 'charitable' enough to provide water by means of occasional tankers, this water is not provided to them as a right or even as a service for which they would be willing to pay.

The DJB's supply network exists in most high- and middle-income neighborhoods. Though these households also suffer from water shortages, the situation of the residents of illegal settlements is much worse. In the *basti* studied by the authors, the DJB does not provide piped water.[11] These areas have hand-pumps, installed by the DJB, which draw sub-surface water. Most households in this *basti* rely on these hand-pumps for their daily water needs.

The number of hand-pumps compared to the number of users is very small, leading to long queues. Users must carry water in many vessels simultaneously to avoid queuing too often. Water is then stored in small vessels in the house and households are able to use it only minimally. The deep groundwater aquifer is the source of fresh water. In summer months, when the water tables fall, the hand pumps do not provide adequate water, and since the hand pump reaches a relatively shallow depth in the ground, the water is also not very pure. When the situation becomes dire during the summer, residents approach the local politicians, who then send water tankers from the DJB to the *basti*.

In order to avoid the trouble and the uncertainty associated with accessing water from the hand-pumps, many residents of this *basti* now buy water from private sector suppliers of piped water. This has provided an adequate solution for many households, who are willing and able to pay for their water.

In one area of this *basti*, piped water is supplied to approximately 80 to 90 households by a private firm. This water is obtained from the ground (at a depth of around 150–160 feet) by means of a pump. The boring for extraction of water was done mechanically, at a cost of approximately Rs. 40,000 (US $909)– a cost which no household in the area could bear on its own.[12] A pump was acquired for Rs.

25,000 (US $568), so the total starting cost was therefore about Rs. 65,000 (US $1,477).

The households were required to pay Rs. 500 (US $11) as a security deposit for access to this service. The terms of the agreement are simple: if the household wishes to discontinue taking water from the supplier, then their security deposit is not refunded. On the other hand, if the supplier decides to discontinue supply then he must return the deposit to the households. Many households in this *basti* are not connected by this water supply because they are unable to pay a lump sum of Rs. 500.

In addition to the deposit, the households paid the cost of the initial supply network of pipes, which amounted to another Rs. 500. The households were free to get the pipes fitted on their own. The arrangement for the maintenance of the pipes is also quite simple: The main pipe that runs through the road connecting the household is the responsibility of the suppliers; from the main pipe to the house, the pipe is the responsibility of the respective household.

The firm agrees to supply water for half an hour, twice a day, with good pressure, which is enough to fill a storage tank with a capacity of 500 liters. The tank costs approximately Rs. 1000 to 2000 (US $23 to $45). In case the tank does not fill up during this time, then the suppliers continue for a little longer on request. There is no way to measure the amount of water supplied, as neither the suppliers nor the households have a meter installed.

Seven to eight households receive water at one time. At the time water is being supplied, the owners of the water supply are watchful of pilferers.

For this service, the households make an advance payment of Rs. 200 (US $4.50) per month. However, the terms of payment are not very severe. The private suppliers – who live in the same neighborhood – typically accept a delay of a month depending on the household's economic circumstances.

The supplier's cost of providing this water supply is mainly in running the pump. Though an electricity connection is available, the pump uses a diesel generator. The pump runs for 7 hours daily,

at a cost of approximately Rs. 9000 (US $204) per month.[13] Since water is supplied to 83 households, the supplier generates a surplus of Rs. 6,400 ((US $145) per month. In addition, on certain occasions, other households buy water from the supplier at a rate of Rs. 30 for 100 liters. These households generally rely on the hand-pumps in the *basti*, but when they require more water for some special event, they choose to buy it from these suppliers.

Private water supply systems like this one connect approximately 40 percent of the households in this *basti*. All the water suppliers in this area supply water more or less at the same price.

Prior to the existence of this private supplier, the households spent significant time and effort to obtain small amounts of water from the hand pumps. In summer when the hand-pumps would dry up, then they would have to go to hand pumps in other areas that were further away. The last resort was a plea to the local politician, who would then ask for a DJB tanker to be sent to the *basti*. An additional hassle faced by these households was fights that broke out early in the morning when people left for work. To avoid all of these costs, these households have chosen to pay Rs. 200 per month – approximately 6.6 per cent of the average monthly salary in the neighborhood – to have water piped directly into their homes. They receive higher quality water since the water is drawn from deeper into the ground than the hand-pump.

Discussion

Significantly, in this system of informal water supply prices, it is access to water (rather than the water itself) which is priced. The monthly charge of Rs. 200 includes access to as much water as the household can draw during the half-hour periods in which water is made available. Household consumption is also limited by the limited capacity of the pipes.

It is well known that the most efficient system of water pricing is based on marginal cost principles (that is, a per unit basis). With marginal cost pricing, delivery systems have the right incentives for producers to supply optimal levels, for consumers to use water efficiently, and as a consequence, the process has a minimal negative impact on the environment. However, the informal system of priced access and unpriced supply in this *basti* is somewhat removed from the marginal cost principle.

The key question, of course, is why this method of pricing has not emerged. Economic principles might indicate that a completely free system would tend to move towards a pricing system based on marginal cost. Are there other forces, technical or otherwise, which affect this market?

Two issues are related to marginal cost in this market: first, the cost of extra per unit of water and second, the extra cost per unit of time. We argue that the extra cost per unit is zero within a certain range, but the extra cost per unit of time is significant. Consequently, it is in the supplier's interest to price access (based on a unit of time) and not to price units of water.

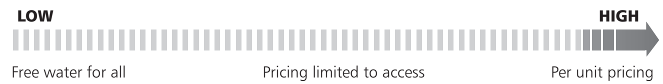
First, the supplier must extract water and supply it at pre-determined minimum pressure levels – otherwise it does not reach households which are more distant, located on higher floors, or at a higher elevation. The diameter of the pipe is also fixed. Consequently, water must be supplied at the given pressure levels, or not at all.

Second, and corollary to the former, sub-surface water extraction cannot occur below a minimum pressure level, and after it is extracted, it is costly to store. If the water was stored, the supplier would not only incur storage costs, but also the costs of re-pressurizing the water. The most energy- (and cost-) efficient system for this market is one where water is extracted and supplied simultaneously, using the same motor.

Third, pricing on the basis of units of water requires the installation of water meters in each household. These are costly, and are not tamper-proof.

This informal market is not the most efficient in terms of environmental considerations, which would require water to be priced on a per-unit basis. By paying the price of access alone, users have some incentive to draw and use as much water as possible. There is no counterbalancing force for misuse or inefficient use. However,

Figure 4.1 **Scale of environmental efficiency versus pricing**



this system is a great improvement on that which is effectively instituted by public sector/government provision – where poor quality water is supplied and priced inadequately.

Moreover, environmental considerations are not the only objective of public policy towards the water sector. Ample coverage of households is equally – if not more – important. Yet the government is seemingly unaware that water can be supplied by entrepreneurs in the private sector to those households which the government neglects.

Delhi's current laws, for instance, allow households to access surface water for their own individual requirements. Likewise, the laws allow similar access to businesses, which then manufacture bottled drinking water. Both of these activities are effectively only for wealthier consumers, who can afford to spend large amounts for their private water needs. They are also the primary consumers of bottled drinking water. Poorer sectors of society can only access sub-surface water through an entity that can supply them with water on a commercial basis – but that option is prohibited by Delhi's laws.

Such regulations and controls are intended to reduce environmental impacts (their effectiveness is another matter altogether). Yet they have perverse consequences for the poor. A good policy towards water provision has to create a suitable middle ground, a level playing field for water to be supplied in various ways. These issues are discussed in the next section.

Policy implications

India's municipal governments have been unable to price water adequately, and this has resulted in their inability to finance service and water supply infrastructure improvements. It has created an artificial water scarcity for many households, and has also encouraged misuse and waste of water.

Current efforts to reform the sector will be limited by the poor quality of current services and infrastructure, the perception that the poor cannot or should not pay for water, and the inability of government functionaries to recover revenue, even when water is priced. Each of these factors contributes to the inability of the government bodies to provide adequate water for households.

However, without per unit charges imposed on water it is likely that water will be misused or wasted. Moreover, without the ability to generate funds from within the sector, cash-strapped local and state governments will be unable to improve existing infrastructure and services, much less expand them to meet the increasing requirements of a growing urban population.

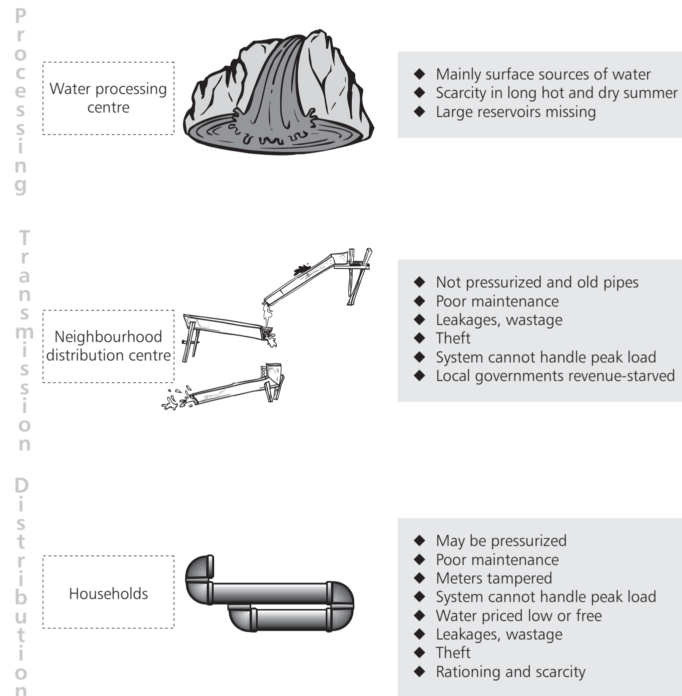
This catch-22 situation exists in almost all cities and towns in India. In a very few of the larger cities, external agencies have stepped in to provide finance concessions and advice – but there are more than 000 cities and towns.

Any improvements in infrastructure and service require capital, and this capital can be accessed from commercial sources. To do that, a revenue stream from water charges would be essential. Indeed, this revenue stream is possible, as we show in the next subsection.

Breaking the vicious cycle: Good water policy

Water supply can be divided into three broad stages: Processing, transmission, and distribution (Figure 4.2). Currently, all three stages are the responsibility of government. A pricing system can only be established if input and output can be monitored. When monitoring is possible, either the government or the private sector can directly undertake these activities. Financing and pricing then

Figure 4.2 **Broad stages of water supply**



becomes much easier. Simple subsidy mechanisms also then become possible.

We start with the last stage – distribution. This is because where revenues may be recovered and if the water supply mechanism operates smoothly at this stage, then the rest will follow. However we do not make specific policy recommendations, instead we suggest a broad policy framework. The specific policy aspects are highly dependent on local factors, and should only be developed on a case-by-case basis.

The distribution stage

The key problem with distribution is the inability and unwillingness on the part of government bodies to recover costs. For that reason, this stage should be wholly in private hands: the water can be supplied to distributors at a price, for which the distributor can charge a mark-up to the consumer. The amount of water supplied to the distributor can easily be measured by the transmission agent (which may or may not be a government entity); and since there are relatively fewer distributors than consumers, it is far simpler to monitor.

In turn, the distributor would supply water to the consumer and it would be the distributor's responsibility to recover revenues from consumers. The government could, of course, subsidize the cost of water meters in the poorer areas. Water for the poor could also be subsidized, and there are many ways of so doing. Some examples are water stamps, direct subsidies, or area-specific water rates (since urban households tend to be clustered according to their economic status).

This system would have numerous advantages over the existing system.

1. The costs of any water losses in the distribution stage are automatically borne by the distributor, and it has a strong incentive to prevent waste or theft (as observed in the case of the private water supplier discussed above).
2. Water is not given for free; those who waste the water are required to pay for it.
3. The consumer pays the distributor, who thereby has an incentive to collect the charges from the consumer as its returns depend upon the revenues it receives.
4. Moreover, as discussed in the case study above, a private distributor has an incentive to show some flexibility where payment is concerned. In contrast, a bureaucratic public sector system rarely has such flexibility; revenue collection often encourages bribery and corruption on the part of government functionaries.
5. Subsidies can be directed to those who are most in need. More importantly, subsidies need not be unlimited.
6. Private entrepreneurs have an incentive to reduce costs, take risks and engage in innovative behaviors, in contrast to public sector distributors which are run by salaried government employees.
7. Since the firm charges a per-unit mark-up to the consumer, it is in the firm's interest to supply adequate quantities of water, but not to waste it. Similarly, it is in the interest of the households to not waste water.
8. Shifting to this system would require no large-scale, up-front investments; distribution of water could be privatized in the system that currently exists.
9. The private distributor has an incentive to provide 24-hour water at the appropriate pressure level, and it is therefore in the distributor's interest to invest in quality and efficiency improvements.
10. Depending upon the particular system instituted by the government, it may not even be necessary to carry out detailed account-keeping and regulatory activities. Transactions can occur merely on the basis of amount of water sold. This implies that the distribution stage need not have formal private sector distribution companies. Informal (unorganized) private entrepreneurs can also be allowed to resell water, with the benefit that these individuals are far better placed to act on local knowledge. In turn, this implies that we do not even require local water distribution monopolies; a market for private distribution of water can develop.

In general, the overall benefit of disassociating water distribution from transmission and production is that it would create flexibility. Different systems could be followed depending upon the local conditions.

Water transmission

The transmission stage essentially requires a transmission agent, which may or may not be a government entity. The entity's primary task would be to prevent water from leaking and being stolen. In the long term, as Indian cities also shift to pressurized water supply, almost all the infrastructure at this stage needs to be overhauled. Since the input (from the processing stage) and the output (sold to the distributor) are both measurable commodities, the problem of transmission is simple in economic terms. However, the process of improving the system, preventing leakages and theft, and overhauling the infrastructure is operationally a very complex one.

The key issue, however, relates to adequate revenue generation. It is not clear whether revenues alone would enable the capital requirements for the large scale overhaul which is needed. In case they are not, some form of government subsidy could be needed; this would have to be judged on a case-by-case basis. In any event, a monitored system that generates revenues would be an essential first step for their overhaul.

Water processing

An urban water supply system depends on an adequate source of water. This is broadly possible, since most of India's cities are located close to perennial rivers or large lakes. However, in the long summer months, the water levels in many rivers reduce and the water levels in reservoirs or lakes are substantially reduced (and sometimes even dry up). This requires an extension of the lakes, tanks, or reservoirs. Minor dams on rivers that trap the surplus water during non-summer months would also help. All of these require capital. Water processing plants in many cases are quite old and need to be improved and their capacity expanded. This also requires some investment.

As in the case of the transmission stage, the processing stage can also occur in the private sector; there is nothing preventing this.

Regulation and markets

It is generally considered that if the private sector were to provide water supply services, some regulation would be essential to prevent monopoly exploitation. However, this is not necessary. The private sector has the ability to provide quality services at a low price provided that sellers are competing with each other. For very large cities in India, it is possible to have more than one or two entities which process and transmit water. Where distribution is concerned, a great deal of competition would be possible in most cities. Private water supply need not be equated with regulation. At the same time, where only one or two companies are feasible, some form of price and quality regulation may be the only way to enable the private sector to play a role.

Conclusion

India's government water suppliers have created an artificial water scarcity in urban areas. At the same time, municipal governments are oblivious to how this problem is being addressed by the private sector (and, remarkably, they do so despite numerous government barriers).

Given the right conditions, entrepreneurs acting in a private capacity (whether formal or informal) have an important role to play in delivering high quality water to households. Where environmental considerations are concerned, it is clear that pricing water leads to less waste and more efficient use, with related environmental benefits. Moreover, private sector involvement may prevent existing problems from getting worse, and often leads to improvements in environmental quality. Given enough freedom to operate and a supportive legal framework, private sector entrepreneurs would also have a positive effect on the existing inequality of service provision and coverage for the poor.

Where processing, transmission and distribution of water is concerned, it is possible to have a unit-based pricing system for water, even in the existing system. Unit-based pricing would create more efficient use of water, and would enable all households to be supplied with high-quality water. However, given conditions in urban India, this is only possible if water supply is left to the private sector at the distribution stage.

This chapter does not intend to present a detailed analysis of the economies of scale, or financial implications of such a system. (Although this would be essential before such a system were established.) It simply demonstrates that such systems are possible, and not too difficult to establish.

Notes

1. We would like to thank Peeyush Bajpai, Mridusmita Bordoloi, Amar Gujral, and Dhyan Singh for their useful comments and invaluable support. We also referred to Anderson and Snyder (1997), de Villiers (1999) and Holden and Thobani (1996) for the general ideas and principles which guided this paper. However, all remaining errors are our own. Comments appreciated at laveesh@indicus.net
2. We would like to thank Dr. Vivek Srivastava of the Water and Sanitation Program, The World Bank, New Delhi, for this information.
3. Generally the reasons ascribed to this are related to inability of the poor to pay. That the water service is poor also contributes to the inability of the government to charge higher prices. But low or no pricing also creates another problem.
4. For instance Katmandu, Nepal, which recently shifted to a pressurized system. The city faced even higher rate of loss, reportedly in the range of 70 per cent.
5. Rupee to dollar conversions assume an exchange rate of Rs. 44 to one US dollar (prevailing exchange rate in February 2005). Small price figures are provided to give the reader an idea of relative prices.
6. For a discussion on these issues see World Bank (2002).
7. As in other poor countries, a large part of urban India lives in slum-like areas where municipal services are almost non-existent. Moreover, this situation shows no signs of improving due to the generally poor financial situation of urban local governments across India; also see Srivastava and Sen (1997) and Khandwalla (1999).
8. In the NSSO 1998 survey, 110,313 rural and urban households were sampled in a representative manner. The survey is used as the basis for subsequent tables in this chapter.
9. Stand posts are stand alone water pipes that are located in low income areas. Many are untapped. Even when tapped, they are rarely maintained properly. And as a result large amount of water is wasted.
10. See Leake (1997) for a detailed discussion.
11. Recently, the DJB has given the people in unauthorized colonies an option to access municipal water:
    UNAUTHORISED UNREGULARISED COLONIES
    - Rates for water development charges for provision of water lines in unauthorized unregularised colonies has been revised from the existing Rs. 55/- per sq. meter to Rs. 110/- per sq. meter. If the payment of full amount of development charges is made within three months of the receipt of first bill, 10% rebate will be given.
    - Water lines will be laid on payment of first advance installment of Rs. 25/- per sq. meter of the plotted area.
    - The tender will be called only on receipt of 50% of the first installment and work will be executed only after receipt of 75% of the first advance installment from the colony [neighborhood] as a whole.

    After execution of the scheme water connections will be released on payment of another Rs. 25/- per Sq. Mt. and the balance will be payable in 20 equated quarterly installments. (Source: Delhi Jal Board) Any such arrangement would require all the residents to contribute otherwise it will not materialize. Once the infrastructure is set into place it might be a cheaper option, but the efficiency may still be questionable.
12. Hand boring is a slightly cheaper option, but after digging to a certain depth it is impossible to dig any lower without the use of machines, since there is a layer of rock.
13. An amount of money (not revealed) must also be given to the police.

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