Stanford
Center for International
Development

Working Paper No. 224

HOUSEHOLD WATER DELIVERY OPTIONS IN URBAN AND RURAL INDIA*

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July 2004

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Introduction

In over 50 years of political independence and economic development, India has not been able to ensure the most basic of human needs – safe drinking water – for all its citizens. In April 2002, then Prime Minister Vajpayee confronted this problem openly and clearly.[3] "Scarcity of water is compounded by its unequal, irrational, and unjust distribution in both rural and urban communities," he said. "Therefore, the situation is forcing us to recognize water security as an overriding national objective…" Accordingly, the 2002 National Water Policy of the Government of India (GoI) states that "provision for drinking water should be a primary consideration" in water resource development projects and that "drinking water needs of human beings and animals should be the first charge on any available water" (GoI, 2002, Sections 6.1, 8).

In a further acknowledgment of the lack of access to water in India, in December of 2002 Mr Vajpayee launched the *Swajaldhara* programme, with the aim of providing drinking water to every village by the end of 2004.[4] This is an ambitious World Bank aided programme that marks a departure from traditional government water provision. Instead, it works on the 90/10 financing model -- if communities come up with 10% of the cost of provision, the government will provide the other 90%. This provision is in keeping with the spirit of the 73rd Amendment to the Indian Constitution, which turned over the responsibility for local water supplies to local level governments (*Gram* and *Zilla Pancahayats*).

These recent and potentially far-reaching policy changes frame our paper on drinking water options for urban and rural India. Given the primacy of drinking water as a national objective, and the policy of decentralization through community ownership, private sector participation and devolution to local governments, we ask: *How can India alleviate its household-level drinking water deprivation, in the near-to-medium term, and in cost-effective ways?* We take the goal of reform in the drinking water sector to be better public health, in particular a reduction in

[*] We thank our discussants Mary Shirley and Scott Wallsten along with participants at the 5th Stanford Conference on Indian Economic Development for their comments. Niny Khor provided excellent research assistance.

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[3] Prime Minister Shri Atal Behari Vajpayee's speech to the Fifth Meeting of the Water Resources Council, New Delhi, April 1, 2002.

[4] *Indian Express*, December 6 2002. 'PM b'day gift: water to drink.'

water-borne and water-washed diseases. Therefore the primary focus of this paper is on universal access to a minimum daily quantity of safe water for drinking, cooking and basic hygiene. The threshold for 'minimum' varies from 20 litres per capita per day (lpcd) (UNICEF 1995); to 40 lpcd (GoI norm) to a more generous 50 lpcd (Gleick 1998). In this paper, we work with the Government of India norm.

Our second focus is the cost-effectiveness of different modes of water delivery and access. In general, national goals should be efficiently rather than inefficiently achieved – and the parlous financial state of rural and urban water agencies prevents them from extending access to those who are unserved. There are also many competing claims on the national budget, therefore we have to accept the reality of limited outlays for water and sanitation.[5] Cost-effectiveness and a measure of cost-recovery should allow more people to be served with the same outlays.

Household- and community-level water options represent the downstream end of the drinking water sector. We focus this paper on conditions and policies for drinking water provision at the downstream end, although we recognize that at the upstream end and in the long term, universal access to safe drinking water also depends on overall water sector priorities and policies. In particular, there are several important issues in the Indian context which we choose not to address in this paper for reasons of scope and space constraints. The first is sectoral allocation of water between industry, domestic use and environmental protection. In 2000, 92% of India's usable water went to agriculture, mainly in the form of irrigation (Development Alternatives 2001). While inter-sectoral water allocation decisions will determine the long term supply of water, we argue that, in the short term, there is plenty of scope for reform even using the share of water that domestic use currently receives. The household options discussed in our paper will remain important even if the aggregate share of water for domestic uses goes up. A second issue is that in many cities and villages, aquifer overdraft and poor groundwater quality pose great threats to a safe water supply. We discuss methods of water provision to cope with this, but do not address in detail measures to deal with groundwater depletion from the supply-side. Thirdly, we do not discuss large-scale water projects such as dams and river-linking schemes, which are not primarily meant to solve drinking water problems. Lastly, although we recognize the strong and well-documented links between improved sanitation services, safe drinking water and public health, we focus solely on drinking water provision. Nevertheless, many of the institutional barriers and political economy issues discussed here apply in equal measure to sanitation service provision.

This paper is divided into three parts. In Part I we provide an overview of the state of access to drinking water in urban and rural India. In Part II we discuss urban water delivery options, with examples of ongoing attempts to reform the urban water sector. In Part III we analyze decentralized technological – institutional options for extending access to water in peri-urban and rural areas. Finally, we draw on the literature and on our own field experiences to recommend fruitful directions for data collection, research and policy reform.

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[5] Of course the limited budget for water and sanitation does not reflect merely India's low per capita income, but also its national priorities.

PART I: ACCESS TO DRINKING WATER

I.1 Nature and extent of access to water

To examine patterns in household water delivery across different geographic and socioeconomic dimensions we employ data from the National Family Health Survey (NFHS), taken in 1992-93 and 1998-99.[6] This is India's version of the Demographic and Health (DHS) surveys taken worldwide and is a nationally representative survey directed towards ever married women of child-bearing age. Approximately 90,000 households were surveyed in each wave. In addition to data on household characteristics and on demographic outcomes, the survey asks several questions of direct interest to household water delivery including the source of the household's drinking water, the time taken to get to water sources for households who do not receive water on their premises, and the method used by the household to purify their water.

Table 1 provides a breakdown of the various water delivery mechanisms for all of India, and separately for urban and rural areas. Urban areas are broken down further into large cities, and small cities/towns. Looking first across all of India, one notes substantial heterogeneity in water delivery, with no dominant mechanism. In 1998-99, only 21 percent of all households have piped water, while 18 percent use public taps, 15 percent private handpumps, 24 percent public handpumps, and 19 percent rely on wells. There are large differences between urban and rural areas in the source of drinking water. Piped water supplies 69 percent of households in large cities, 45 percent in smaller cities and towns, and only 9 percent of rural households. Public taps are used more in smaller cities than either in rural or in large cities. Handpumps are the predominant source of drinking water in rural areas, with 47 percent of households in 1998-99 receiving water from either private or public handpumps. Wells also supply a substantial number of rural households with their water. Very few households use tanker trucks, rivers, streams, and the other such sources.

Comparing the 1992-93 data with the 1998-99 data allows some insight into areas where there were most rapid changes in water provision during the 1990's. Piped water expanded in the large cities, to cover 12 percent more of the population. There was much less expansion in the rural areas and smaller cities, and so national coverage only increased by 2.6 percentage points. This expansion in piped water access is seen to result in less large city urban residents relying on public wells, public handpumps, and public taps. In contrast, public taps expanded in rural areas and smaller cities. Use of public wells is seen to have fallen across both rural and urban areas, with the decline largest in rural areas. Public well usage fell 9 percentage points among rural households, with increased handpump, public tap, and piped water use accounting for this change.

The World Health Organization (WHO) defines access to water supply services as the availability of at least 20 litres per person per day from an "improved" source within one kilometre of the user's dwelling.[7] Improved sources are those likely to provide safe water such as household connections, public standpipes, protected dug wells, rainwater collection,

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[6] Data from the ongoing Measure DHS+ benchmark survey 1998-2003 are not yet available. Available surveys can be downloaded from http://www.measuredhs.com/.

[7] See the website of the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation http://www.wssinfo.org/en/welcome.html.

boreholes, and protected springs. "Not improved" sources include unprotected wells and springs, vendor provided water and tanker truck water. The foot of Table 1 shows the proportion of Indian households receiving water from these improved sources. Note that the survey does not provide any data on the quantity of water obtained from these sources, so these numbers are likely to overestimate the proportion of households with improved water. In 1998-99, 98 percent of households in large cities, 92 percent in small cities, and 75 percent in rural areas are estimated to receive water from improved sources. This represents an improvement over the 1992-93 survey, especially in rural areas.[8] Overall, 71 percent of Indian households in 1992-93, compared to 80 percent in 1998-99, were estimated to receive their drinking water from improved sources.

Data from the 1981 Census show that 75 percent of urban households and 27 percent of rural households had access to improved sources of water, while the 1991 Census shows 81 percent of urban households and 56 percent of rural households with improved sources (WHO-UNICEF 2001). The 94 percent of urban and 75 percent of rural households with access to improved sources in the 1998-99 NFHS therefore represents a substantial improvement in access to safer sources of water during the 1980s and 1990s.

There is considerable variation in the sources of drinking water across Indian states. Table 2 shows sources used in urban and rural areas by state. Figure 1 plots access to piped water against per capita state domestic product. There is a strong positive relationship between state incomes and access to piped water. As a result, access to piped water in urban areas ranges from 18 percent in Kerala, 21 percent in Orissa and 26 percent in Bihar to over 75 percent access in urban areas in New Delhi, Sikkim, Gujarat, Jammu and Rajasthan. There is a great deal of cross-state variation in use of other methods, with different mechanisms for supply in different states. In urban areas, use of public taps ranges from only 2 percent in Punjab to 43 percent in Andhra Pradesh; use of private handpumps ranges from less than 1 percent in Goa to almost 40 percent in Uttar Pradesh; and wells range from less than 1 percent in several states to 60 percent in Kerala. Rural areas show just as much cross-region variation, with rivers, springs and ponds, which supply drinking water to less than 3 percent of rural households in the nation as a whole, supplying 25 percent or more of households in Jammu, Manipur, Meghalaya, and Nagaland.

Access to piped water is therefore seen to be more prevalent in richer states. The NFHS does not collect income data at the household level, but does ask households questions on ownership of a number of durable assets. Filmer and Pritchett (2001) show that the first principal component of these indicators provides reasonable estimates of wealth effects. Since households in rural and urban areas may hold different portfolios of assets, we define asset deciles separately for rural and urban households, as well as for all of India. Table 3 then reports our estimates of the percentage of households with access to piped water by asset decile. One finds a strong relationship between asset wealth and access to water. Even within large cities, in which 70 percent of households have piped water, we see considerable variation across asset levels. Only 26 percent of households in the bottom decile and 42 percent in the second decile have piped water, compared to 87-90 percent in the top three

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[8] The 1992-93 survey does not separate wells into open and covered, and so our calculations for 1998-99 assume that the ratio of covered wells to total wells was the same as in 1998-99.

deciles. Also notable is the levelling off of access at the top of the distribution; even among those with the highest level of assets 12 percent of households do not receive piped water.

Households that do not receive water supply at their housing structure encounter several costs in obtaining water from other sources. In addition to the direct costs of storage containers, households spend time travelling to the water source, and then potentially waiting in line to use community supplies. Table 4 details the breakdown of time taken to get to the alternative water supply for households without water on their premises. While roughly 50 percent of such households spend 10 minutes or less getting to the water supply, 21 percent of these urban households and 26 percent of these rural households spend 20 minutes or more getting to the water source. Households may then pay financial costs for transporting water from standpipes to their homes.

I.2 Quality of drinking water

The *WHO Guidelines for Drinking-water Quality* (WHO 1993, 1997, 1998) assess the health risks posed by contaminants in drinking water. The guideline values for biological and chemical pathogens in drinking water safety are not mandatory – the WHO recognises that on-paper mandatory limits are not useful for most developing countries. Rather, the guidelines are intended to develop risk management strategies, and national or regional standards in the context of environmental, social and economic conditions. The WHO's primary health requirement is a sufficient water supply, aside from quality, which the Government of India takes to mean 40 lpcd.

The second requirement is that the water be microbiologically safe, since these waterborne pathogens are the leading cause of those diseases that kill or seriously debilitate the affected (Esrey et al, 1991). Children under 5 years of age are especially vulnerable to acute diarrhoeal episodes. In most developing countries, India included, the primary contaminant of surface and ground waters is human and animal waste.[9] The WHO guidelines suggest that *E. coli* (the indicator organism for bacterial contamination) should not be detectable in a 100-ml sample of water. In practice, with fewer than 10 coliforms in a 100ml sample, the water is considered to be of 'moderately' good quality. The Government of India accepts these guidelines, but has generally been unable to ensure that they are met. Water-borne diseases from faecal contamination are one of the biggest public health risks in India -- diarrhoeal diseases are the largest killers of children. Repeated bouts of diarrhoea also cause stunting through malnourishment – children with diarrhoea are unable to absorb the nutrients from any food they eat. It has been argued that India loses 90 million days a year due to waterborne diseases, costing Rs 6 billion in production losses and treatment (Chaudhuri 1998). Another study estimated that each year India lost 30.5 million 'disability-adjusted life years' because of poor water quality, sanitation and hygiene (WSP 1999a).

The third requirement of the WHO is that the water be chemically safe, although there are different levels of risk associated with different chemical parameters. Though chemical residues in water are not as widespread as biological pathogens, chemical contamination through agricultural runoff and unregulated industrial pollution is a rapidly growing problem.

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[9] For this reason, most water and sanitation practitioners think that it is a fundamental error to treat water, sanitation and hygiene separately – however this separation is still the norm in the literature and in policy (Jolly 2003).

The most widespread and significant naturally occurring waterborne toxics are arsenic and fluoride (guideline maximum concentrations of 10 μg/l and 1.5 mg/l respectively). Fluoride problems exist in 150 districts of 17 states in the country [10] -- with Orissa and Rajasthan the most severely affected. Excessive fluoride in drinking water causes fluorosis, manifested in weak bones, weak teeth and anaemia. The calamity of arsenic – a poison and a carcinogen – in the groundwater of the Gangetic delta, affecting 35 – 70 million people in West Bengal, Bihar and Bangladesh, is by now well known (WHO 2001). It has been hypothesized that the naturally-occurring arsenic leached into the water from underground geological strata because over-pumping lowered the local water tables. There are no national standards for chemical concentrations in water, a point which caused much public outrage when pesticide residues were found in bottled sodas and waters (CSE 2003). However, the central government intends to introduce an ordinance that classifies drinking water as a 'food', with its own norms for biological, chemical and other 'additives' (Rastogi 2004).

Standards for drinking water that are actually enforced could have enormous positive impacts on public health, but for this to occur, the procedures for water testing and data sharing have to be made regular, standardized and public. As of today, multiple organizations including Public Health Engineering Departments, Central and State Groundwater Pollution Boards, the Central Water Commission, and other government and research groups are all involved in assessing water quality. However these groups rarely coordinate their activities, and overlapping responsibilities result in inefficiency, negligence and delays (Sridhar 2003). Additionally, published information on much of this water testing is not readily available. GoI (2001) reports that much of the information, if available at all, can only be obtained upon request at the regional office level (and informal reports from water researchers confirm that some state and regional offices jealously guard these data). As a result, standardized comparison of water quality across locations or over time is not possible, and baseline information is not reliable.

PART II: URBAN WATER SUPPLY OPTIONS

Authority over urban water services lies with each state, with some decentralization to the municipal level. The institutional arrangements vary across states. Some state water supply boards, such as Karnataka's, are responsible for operation, maintenance, and capital works, while in other states operation and management is run by municipal bodies. In some of the larger cities, such as Delhi, Chennai, Bangalore and Hyderabad, separate municipal corporations have been created. These are responsible solely for water and sewerage facilities, in contrast to municipal bodies which also carry out other local government activities. The World Bank (2000) reports that although some service providers are semi-autonomous in theory, there is considerable political interference in operations, managerial decision-making and tariff-setting.

II.1 The current state of urban water provision

Municipal provision of water is the status quo in most parts of India. While only half of all urban households have a piped water connection, even those with a connection generally do not receive a regular supply of good quality water. The municipal water supply in most

[10] Source: Department of Drinking Water Supply, Ministry of Rural Development, http://ddws.nic.in

Indian cities is only available for a few hours per day, pressure is irregular, and the water is of questionable quality.

Irregularity

Table 5 summarizes some key indicators of irregularity, wastage, and poor performance of water suppliers in the largest Indian cities. For comparison purposes, these same indicators are also provided for Lahore, Kathmandu, Bangkok, Beijing, and an average of 50 cities surveyed by the Asian Development Bank in 1997 (ADB 1997). No major Indian city has a 24 hour supply of water, with 4 to 5 hours of supply per day being the norm. This compares to the Asian-Pacific average of 19 hours per day supply, with both Bangkok and Beijing having 24 hour coverage.

These averages conceal a great deal of heterogeneity within cities in terms of the regularity of supply. In a 1995 survey of Delhi households with in-house connections, Zérah (2000) finds that only 40 percent had 24 hour supply of water, while more than 25 percent had less than 4 hours a day of service. Moreover, there were large differences in supply from floor to floor of a house or apartment. Ground floor apartments averaged 16 hours per day, compared to 8 hours on the first floor and 4-5 hours on second and third floors. Fewer than 20 % of households surveyed received water at uniform pressure during different days of the week.

McIntosh (2003) refutes the assertion that there is not enough water for 24-hour supply. Much of the available water is wasted, both through leakages, and a lack of incentive to conserve water due to low tariffs. He gives the example of Malé which has achieved 24-hour piped supply, along with a high tariff, and strict metering, billing and collection. He notes that consumers without 24-hour supply tend to use *more* water than those with 24-hour supply. Because they can never be sure when they will next be served, consumers store water, which they then throw away to replace with fresh supplies each day. Additionally, in India, household use accounts for only a small fraction of overall water usage. Agriculture is the prime user, with 92 percent of utilizable water going to this sector (Development Alternatives 2001).

Urban Water Quality

An unreliable water supply, characterized by intermittent water supply, insufficient pressure and unpredictable service, imposes both financial and health costs on Indian households. Based on a survey conducted in Delhi in 1995, Zérah (2000) estimated that each household on average spent around 2000 Rupees annually in coping with unreliable supply of water, which is 5.5 times as much as they were paying their municipality for their annual water consumption. Most households with in-house connections were found to have undertaken long-term investments in the form of acquiring storage devices such as water tanks or buckets, or acquiring handpumps or sinking tubewells. Households with water tanks would install electric booster pumps on the main water line itself and pump water directly to water tanks. This increases risks of contamination of the general water supply and reduces the pressure in the network for other users, leading them also to install motors on the main line. In addition to the contamination that can occur through household use of booster pumps, the vacuum conditions created when supply stops can draw in foul water (McIntosh 2003).

Monitoring of water quality is haphazard. While municipal boards claim to conduct regular tests of water supply, the results of these tests are generally not made public.[11] The information that does exist points to generally poor quality of water in a number of cases. The most reliable testing information we have encountered comes from the Sukthankar Committee (2001) report to the Government of Maharashtra, which reported results from 136,000 daily tests of bacteriological contamination carried out on water samples from the various municipal corporations in Maharashtra over the course of 1999. Ten percent of samples were found to be contaminated, with 14 percent of samples from Mumbai being contaminated. The Committee noted that no testing is done for chemical or physical contamination, so it is likely that the actual level of poor quality samples exceeded 10 percent. Water quality in Mumbai remains poor, with a study by the Society for Clean Environment (SoCleen) in July 2003 finding that a significant percentage of water in many parts of the city was not potable and contaminated with excessive bacterial pollution.[12] Thermotolerant coliform organisms, an important indicator of water safety, were several hundred times higher than the norm. Water quality was poor across socioeconomic groups, with 70 percent of samples from middle-class housing societies found to be not potable.

Water monitoring conducted in January-March 2003 by Clean India in 28 cities found that ground water in most areas exceeded permissible limits in terms of fluoride, ammonia and hardness. Municipal water supply in some cities also contained high numbers of contaminants. For example, in Jaipur in the state of Rajasthan, permissible limits of nitrates, ammonia, coliform bacteria and hardness were exceeded in more than 50 percent of samples from the municipal water supply.[13] A 2003 survey of 1000 locations in Calcutta found that 87 percent of water reservoirs serving residential buildings and 63 percent of taps had high levels of faecal contamination.[14] Even bottled water is not completely safe. A 2003 study by the Centre for Science and Environment (CSE) in Delhi found that most of the most popular brands of bottled water had high levels of pesticides, some of which were over 100 times EEC limits (CSE 2003).

The demand for and cost of improved quality

There are a range of mechanisms households can use to improve the quality of the water they receive before drinking it. These range from low-grade technologies such as straining with a cloth, using chlorine and safe storage vessels, to relatively more sophisticated technologies like electronic filters. Based on their own cost survey in Delhi, Jalan, Somanathan and Chaudhuri (2003) estimate the annual average cost per person of different purification methods. The cheapest method is straining with a cloth, which provides some protection against cholera, but does not filter out most free-floating bacteria. Alum tablets are estimated to cost Rs. 73 per person per year, and are effective at reducing turbidity and in reducing bacteria, but do not remove all pathogens of concern. The two most effective methods are also the most expensive. Electronic filters which first filter particulates and then irradiate the water with ultraviolet light are very effective provided they are properly

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11 For example, the BWSSB in Bangalore now collects 1200 samples a month from several parts of Bangalore City and tests them in a Central Lab to measure water quality (see http://www.bwssb.org/BSWW_news.cfm). However, results from these tests are not readily accessible.

12 See Sridhar (2003) for a report on this study.

13 See results reported in Clean India July 2003 Newsletter "Watch that water you are drinking!" Available online at http://www.devalt.org/newsletter/jul03/ [accessed January 2004].

14 See "Warning over Calcutta water quality", BBC News UK edition, 29 August, 2003.

maintained, and are estimated to cost Rs. 791 per person per year. This is still about half the cost of boiling, which is estimated to cost Rs. 1635 per person per year.

Using the 1999 NFHS, Jalan, Somanathan and Chaudhuri (2003) report that 47 percent of households do not use any purification method, with 32 percent of the top wealth quartile also not purifying their water. While the cost of electronic filters and boiling may preclude their use for the poor, cost should not be a factor in determining whether to strain with a cloth, while the alum tablets and ordinary filters are also relatively inexpensive. Lack of use of these methods must therefore arise from household perceptions that there is no need to filter, or not large benefits from doing so. Some households receiving piped water may believe it to be of sufficient quality not to require filtering. However, Jalan and Ravallion (2003) find that while provision of piped water does reduce the incidence of diarrhoea among children in rural households in India, health gains are lower for children with less well-educated women in the household. One explanation might be that more-educated households enjoy better quality piped water, while another is that even piped water needs to be treated or purified, and stored safely due to irregular supply.

Jalan, Somanathan and Chaudhuri (2003) provide support for the latter explanation. Controlling for wealth, they find that higher female education and more exposure to the mass media, such as newspapers, increases household willingness to pay for purification. They conclude that a lack of awareness of the adverse health effects of poor water quality is a significant barrier to the adoption of different home purification methods. As a result, public awareness campaigns to educate the population about the health consequences of poor water quality are needed to accompany policies designed to provide and promote the use of in-home water purification methods.

II.2 Inefficiencies in the supply of water

One of the prime reasons for the poor quality of the water supply is inefficiencies in the water delivery suppliers. Prime symptoms of this are the large amount of unaccounted for water, overstaffing, and low cost recovery.

Unaccounted For Water

A standard indicator of inefficiency and wastage is the percentage of water produced which does not reach water board customers. Unaccounted for water results from both leakages and illegal connections. In addition to the financial costs to the water utility, high levels of unaccounted for water are also a major reason for intermittency in the supply of water, since leaks and illegal connections lower water pressure in the distribution system (McIntosh 2003). Table 6 shows that unaccounted for water accounts for 25-40 percent of water produced by utilities in the main urban areas in India. While this is no higher than the Asian-Pacific average, McIntosh (2003) claims that the large number of obvious leaks means there is still substantial scope for improvement. He cites the example of Singapore, which has reduced unaccounted for water to 6 percent as an example of what can be achieved by metering, leak surveillance, proper billing procedures and strong management.

Overstaffing

A second indicator of inefficiency is high staffing levels. A good utility will have two staff for every 1,000 connections (McIntosh 2003). Such levels have been attained by water utilities in Taipei, Kuala Lumpur, Singapore and Seoul, and can be considered as 'best practice' numbers. Table 6 shows that the Asian-Pacific regional average is around 12 staff per 1000. Hyderabad and Bangalore are around this level, but staffing levels are double this in Chennai and Delhi, and higher still at 33 per 1000 in Mumbai. While staffing levels are high, the average quality of workers in many utilities is low. Based on visits to different water utilities in Maharashtra, the Sukthankar Committee (2001, p. 90) reported that "most of the operating staff was not qualified to work in water works installations". Many were unskilled labourers who had worked on the construction of the works and stayed on to work as operators. The Committee is even more damning of staff dealing with the water treatment processes and operations, remarking that such staff "were found to be hardly having even the basic understanding of the unit process and unit operations which they were handling" (Sukthankar Committee, 2001, p. 90).

Low cost recovery

The consequence of overstaffing, underpricing, and high levels of unaccounted for water is that most urban water utilities in India are unable to even cover operating and maintenance costs out of revenues from tariffs, let alone provide for expansion and improvement of the network. Table 6 shows that only Chennai has managed to cover operating costs, while Bangalore and Mumbai come close. The situation is worse in Hyderabad and Delhi where only 66-68 percent of costs were met, and severe in Kolkata, with only 15 percent of operational costs being recovered. The Kolkata Municipal Corporation (KMC) itself reports that in 2001 57 percent of water generated by the KMC did not fetch any revenue at all.[15]

II.3 Pricing of water

State Governments in India are responsible for choosing urban tariff structures. Municipal boards and corporations can propose tariff structures, but these are subject to State Government approval. The result is a wide variety in pricing practices. Raghupati and Foster (2002) surveyed water charging practices in all 23 metropolitan areas (cities of over 1 million population) and 277 smaller cities of populations 50,000 to 1 million. They find that most cities operate a mixture of measured and unmeasured tariffs, due to relatively low coverage of metering (see Section II.4). For unmeasured areas, a flat rate is the most common form of tariff. Other options used include a ferrule-based tariff, which charges according to the diameter of the connection, and water rates based on the value or size of the dwelling. Two tariff structures are found for metered connections. The most predominant are uniform volumetric charges, which charge a constant rate per Kilolitre of water. This system is found in 77 percent of smaller cities and 58 percent of metropolitan areas. In the remaining 42 percent of metropolitan areas and 23 percent of smaller cities an increasing block tariff (IBT) is used.

Under an increasing block tariff, a low rate is charged for the first few units of water each month, and then higher amounts of use are charged at higher marginal rates. Boland and Whittington (2000) outline the arguments made by supporters of Increasing Block Tariffs. Public health externalities and the idea that water is a merit good are used to argue that all households should have access to some baseline level of water at low rates. Since water is assumed to be a normal good, increasing rates on higher amounts forces wealthy households to subsidize poorer households, which is seen as desirable for equity reasons. Prices can then be kept low for the poor, while the higher prices at increased levels of use can allow

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[15] See http://www.kolkatamunicipalcorporation.com/water.html

revenues to cover costs. Proponents also argue that charging higher rates for more use can act to promote conservation and sustainable use.

Table 7 provides examples of the prevailing tariff structures in Hyderabad, Bangalore, Delhi and Chennai, which are the cities for which we could obtain recent data. All four cities use IBTs for metered customers. The size of the blocks or slabs can be seen to vary across cities, with the initial monthly block being 10 KL in Delhi and Chennai, 15 KL in Bangalore, and 30 KL in Hyderabad. To compare prices across cities, Table 8 reports the effective price for 10-50 KL in each of the four cities. Delhi has the lowest rates by far for all quantities, with the cost of 50KL only one-third of that in Hyderabad, and less than one-sixth of that in Chennai. Among the other cities, Chennai has the lowest price for 10KL, but then the rates for subsequent blocks increase more rapidly, so that larger amounts of water are more expensive there.

Raghupati and Foster (2002) note that relatively little information is available as to the level of tariffs needed for full coverage of operating and maintenance costs. They provide results from several consultant studies which suggest operating and maintenance costs average rates of Rs. 13 per KL for Chennai, Rs. 16 per KL for Bangalore, and Rs. 17 per KL for Hyderabad. As outlined above, there is substantial inefficiency in terms of excess staffing and wastage of water, which may reduce the tariffs needed in an efficient company. However, incorporation of capital costs, which no public information is available for, would raise the tariffs needed. Comparing these rates to those in Table 7, one sees that only the metered tariffs above 50 KL in Bangalore, above 200 KL in Hyderabad and above 15 KL in Chennai are likely to cover operating and maintenance costs. However, very few households in Chennai are metered (see Table 6) so these higher rates do not cover many households there. These results are not unique to this selection of cities; Raghupati and Foster (2002) find that the typical price charged in their larger sample of cities is Rs. 1.5 per KL, or only approximately 10 percent of operating and maintenance costs.

The main rationale used for subsidizing the initial block of water is to provide some lifeline level of access to water. However, as Brocklehurst, Pandurangi and Ramanathan (2002) note, the size of the first block in all the Indian cases exceeds what would generally be considered a true lifeline level. They give the example of a family of five using 40 litres per capita per day for 30 days, which would require 6 KL a month.[16] This is the size of the lifeline block in South Africa, whereas the blocks in India are two to five times this level. Brocklehurst, Pandurangi and Ramanathan (2002) report the proportion of customers consuming in different blocks in 2001 in Bangalore and Hyderabad. In Hyderabad they find that 70 percent of customers consume in the 0-15 KL/month range, 20 percent in the 15-25 KL/month range and only 10 percent consume 25 KL/month or more. In Bangalore, 66 percent of customers are in the 0-25 KL/month range, 28% in the 25-50 KL/month range, and only 7 percent consumer more than 50 KL/month. Coupled with the low tariffs in the first couple of blocks, the result in Bangalore is that 93 percent of the customers account for less than 15 percent of revenues, and are paying less than 41 percent of the cost of providing them with water.

[16] Boland and Whittington (2000) report that international standards for basic water needs are in the range of 25-30 litres per capita per day, which is 4-5 KL/month for a household of five.

In practice then, the increasing block tariff has resulted in a large initial block, with the majority of households consuming in the first couple of blocks. Boland and Whittington (2000) find this to be a general phenomenon experienced in many places across the world where IBTs are used. They remark that there is large political pressure for politicians to increase the size of the first block, since all households with piped connections benefit directly from this (whereas the costs of having to subsidize the underfunded public corporation remain opaque). The result is that the IBT does a poor job of targeting subsidies for water towards poor households. There are large numbers of non-poor households who benefit from the large initial block, while poor households with larger families may actually be pushed into the higher-priced block. Moreover, since poorer households are less likely to have a metered connection in the first place, many poor households do not benefit from the increasing block structure. Foster , Pattanayak and Prokopy (2003a) calculate that altogether the state and federal governments in India spend US $1.1 billion or 0.5% of GDP in subsidizing water, but find that 70 to 80 percent of these subsidies fail to reach the poor. Moreover, the average amount of the subsidy received by the top decile of the population is 2-3 times as high as the average subsidy received by the bottom decile.

These low prices for the majority of consumers are one of the prime determinants of the low cost recovery ratios seen in Table 6. The extremely low prices in Delhi make this a particular problem, and there has been no change in Delhi water prices since 1998. The gap between revenue and expenditure has been growing. The shortfall in 2003 was Rs 5 billion, on annual revenue of less than Rs 2 billion. The Delhi Jal Board put forward a proposal to increase rates in January 2004, with the new rates proposed between 2.5 and 6 Rupees per Kilolitre, however this proposal was put aside by the state government due to election pressures.[17]

II.4 Scope for Pricing Reform

Average tariffs in India are clearly low relative to costs. A cross-region study by the Asian Development Bank in 1997 found average rates in Calcutta and Delhi of 1-3 US cents per KL, 6 cents per KL in Mumbai and 25 US cents per KL in Chennai. In comparison, rates were 5 cents per KL in Beijing, 9 cents per KL in Dhaka and Karachi. 20 cents per KL in Lahore, 23 cents per KL in Manila, 31 cents per KL in Bangkok, 34 cents per KL in Kuala Lumpur and 55 cents per KL in Singapore. With the exception of Chennai, where few customers are metered and therefore paying this rate, Indian cities therefore tend to have much lower prices than other Asian cities.

Existing evidence suggests that even poor households in India can afford to pay more for their water service, particularly if the increase in prices is accompanied by better service. Under the current system, households may pay several times the municipal charges in coping costs arising from the irregularity and unreliability of supply. For example, Zérah (2000) estimates that households in Delhi in 1995 were paying 5.5 times the cost of their municipal water rates in coping costs, while WSP (1999b) reports that a 1996 survey in Uttar Pradesh found these coping costs averaged Rs 10 per KL, five times the prevailing tariff rate. Willingness to pay (WTP) studies summarized in WSP (1999b) also suggest that households are willing to pay more for adequate and safe water supplies.

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[17] source: The Times of India, January 5, 2004 "Water watch", http://timesofindia.indiatimes.com/articleshow/406554.cms [accessed April 11, 2004].

Raghupati and Foster (2002) calculate that even the poorest households could afford to meet their subsistence needs with water tariffs several times higher than current levels. Based on a World Health Organization definition, in which water is affordable if it constitutes less than 5 percent of a household's budget, they calculate that even a typical five-member family living under the poverty line with a per capita monthly budget of Rs 350 could afford to pay up to Rs 6 per KL for a subsistence block of up to 10 KL per month. Given current income levels, prices above Rs 10 per KL would make the service unaffordable for a significant proportion of the population. Given estimates of operating and maintenance costs in the range of Rs 15 per KL, some subsidization therefore appears inevitable, although more efficient operation could substantially lower this gap.

Although some subsidization seems inevitable, the current system effectively directs most of the subsidies towards the non-poor, while many poor do not benefit from low initial tariffs due to a lack of access to the piped connection. Foster , Pattanayak and Prokopy (2003b) provide evidence that a geographically-targeted subsidy system would result in significant improvements in performance. For example lifeline rates could be set at lower levels in designated slum areas. Additionally, subsidizing connection rather than use appears to be a better way of directing subsidies towards the poor. It is also desirable to spread the connection fee over several years rather than requiring a one-off advance payment for connection from the poor.

Boland and Whittington (2000) suggest replacing the increasing block tariff with a system of uniform price with rebate. Under this method, a volumetric charge is set equal to marginal cost and coupled with a negative fixed charge, or rebate. In practice they note that a minimum charge would have to be set to avoid zero or negative bills, and so at very low use households would effectively face zero prices. However, they note that water demand is likely to be very price inelastic at very low levels, and so this feature is unlikely to result in large inefficiencies. The advantage of such a method would be that it is simple, transparent, easy to implement, and avoids several of the problems inherent in the IBT.

In sum, there appears to be considerable scope for reform of the existing water pricing system in India. Two key elements needed for reform are the ability to charge in proportion to use, which requires metering, and political will for reform. We consider these features next.

II.5 Metering

Some form of metering is necessary in order for suppliers to be able to charge in proportion to water used. Metering has other advantages as well, such as helping suppliers keep track of how much water is being used in different parts of the system, allowing detection and reduction of illegal connections, and providing for identification of leakages. Despite these advantages, not all municipal corporations have implemented widespread metering. Table 6 reports that the percentage of customers with metered connections ranges from less than 5 percent in Chennai in 2001 and 5 percent in Kolkata in 2004, to approximately 70 percent in Delhi and Mumbai and 100 percent coverage in Bangalore. Only Bangalore has metering above the Asian-Pacific average of 83 percent.

Of course in order to benefit from the advantages of metering, the meters must be operational. Data on whether or not the meters are functioning is even scarcer than the scattered data on metering itself, but available evidence shows very high-levels of non-functioning meters. Zérah (2000) reports that officially three-quarters of all connections in Delhi in 1994 were metered, but that approximately one-third of the meters were not working due to breakdowns and theft. The current situation in Delhi is no better, with approximately one half of the 75 percent of meters not working.[18] ADB (1997) reports that 70 percent of meters in Mumbai were not functioning in 1997, while 81 percent of meters in Mumbai in 2000 were reported to be non-functional (Mathur, 2001). Even with functioning meters, bureaucratic inefficiency in the bill collecting process means that a good number of customers do not pay their bills regularly. For example, in February 2004, only 50 percent of metered customers of the Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) were paying their bills regularly.[19]

One might question whether metering the poor is cost-effective for the water utilities. As Noll, Shirley and Cowan (2000) note, externalities may be a substantial part of the cost in urban water systems, so that even if the direct benefits of metering are low, there may still be a strong argument for charging in proportion to usage in order to curtail wastage and prevent spills that cause community health problems. Municipal water boards in India generally charge either a security deposit on the meter (Rs 400 for a 15mm meter in Delhi), or a monthly rental rate (Rs 15 per month for a 15mm in Hyderabad), which allows for the costs of metering to be born by customers. Even among very poor households, such as slum households, there is scope for metering with some adaptation. For example, the private concessionaire in Manila put banks of meters in poor areas, from which families who wanted a private connection could install and run a rubber piping connection to their own home. A meter was provided for each private connection. (WSP 2001). This resulted in an increase in coverage from 67 percent to 80 percent of households, providing direct connections to one million urban poor.

II.6 Political Economy of Reform

In light of the widespread inefficiencies in the Indian water sector, there is clearly ample scope for reform. However, given the predominantly state- and municipal-run water system, any major reform needs to survive the political process, while even small changes in prices require political approval.

Although the poor state of the existing system may suggest that reforms would be popular, in practice reform has been difficult and several reform efforts have been killed by political opposition. As Noll, Shirley and Cowan (2000) argue, several features of urban water systems generally make reform politically difficult. In particular, they note that the political benefits of water reform are often low, while, in contrast, reform will often involve giving up political command of employment and investment in the public enterprise, and raising prices. Changes in prices and layoffs are more transparent to the public than improved operating efficiency, a reduction in the need for state subsidies, and small improvements in quality, while larger long-term benefits of reform may take longer than an electoral cycle to materialize. As a result politicians may not find the political benefits of reform outweigh the costs.

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[18] Reference: private communication with Bunty Gupta, PriceWaterhouse consultant on water in New Delhi.
[19] Source: The Hindu, February 6, 2004 "Illegal connections prick water board", www.hindu.com.

Promoting reform therefore requires finding a way to raise the political benefits of reform efforts, or of increasing the political costs of not-reforming. One key element in this regard is increased information and public awareness. The Sukthankar Committee (2001) suggests that local bodies should be made to publish fact sheets containing data on operations periodically and subject themselves to public review.[20] This would appear to be an important first step in increasing the transparency of the existing system, and would allow for benchmarking of local water utilities with other cities. Taking this further, it would seem that benchmarking additionally against neighbouring countries, such as Nepal and Pakistan, might be a good way of increasing public dissatisfaction with the status quo.

Public awareness could be further increased by explicit reporting of regular quality testing of the water supply, along with information on hours of service and pressure, again benchmarked against other states and neighbouring countries. This information should be coupled with explicit information on how much water subsidies take from the state budget. Reform goals in terms of quality improvement and expansion of access could then be easily compared to the existing state of affairs, and price increases could be explicitly linked to targeted improvements in key factors.

The lack of reliable, up-to-date, and publicly accessible information on many of the key elements of municipal water supply acts as an important constraint on the transparency of reform efforts. Additionally, benchmarked information is necessary in order to be able to provide a baseline against which to evaluate reform efforts, and in order to help determine where reforms seem to be having the most effect.

II.7 Private sector participation in urban water delivery

Although some improvement in public utilities may be possible, Harris (2003) finds that there seems to be little evidence of the types of rapid improvements that have been documented following private participation in many inefficient and poorly performing utilities around the world, and that improvements which do occur under the existing framework tend to be unsustainable. As a result, Governments have increasingly used private sector participation to improve the efficiency and service of water provision. Although widespread in much of the developing world, especially in Latin America, private sector participation in water delivery is still rare in India. However, the 2002 National Water Policy of the Government of India for the first time called for the encouragement of private sector participation in water resources. Section 13 reads:

> "Private sector participation should be encouraged in planning, development and management of water resource projects for diverse uses, wherever feasible. Private sector participation may help in producing innovative ideas, generating financial resources and introducing corporate management and improving service efficiency and accountability to users". (GoI 2002, page 5).

We outline the arguments put forward for private sector involvement and summarize the evidence from other countries, before highlighting the areas of debate in India.

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[20] Several NGOs such as Samaj Pragati Sahayog do this already. In the state of Rajasthan, as a result of a campaign led by Mazdoor Kisan Shakti Sangathan, the right to information on public spending is now the law.

The argument for private sector participation

The above Section of the 2002 National Water Policy captures many of the arguments made for involving the private sector in water provision. Supporters argue that the private sector can introduce higher levels of management and technical skills, increase operating efficiency and therefore lower costs, and provide investment financing to provide for expansion of infrastructure (ADB 1997).

Private sector participation (PSP) incorporates a wide range of levels of private sector involvement. At one end lies contracting out of services to the private sector, such as mains repair, billing and collecting, and meter reading. Such arrangements are relatively straight-forward and usually involve short-term renewable contracts. Under a management contract, operation and maintenance of the water network is carried out by a private firm in exchange for a management fee, with a typical contract lasting 3-5 years or more. Leasing and Affermage contracts are similar to management contracts, although the private firms revenue is determined by tariffs collected, resulting in more commercial risk being shared than under a straight management contract. Typical contracts last 8-15 years. More private involvement occurs under concession and Build-own-transfer (BOT) contracts. Under a concession, a private firm manages and operates the whole utility at its own commercial risk and is also required to finance new investment. Contracts tend to be for longer periods, such as 25-30 years. BOT contracts are used for major investment in new facilities. A private firm is selected to build new infrastructure, such as a treatment plant, operate it under license for the contract period, and then transfer it to the Government at the end of the contract. As with concessions, contracts are generally for periods of 20-30 years. At the other end of the public-private spectrum lies full privatization or divestiture, whereby the Government sells the assets of the water supply company to a private firm, who runs it on a permanent basis subject to government regulation.[21]

The term privatization is often used in both the literature and in public debate to encompass both divestiture, and many of the other forms of private sector participation, such as concessions and BOT schemes. Examples of full privatization, or divestiture are rare, limited mostly to the United Kingdom (UN-HABITAT 2003), so studies which examine the effects of privatization will generally include these other forms of private sector participation in their analysis.

Evidence from other countries

Evaluation of the effects of private sector participation on urban water supplies has been severely constrained by the overall poor quality of data available and the small number of cases from which to draw general conclusions. As in India, in many parts of the world the public utility does not release regular and informative information on costs, water quality, the size of the network, etc. Moreover, with a change in ownership, any such information is often lost as the private firm begins its own set of records. These features make it difficult to measure the pre-privatization trends in access, prices, costs, and quality, which are key elements in determining a counterfactual of what would have happened in the absence of private involvement.

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[21] See ADB (1997) and UN-HABITAT (2003) for an expanded discussion of the pros and cons of each arrangement, and examples of where each type of system has been applied.

As discussed above, privatization is not a yes/no decision, and there are several levels of private sector participation. Moreover, the success of privatization is likely to depend critically on the precise features of the contract itself, the extent of regulation and competition, and the criteria set out for contracting. To take one example, Governments which privatize in situations of fiscal distress may be primarily contracting on the basis of highest Government revenues realized, whereas other contracts may be awarded on the basis of least expensive network expansion coupled with lowest tariff.

Much of the literature has focused on examining the effects of privatization on the efficiency of the former public firms (see Megginson and Netter 2001 for an excellent summary), with some empirical support for greater efficiency with private operation.[22] However, much of the criticism regarding water privatization in particular is that it will result in large increases in water tariffs, making the service unaffordable to the poor. This is one of the chief fears raised by critics of moves towards greater private involvement in the Indian water system, with the experiences in Cochabamba (Bolivia), Manila and Ho Chi Minh City provided as evidence of this (see for example Sridhar 2003b).

Several recent studies have attempted to evaluate the effects of privatization of water and other utilities on the welfare of the poor, explicitly attempting to control for existing trends and using non-privatized firms or regions as control groups where possible. Most studies focus on access to the water network and prices, since detailed information on water quality and regularity is not generally available. However, the one careful study which does look at quality does find significant gains. Galiani, Gertler and Schargrodsky (2002) compare privatized to non-privatized municipal water systems in Argentina, and find child mortality fell in the privatized areas through less water-borne diseases.

Three sets of studies which examine how water connections change with privatization are Shirley (2002), which examines Buenos Aires, Santiago, Mexico City, Lima, Conakry (Guinea) and Abidjan (Côte d'Ivoire); McKenzie and Mookherjee (2003) which examines Argentina, Bolivia and Mexico; and Clarke, Kosee and Wallsten (2003), which examines Argentina, Bolivia and Brazil. All these studies find increases in access following privatization, although only part (or for Clarke et al. (2003), almost none) of this increase can be attributed to privatization rather than other existing trends. The poor are the main beneficiaries of this expansion in access, since the upper part of the income distribution in most cases already have a piped connection.

The evidence on prices is more mixed. Shirley (2002) reports prices falling in Abidjan and rising in Conakry. McKenzie and Mookherjee (2003) find that water prices fell in Buenos Aires following the introduction of a concessionaire, and increased less under the water concession in La Paz than in other areas of Bolivia. However, the most infamous water privatization case, in Cochabamba, Bolivia, resulted in an average tariff increase of 43 percent. The result was the so-called 'water war', whereby violent strikes and demonstrations resulted in the cancellation of the concession and reversion of the water network to the old public utility.

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[22] See also the literature survey in Clarke, Kosee and Wallsten (2003) for more studies explicitly focused on the water sector.

McKenzie and Mookherjee (2003) provide a method to calculate the effects of water privatizations on poverty and inequality by valuing the effect on consumers of both the increase in access and the change in prices. Using this method in Bolivia, Barja, McKenzie and Urquiola (2003) estimate that gaining access to the water network is valued at approximately 11-25 percent of per capita expenditure for the poorest deciles, whereas relative price changes are found to have much more modest effects due to the low share of water in total expenditure. As a result, the water concession in La Paz is estimated to have resulted in a 2 percent reduction in headcount poverty and a small decrease in inequality. Even the price increases during the Cochabamba failed privatization are estimated to result in at most a 1 percent increase in headcount poverty.

The experience in other countries therefore provides some support for the view that appropriate private sector participation in the urban water sector can both improve efficiency and provide better service to the poor. While it is too soon to evaluate the effects of private involvement in water in India, several projects are now underway.

Examples of Private-Sector Participation in India

1.Leak reduction in Bangalore

An example of contracting out services to the private sector can be seen in a pilot project which began in June 2003 in Bangalore. The private firms Larsen and Toubro (L&T) and Thames Water-UK in a 70:30 joint venture received a Rs. 500 million contract from the Bangalore Water Supply and Sewerage Board (BWSSB) for a project designed to reduce leakage and unaccounted for water through district metering, replacing consumer meters, and relaying of supply lines. The project is funded by the Japan Bank for International Co-operation (JBIC). Competitive bidding was used to select the contractor, which was awarded a contract for a pilot area of 35,000 house water connections. In 18 months the two companies have to cut unaccounted for water for these connections from 31 percent to under 15 percent, and then operate and maintain the area for 18 more months, at which stage the BWSSB will take over management. Upon successful completion of the pilot projection, the BWSSB proposes to then invite global tenders to expand the project to cover 400,000 household connections.[23] To date there has been little controversy regarding this project.

2. The Sonia-Vihar Water Treatment Plant in Delhi

In 2001, after an international call for tenders, the Delhi Jal Board (DJB) (the Delhi Government water supply department) awarded a 10-year Build-Operate-Transfer (BOT) contract to Ondeo Degrémont, a subsidiary of the French company Suez Lyonnaise des Eaux. The contract covered the construction and maintenance of a 635 million litres per day water treatment plant, intended to supply 3 million Delhi residents with drinking water, at a cost of Rs 1.8 billion (approximately 50 million dollars). The plant itself has been completed and is now waiting for the water supply to reach the plant. It is scheduled to become

[23] See D.S. Madhumathi in The Hindu Business Line, December 26, 2002 "Project to plug leakages: BWSSB to shortlist bids" (http://www.blonnet.com/2002/12/26/stories/2002122600811100.htm), Larsen and Toubro announcements on the National Stock Exchange of India website http://www.nse-india.com/marketinfo/companyinfo/eod/announcements.jsp?symbol=L%26T, and The Hindu (2004).

operational in June 2004.[24] Water for the plant will be supplied from the upper Ganga canal of the Tehri Dam project, treated in the plant, and then distributed by the DJB.

This project has proved contentious with opposition from several groups. Critics such as Shiva et al. (2002) suggest that details of the contract and tendering process remain oblique, with allegations of corruption linked to claims that the contract was not in fact awarded to the lowest cost bidder. Farmers contend that the use of water from the Ganga river will deprive them of irrigation water, while there is also religious opposition to privatizing water from the Ganga, a holy river for Hindus (Ninan 2003). The Delhi BJP recently claimed that the project was a surreptitious government plan to privatize water in Delhi through the backdoor, and would result in huge price increases once privatization was completed.[25] These claims were denied by the Delhi Jal Board, but a lack of information regarding the specifics of Degrémont's contract continues to fuel speculation.

3. Bangalore Operation and Management

In September 2000, the Bangalore Water Supply and Sewerage Board (BWSSB) signed agreements with Vivendi Water and Northumbrian Water Group (NWG), a subsidiary of Suez Lyonnaise des Eaux towards operating India's first delegated water management. It was proposed that each company would be given a 5 year contract for a city zone, each of population 1 million. In their pilot zone, each company would be responsible for all of the services of the board, including water supply and waste water management, revenue improvement measures, billing and collection, and customer relations. The companies were expected to reduce leakage and improve distribution, and it was suggested that successful completion of the pilots would lead to 25-year contracts. However, political opposition and allegations of corruption in the awarding of the contracts have meant that as of January 2004, no follow-up action has been taken on the contracts. Northumbrian Water, having changed its name to Ondeo Water services, exited in January 2003, citing political instability and uncertainty as reasons for its withdrawal.[26]

4. The Tirupur Area Development Program

India's furthest step towards full privatization of water supply is the Build-Own-Operate-Transfer (BOOT) contract carried out by the New Tirupur Area Development Corporation Limited (NTADCL). Tirupur, in the state of Tamil Nadu, is India's largest producer of cotton knitwear and the textile exporters depend on water for their production. The industrial sector played a lead role in the development of a project to supply water to the dyeing and bleaching industries in Tirupur along with domestic consumers in Tirupur Local Planning Area. A BOOT contract was awarded after an international competitive bidding process to a consortium of India's Mahindra and Mahindra, Bechtel, and United Utilities JVC of the United Kingdom. These companies became equity owners in the project along with the Governments of India and Tamil Nadu, and the Tirupur Exporters' Association.

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[24] Sources: Delhi Jal Board (www.delhijalboard.com), The Hindu (2004), Sasi and Jain (2004).

[25] Reported in the NCR Tribune, February 24, 2004 "BJP resents foreign origin of Sonia Vihar water project", http://www.tribuneindia.com/2004/20040224/ncr1.htm

[26] Sources: The Hindu, August 2, 2002 "Row over "privatization" of water supply", http://www.thehindu.com/2002/08/02/stories/2002080204030600.htm; The Hindu (2004).

The project was first conceived in 1991, and after a long inception phase, construction began in November 2002. By February 2004, 47 percent of construction was completed, and the project is scheduled to complete construction in November 2004, and begin supplying water in April 2005. The project will supply 185 million litres per day, with 125 million litres destined for the knitwear industry, 25 million litres to domestic users in Tirupur municipality, and a further 35 million litres to surrounding villages and towns. The planned price will be Rs. 45 per Kl for industrial users and Rs 3.5-5 per Kl for domestic consumers.[27]

Although the Tirupur project has not met with as much resistance as the Sonia Vihar project, anti-privatization activists have still raised several objections. The first is that the prevailing groundwater in the area is of poor quality due to pollution from effluents from the textile producers, and now these producers will come to control the community's water supply. The involvement of Bechtel has also led to comparisons with the involvement of a Bechtel subsidiary in the failed privatization in Cochabamba, Bolivia, which resulted in large price increases (AID 2003).

II.8 The challenge ahead

The current system of municipal water provision in urban India has not succeeded. Many poor households are excluded from the water network, while a piped water connection still means irregular pressure and water supply, and questionable water quality for a large majority of customers. Moreover, in most cities water is underpriced, with much of the subsidy not being well-targeted to the poor. The result is that revenues do not cover operating and maintenance costs in most areas, let alone providing financing for needed quality improvements. The next few decades are predicted to place more pressure on urban water supplies, with large increases in the urban population adding to increased demand from growing incomes. The urban population of 244 million is projected to expand to about 660 million by 2025 (Pitman 2002). As a result the status quo is not sustainable, and reform is clearly needed.

Water is currently priced well below cost. Water rates in Delhi are currently less than one-sixth of operating and maintenance costs for many consumers, while at least a doubling of prices is required in many other cities. Such rates mean that even with efficiency improvements, water prices need to rise in order to cover costs. This provides both the reason for substantial reform and the biggest challenge. Successful pricing reform requires functioning meters, which allow prices to be tied to units of use, and political will. Experiences in several cities suggest that near full coverage of metering is possible. This seems to be an area where contracting out services to the private sector under a competitive bidding process could lead to improvements. The leak reduction project in Bangalore provides one such example.

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[27] Sample sources: http://www.water-technology.net/projects/tirupur/; Government of Tamil Nadu (http://www.tn.gov.in/policynotes/maws2003-04-12.htm); FIRE(D) (1999); The Hindu, February 16, 2004 "Tirupur water supply may begin by April 2005"
http://www.hindu.com/2004/02/16/stories/2004021604850400.htm

Concessions, Management and Leasing agreements will be difficult without prior pricing reform. The proposed operation and management contract in Bangalore has hit resistance, while a construction management project was also cancelled in Pune, in part due to pricing concerns. Opponents also cited a lack of transparency and corruption allegations in both projects. While there are possible gains from private management of utilities, given current pricing levels, it will be easy for critics to argue that privatization causes rises in price in such a situation. Successful reform therefore requires public awareness campaigns of the true costs of the current policies, and for price rises to be clearly linked to goals such as improvements in access, quality and service, and to the tax implications of reduced subsidies.

There is perhaps more scope for private involvement in providing new service, such as the BOT contracts in Tirupur and Sonia-Vihar. Providing a new service provides more visible benefits than improvements in management of an existing service. Nevertheless, if the new service operates alongside or in addition to an underpriced municipal service, the higher prices are again likely to be a political barrier to reform. Again general pricing reform is needed to make such projects politically viable in most areas. While increases in price are required in most cities, subsidies will still be needed to provide for the needs of the poor. However, the current system effectively subsidizes almost all connected users, while many of the poor do not benefit due to a lack of connection. Geographical targeting of subsidies along with increased emphasis on connection subsidies should be used to provide for lifeline water needs of the poor while increasing prices for other users.

Pricing reform is likely to be politically unpopular in the short term, while the benefits of an improved system will take time to materialize. For this reason it is vital to increase the amount of information provided, both in terms of the failing state of existing water systems, and in terms of transparency of the reforms sought. The World Bank's South Asia Water and Sanitation Program is in the initial stage of a regional water utility benchmarking project which should provide some useful information in this regard. However, much more information needs to be collected and made publicly available in India in order to make reform politically more popular.

While it is important to provide transparent and clear goals of the reform process in order to generate public support for reforms, it is important not to oversell the reforms. Unrealistic goals and public statements can cause the public to become quickly cynical and disillusioned above the reform process, and frustrate further efforts. Barja, McKenzie and Urquiola (2003) posit that overselling of the capitalization process in Bolivia was one reason behind public discontent with the process, despite overall results which appear quite positive from an economic perspective.

PART III: PERI-URBAN AND RURAL WATER SUPPLY OPTIONS

In this part of the paper, we start with a brief overview of water services in rural and peri-urban regions, and make the case for 'intermediate' technological options and multi-institutional partnerships for these regions. We then review low- to intermediate-cost options for water delivery, water augmentation and water treatment. In each case, we review the technology, give examples of the capital and operational costs (from field situations in India wherever possible), discuss the challenges to extending access through this means, and cite case studies showing how access was extended to previously underserved populations.

Unfortunately there are few peer-reviewed articles evaluating drinking water interventions in rural India. Case studies from the 'grey' literature, on which we have drawn, tend to be brief, optimistic, and not easily comparable to one another – therefore it is not always clear how to distinguish the features of a case from its 'lessons'. Consequently, our discussion of costs and of 'successful cases' should be considered illustrative rather than representative. In our concluding remarks, we summarize the recurrent themes in the literature, draw out the policy implications that these have, and point out some important themes on which the literature is scanty. We suggest directions for research and data collection that should make it easier for future researchers to understand what is working or not working, where and why.

III.1 Overview of water services in peri-urban and rural India

Rural India (which contains the largest number of people without access to safe water) and peri-urban India (which contains the fastest growing segment of such people) are different from urban India in that household water and sewage connections from and to centralized piped systems are not the norm. Investment in water supply and sanitation has been for decades skewed towards core urban areas rather than rural or peri-urban ones, and to water supply rather than sanitation (Christmas and de Rooy 1991). Patterns of access naturally reflect these investment decisions.

The consensus among water policy experts is that, as living standards rise, the demand for household water connections will increase. However, with the exception of the better-off residents of large slums and well-connected villages, in-house piped water and sewage will remain inaccessible to most poor people in the near- to medium-term. Community-based (shared) water facilities, therefore, which have always been the mode of access in Indian villages, have to be extended and upgraded in ways that are affordable, relatively convenient and sustainable for poor and unserved populations. Given the enormous diversity of income, community capacity, local and state government capacity, topography and rainfall in India, the range of feasible technological, institutional and financing solutions for access to drinking water will also be diverse. Where decentralized technologies and decentralized management are possible – through local entrepreneurs, local governments and community management – they have to be recognized as mainstream rather than 'alternative' methods of service (Ruet 2004).

Water services in peri-urban regions

For each major city in the developing world, India included, there is the city proper where roads, piped water, and electricity are relatively accessible. But either on its fringes or in slums and tenements at its centre, informal settlements spring up, populated mostly by migrants in search of work. These *peripherally urban* zones are called peri-urban areas. Peripheral urbanization is growing fast -- the Government of India estimates show that 20 – 25% of the urban population lives in slums. This is likely an underestimate because only official or 'notified' slums are counted. Peri-urban incomes are low, because of the lack of job opportunities and the low skills of many of the migrants. 32.4% of the urban population lives below the poverty line (Reddy 2002). The haphazard build-up of the settlements, the lack of funding for infrastructure, the unwillingness of governments to legitimize such settlements, and high population densities combine to make these places water-stressed and disease-prone. Diarrhoea is the most common disease, and human waste is the most common contaminant. Indeed, sanitation is generally a more pressing need than water supply in these slum conditions.

Peri-urban areas are rarely connected to their main city water supply or sewage systems. The settlements are generally illegal, so municipal governments are unwilling to legitimize them by providing or extending their water and sanitation services. The Brihanmumbai Municipal Corporation (BMC), for example, recognises only those peri-urban settlements that were in existence before 1995. In other instances, the poor financial state of the water agency prevents the central network from being extended to these unplanned areas.

Peri-urban residents without in-home connections meet their water needs in different ways. Where groundwater conditions permit, residents have constructed shallow wells with handpumps. Some urban slums in India have communal standpipes, fed by the city mains, and shared by groups of families (from a few households to several hundred people). But such water is often of poor quality. Where there is no potable groundwater, or the residents have not been able to construct communal wells, or to arrange for standpipes, the two most common options are illegal water siphoning and water vendors. Illegal water siphoning occurs by breaking into the city pipes or storage systems, diverting the needed water, and in the process allowing biological and other contaminants to enter the city's water supply. Newspaper reports on how, for example, the BMC repaired water pipes that had been broken only to find that in a few days the holes had reappeared are not uncommon. Water vendors are also common in India, especially in the unserved areas of water-short cities such as Rajkot, Ahmedabad and Chennai. Such privately vended water -- which seldom has any quality controls -- sells for from 5 to 50 times the price of piped city-supplied water.

Water services in rural regions

Rural areas are characterized by 'traditional' activities such as fishing, farming, herding and crafts-based production such as food processing, textile weaving and printing, pottery etc. Populations in rural areas are more dispersed than in urban centres, though South Asian rural habitations are denser than in Africa and Latin America, and the boundaries between 'villages' and 'towns' are uncertain and shifting. In developing countries, rural areas typically account for between 60% and 70% of the population, but only 30% - 40% of the gross domestic product. For India these figures are 70% and 40% respectively (GoI 2001). Extreme poverty (defined as earnings of under $2 a day) is concentrated in such areas.

The simplest way to capture the state of rural access to drinking water is to quote from the 10th Five Year Plan of the Government of India. After explaining that only a third of rural households have water within their premises, and therefore the rest have to fetch water, the report says:

> "About 60 per cent did not have to go beyond 0.2 km for this. Seasonal disruption of supply was common, especially in the summer months. Households still depended on supplementary sources, especially where tubewell or handpump was the main source. Practices of filtering or boiling water before drinking were almost non-existent." (GoI 2002 - 2007, Chapter 5.5).

The national cost of fetching water has been estimated at 150 million person-days a year, costing the Indian economy Rs 10 billion in (potential) lost production (Chaudhuri 1998). The task of fetching is overwhelmingly female – a study of the Konkan region of Maharashtra estimated that each woman spent an average of 1.8 hours per day fetching drinking and cooking water (Ahmed 1999). Common methods of carrying water are a large pot on the hip or two nested pots on the head, with a total capacity of between 20 and 30 litres (Reddy and Rathore 1993).

The majority of the rural population (67%) draws its drinking water from open wells and handpump systems, and aquifers supply almost 80% of rural India's drinking water. Handpumps have been used in India for decades – over 3 million have been set up by the Rural Water Supply Programme alone – so they have been exhaustively refined and field-tested. Modern handpumps are widely manufactured in India and are designed for easy maintenance using few tools. Well drilling has also become cheap and efficient, especially in the alluvial North. Despite these advances, a third of South Asia's rural water infrastructure is estimated to be dysfunctional (Parker and Skytta 2000).

In rural areas of India, the primary reasons for inadequate access to drinking water are aquifer overdraft, diversion of surface water sources towards agricultural and urban uses, biological contamination of (especially surface) water sources from human and animal waste, terrible sanitation conditions (a major cause of biological contamination), groundwater pollution, the failure of water services to keep up with population growth and the failure to maintain existing water delivery systems such as handpumps. The Tenth Plan cited above shifts the responsibility for "drinking water and maintenance of community assets" from state level entities to Panchayati Raj institutions (PRI), which, being closer to their constituencies, are presumably more accountable to them.

III.2 The case for mixed and 'intermediate' delivery systems

As with urban systems, the shortage of investment capital and the lack of cost recovery are major constraints to extending water and sanitation access in rural and peri-urban areas. Centralized piped delivery systems are not the norm here, and in this section we make the case that, to extend access within a reasonable time frame, low- to intermediate-level technologies and multi-institution collaborations will play a significant role (Ruet 2004). These are technically and financially more feasible than in-home piped water supply and sewage, given the costs of the latter, and given the likely future outlays for water and sanitation in India.

If full access (defined by Indian national standards) were to be extended to all the currently unserved using traditional, government provided systems, public expenditures on water supply and treatment would have to go up by several orders of magnitude. A joint GoI / World Bank estimate, reported in WSP (1999a), concluded that Rs 29 billion a year would be necessary just for operation and maintenance (O&M) in rural areas, plus investments of Rs 200 billion to rehabilitate and repair existing but malfunctioning systems, and Rs 450 billion to achieve full rural coverage.[28] As against these numbers, the actual O&M expenditures were Rs 2.5 billion a year. For urban areas, if O&M could be fully covered through higher tariffs, an investment of Rs 284 billion over five years would be needed for full coverage. The report also suggested that the maximum expected outlay would be Rs 30 billion annually for rural and urban water supply. New technical, financial and institutional options would clearly have to be sought.

[28] All costs in 1999 rupees, when $1 = Rs 43. We have quoted costs both in Indian Rupees and US dollars, depending on the source. Consistent conversion to one currency was difficult because some source documents do not give the base year for their cost and price information.

In a study of the global water situation, UNICEF argued that, to cover those without access to safe water, it was imperative to focus on cost efficiency, including low-cost but effective technical choices (Christmas and de Rooy 1991). The study estimates were that for urban-type systems with treated, piped, in-home delivery, the capital and recurring costs would be on average $200 per capita (in 1990 $); minimally treated piped water delivered to public standpipes would cost $100 per capita; and low cost options such as borewells with handpumps, rainwater harvesting or gravity-flow piped systems would cost only $30 per capita. These are, of course, very rough estimates, but they indicate the relevant orders of magnitude. Similar (though somewhat higher) estimates can be found in Briscoe (1995).[29] In comparison, per capita GDP in India in 2002 was US $480 (World Bank 2004).

Many low-cost (and low-maintenance) water delivery, augmentation and treatment technologies have been, and are being, developed to serve the rural and peri-urban poor. Many of these have remained at the 'demonstration' level, others have been more widely implemented but are of dubious effectiveness in real-world settings, and yet others have failed outright. We focus on technical options and institutional partnerships that are:

1. already in existence in India, but should either be more widespread, or made more effective and reliable; or
2. not common in India, but *tried and tested* in other low-income settings.

III.3 Water delivery mechanisms

A *water delivery mechanism* is a method by which water that is already available to a water agency or community can be accessed by individual users and households. These include rural piped water systems that serve one or several villages from a small reservoir or overhead tank; shared standpipes in slums and small towns; spring-fed gravity flow systems (very common in hilly areas); water sold from tankers or lorries by small-scale private entrepreneurs; and, of course, the handpumps on which the majority of the rural population still depends. We discuss below the role of non-networked (or mini-networked) piped water schemes, water vending and handpumps.

Small-scale piped water systems

Piped water schemes serve about 9% of rural India and 45% of small-town India (Section I.1 above). Rural piped systems are either single village or multi-village schemes. Water is pumped into an overhead holding tank, ostensibly managed by the *gram panchayat(s)*, from which a small network of pipes carries water to communal collection points in the served villages. Very few rural homes have individual connections. Recognised (or 'notified') slums are served by piped water from municipal water agencies, when they are served at all. Peri-urban piped systems usually terminate in standpipes shared by a large number of households. The Government of India considers a household to be 'served' if there is a water point no

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[29] We have found cost comparisons extremely difficult to carry out. First, they are not always available. When available, they are rarely complete – so they might include upfront capital costs and perhaps the annual cost of consumables. They almost never include transactions costs such as capacity building, contract negotiations etc. Nor do they include the costs of community education etc when these have been facilitated by NGOs. Even reports written by economists do not consistently impute an opportunity cost to 'donated' labour. Aggregated cost estimates with missing components make it hard to see who is paying the cost of what, relative to who is receiving the benefits.

more than 1.6 km from the dwelling, shared by no more than 250 people, and capable of delivering 40 lpcd.

Piped water is considered more desirable than shallow well water or surface water because it goes through at least secondary, and usually tertiary, treatment.[30] However the small-networked piped system in India is in very poor condition. In 1994 the Government of India estimated that 26% of rural piped schemes needed repair (WSP 1999a). Many standpipes are defunct – they are either dry or have 'lost' their faucets and run continuously. Municipal agencies or *gram panchayats* are nominally in charge of standpipe repairs, but in reality there is little follow-through. There is generally no arrangement to recover costs from piped systems except through the relatively few in-house connections. Where the electricity supply is intermittent, the large number of users per tap and restricted hours of operation make for long queues, mostly of women and girls. In addition, as mentioned above, low pressure in the pipes allows sewage to enter the water system. In short, public standpipes are a classic public good that display the classic symptoms of lack of ownership and free-rider neglect.

As individual households become better off, and able to afford individual connections, the demand for public standpipes is likely to fall. For example, SEWA, the trade union for self-employed women, offers micro-credit and capacity building services so that its small-entrepreneur members can afford in-house water connections and toilets.[31] SEWA's *Parivartan* Slum Networking Project in Ahmedabad, in partnership with the World Bank and the Ahmedabad Municipal Corporation, has been particularly successful in improving piped water deliveries to Sanjay Nagar and Sinheshwari Nagar (see WSP n.d. for a detailed account of SEWA Bank's innovative and accountable micro-credit structure). However, shared standpipes remain important sources of drinking water for those slum dwellers and rural residents who cannot afford, or do not want to pay for, in-home connections, or whose slums and homes are not 'legitimate'. They will also remain important for pavement dwellers and the rural landless who do not have *pukka* homes.[32] In the near- to medium-term, therefore, small-scale piped water systems will likely comprise both private connections and shared taps. The question is, how can they be made more reliable and effective for rural and peri-urban residents?

We discuss in some detail a multi-village case study – which elucidates both the financial and organizational arrangements through which piped systems can be effective in the medium term, and some sustainability-related concerns for the long-term. The case is a four village piped water scheme from Kolhapur district in the state of Maharashtra.

For over 20 years now, the joint water management body (*mandal*) of the villages of Lat, Latwadi, Shiradwad and Shivnakwadi has run its own multi-village piped water supply scheme, and has produced a healthy revenue surplus in the process. The water committee

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30 Secondary treatment separates solids from liquids and includes processes to remove microbiological contaminants. Tertiary treatment removes additional solids and nutrients and inactivates pathogenic organisms. Chemical coagulation, filtration and disinfection are all tertiary processes. (Gleick 2000, Ch 7)

31 SEWA's drinking water campaign in rural western Gujarat encompasses individual as well as shared piped water (Joy and Paranjape 2003); its slum upgrading programme, however, is a response to the growing demand of its members for private water supplies and toilets.

32 A *pukka* home is one that is built out of sturdy materials (clay, brick, thatch, sheet iron…) and can be expected to last some years.

came into being with the active encouragement of the Irrigation Department engineer and the *gram panchayats* – in particular the *sarpanch* (headman) of Lat. In this scheme, water is pumped from the river to a settling tank, particulate matter is allowed to settle, and then the water is released through pipelines at fixed times. Piped water supply is given to individual households and to public standpipes (for poorer people and for common use). Individual connections cost Rs 520 (in 1999), of which Rs 200 is a recurring annual fee;[33] water from the standpipes is free. The operation and maintenance of the public standpipes is paid for by the *gram panchayats*, and they in turn collect a small '*Panchayat* charge' from all the village residents. The annual water charges and the *Panchayat* charge cover the costs of repairs, electricity and salaries, plus surplus revenues have been used to create common village assets. Essentially, the Kolhapur scheme has found a way to use individual connection revenues to cross-subsidize the public water points.

The World Bank assessment (WSP 1999c) of Kolhapur's multi-village system highlights its three important lessons (presumably for scaling up and/or replication). First, it brings out the role of advocacy and mobilization, in this case performed by government officials (we see throughout the case studies in this paper the enabling and facilitating role of the state). Second, it shows how innovative cross-subsidies can make public standpipes financially viable (a problem that bedevils most public piped systems in the country). And third, the small size of the scheme enabled multi-village cooperation to be sustainable (this is a critical insight, well understood in the common-pool literature, to which we shall return below).

The Kolhapur scheme also reveals some problems – the source water in the river is getting polluted, the pumps are aging and need replacement etc. We focus here on two aspects that are relevant to the sustainability of, and to access from, piped systems everywhere, not just in Kolhapur (and that are just as much 'lessons' as the positive lessons cited in the literature).

1. *Declining water availability per capita over time*

With growing populations and growing demands, the scheme can no longer sustain its designed allocation of 70 lpcd. The 1999 assessment projected an availability of 31 – 35 lpcd by 2004 (lower than the GoI norms of 40 lpcd). In these circumstances, those with private connections will almost certainly withdraw more than 40 lpcd while those at the public standpipes will get less.

2. *Low water pressure in the pipes as a result of more household connections*

With more in-home connections, the withdrawal of water is spread out through the day. The standpipes, however, have fixed hours of operation. The staggered withdrawal lowers the water pressure in the pipes for everyone, allowing surrounding contamination to enter through cracks and leaks in the system. The declining pressure also increases the waiting time at the standpipes, disproportionately affecting the worse-off.

One option in such cases is to increase the water supply overall, perhaps through a larger allocation from the state, or through re-allocating a fraction of agricultural water, or through treating and recycling water. But this may not be possible (for scarcity or political reasons). Another option would be to meter the individual connections with steep charges beyond a minimum first tier (see section II.5 above). This is not the norm today, even in the

[33] To contextualize these numbers, it may be helpful to note that in 1998 the minimum agricultural wage in Maharashtra ranged from Rs 35 – Rs 40 per day. Minimum wage laws, however, are not consistently followed.

'successful' piped water schemes, and the viability of individual metering in rural and peri-urban areas is yet to be determined. A third option for water stressed regions would be to increase the number of standpipes and keep the charges for in-home connections high. The standpipes could serve fewer than, say, 150 people each, and either be run as common-pool resources (if the user communities are able and willing), or on the 'ration-card' model (where each household's withdrawal is monitored to ensure that everyone has access to an affordable first tier of water), or on the 'kiosk' model where water is sold to the users – or perhaps some combination of these. But we do not know of any piped water projects that incorporate these or similar safeguards. Finally, local water agencies could resort to tanker-supplied water for the poor, even in areas with piped water (see below).

The general problem is – what works well for the principle of cost recovery does not automatically work well for the principle of 40 lpcd for everyone. A casual line in the Kolhapur report from WSP reveals that: "The *mandal* reduced the number of public standposts to promote revenue-yielding household connections within the villages." That is, rather than make the standpipes on which poorer people depend more accessible, the *mandal* made them less convenient in order to 'encourage' more household connections. We see from numerous case studies in the literature that people are willing to pay for in-home connections rather than walk 1.6 km to a shared tap (naturally); but we do not see from these studies how to ration water (in water-short regions or in water-short years) so that the public health goal of 40 lpcd can sustainably be met. We do not know if and what people would be willing to pay for a standpipe-only system, but within 0.2 km of their dwellings rather than in the central village area. Our argument here is *not* against in-home connections or cost recovery, but against institutional and financial arrangements through which these goals could undermine, rather than support, the goal of wider access.

Water vending

Water vending encompasses many different kinds of water transactions that occur outside of, on the one hand, municipal distribution of tap water, and, on the other, direct collection of water by a community from a standpipe or handpump. The vendors play an intermediary role, which can involve re-selling water from a municipally supplied standpipe or obtaining water from a groundwater source and transporting it by tanker or cart to slum areas where residents purchase it. As a rule, vendors sell water for many times the rate charged by the city to its networked customers.

Though the *bhishti* (water carrier) is a traditional figure in India, the nature and extent of water vending has not received serious study in the Indian context. If vendors are discussed, they are generally vilified for exploiting the poorest. However, Crane (1994) reports that the legalization of water re-selling from municipal connections in Jakarta acted as a costless extension of the city's piped system (and as a transfer from those without connections to those with). Zaroff and Okun (1984) also argue that vending is a low-cost alternative form of water delivery. Kjellén (2000) shows that, given the inadequate state of Dar-es-Salaam's water infrastructure, small-scale water providers complement the public distribution system and do not provide poorer quality water to the slums than the city does to its official customers. Similar points were made by a comprehensive study of water vending and re-selling in ten African countries (Collignon and Vézina 2000).

Though few urban residents in India (1% according to the National Sample Survey, 54th Round) depend exclusively on water vendors, during periods of scarcity they are *the* mechanism of water service provision to the poor (and in some cases the rich as well). In peri-urban areas the exclusive dependence on vended water is greater than at the urban core. In water-short cities and rural areas, e.g. in and around Rajkot and Ahmedabad, city governments themselves operate tankers to serve areas without piped connections or clean groundwater. But the government may not own enough tankers to cover the unserved areas, and private water vendors operate in addition to these municipally approved tanker suppliers (Matzger and Moench 1994). We argue that, given the significant infrastructure investment needed to extend piped connections to the urban unserved, the operating deficits of most Indian utilities (Ruet et al 2002), the increasing focus on cost recovery (including capital costs), the inability of the majority of slum dwellers to contribute to capital -- though not necessarily operating – costs (Bajpai and Bhandari 2001), and the unattractiveness of peri-urban areas to the formal private sector (Derby and Gadgil 2003), more cities should consider recognizing, contracting with, and regulating local water 'entrepreneurs'. In the absence of such recognition and regulation, water vendors will continue operating anyway, but without quality controls, price monitoring or accountability. Because access to water (or the lack thereof) has clear public health externalities, the current lack of quality and price regulation is not tenable. Chennai's Metro Water Board, as reported by Ruet et al (2002), offers an example of devolution to local contractors as an interim way of coping with the joint scarcity of water and funds.

Chennai provides tap water for an average of just 4 hours a day, and has a slum population of about 400,000, but 97% of its residents are covered via tap and tanker services (MIDS 1995). The Water Board, which enjoys more autonomy than its equivalent in most other cities, has contracted with 500 private contractors to supply various parts of the city, including slums that do not have public standpipes. Exnora, a Chennai-based NGO, works with the Board to organize the slum dwellers into committees that distribute the tanker waters. The tanker transporters buy water from farmers outside the city centre,[34] paying them just over Rs 3 per cu m, and being paid Rs 15 per cu m by the Water Board (this includes the cost of transport and maintenance, in addition to the cost of water). Approximately 10% of the Chennai Water Board's annual expenses go towards hiring and monitoring these tankers. The contract is monitored by the Water Board -- the tanker owners attend regular vigilance committee meetings (at which Exnora is also represented) and train their drivers. In return, they are guaranteed daily business and prompt payments. Private tankers that are *not* under contract to the Board, in contrast, also buy water from farmers and sell the water in bulk to consumers – but for twice the price the city charges. The Board therefore has a chance to monitor the quality of water and service provided by those under formal contract.

Ruet (2004) suggests that such public-private-civil partnerships, some of which are already under way, should be expanded and formalized in several Class I cities. He argues that cities could start with delivery arrangements through local entrepreneurs, and only then consider contracting out to national or global service companies. This would lower the risk borne by

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[34] These groundwater withdrawals are unregulated, but groundwater withdrawal for domestic use is not a threat to the water table. Tamil Nadu's dire aquifer situation is almost wholly attributable to pumping for rice paddies and the resulting salt ingress along its coast.

the companies (who would not have to reach distant and unconnected households), better target the city's investments, and reduce the chance of cutting out the poor and unconnected – at least where institutional safeguards have been built in. This implies that exclusivity provisions in concession contracts, such as those granted to the privatized Aguas del Ilimani in Bolivia, should generally be discouraged, lest they "close down the possibility of employing competition in the market to reduce prices, improve service, or provide alternative service options" (Komives 2000).

Wells and handpumps

Well and handpump technology can be divided into three general categories:[35]

1. *Open wells*: The basic village well. New open wells are inexpensive to construct and require a minimum of external expertise and equipment. They are still appropriate in locations where the water table is high and regularly recharged, such as in canal command areas. Even where the lower layers of groundwater are brackish or saline, canal seepage forms a layer of fresh water above the brackish layer, which can then be accessed via a well (van der Hoek et al 2001). Simple open wells are an ancient technology, but are susceptible to biological contamination. Sealed bore-wells fitted with handpumps are therefore a public health improvement.
2. *Shallow well handpumps*: can lift water from depths of up to 7 m. Shallow-well pumps operate by suction, which limits their effective pumping depth, but means that all the moving parts (that eventually need replacement) in the system are above ground-level, making maintenance and repairs relatively simple. Many different Village Level Operation and Maintenance (VLOM) shallow handpump designs exist and are currently in operation. The choice for a given village / community would depend on the availability of the pump and the supply chain of spare parts and technical expertise in a given area.
3. *Deep-well handpumps*: are generally referred to as 'lift' pumps, since they use a pump mechanism placed underground rather than using suction at surface level. This design enables deep well handpumps to lift water from 50-60 m below the surface, but the configuration makes maintenance more difficult in comparison with shallow-well designs. International and Indian research and development efforts over the past 25 years have produced several VLOM deep well handpump designs, including the India Mark III and Afridev. These pumps are widely manufactured in India (and Pakistan) and have been field tested in thousands of locations.

Handpump technology has two upfront costs: digging the bore, and purchasing and installing the pump, which includes pouring a concrete pad. The generally-accepted $25 average cost per capita rule of thumb for water supply and sanitation projects in Asia (Nigam and Ghosh 1995) is based on (shared) handpump installation, because the vast majority of community water projects in developing countries, including India, have been of this type. Nigam and Ghosh (1995) estimate that per-capita best practices costs (BPC) for deep well boring and handpump installation in rural areas are of the order of $6 in Asia.[36] Actual costs vary depending on the availability of pumps and spare parts, drilling equipment, road

[35] The technology descriptions and some of the cost estimates for handpumps, rainwater harvesting and water treatment methods borrow heavily from Downing and Ray (2002). We thank Jim Downing for generously allowing us to draw upon this work.
[36] South and South East Asia have the lowest costs – the per capita BPC is $15 in Africa (because almost all supplies spare parts have to be imported) and $30 in Latin America (because of relatively high labour costs).

conditions, and local management expertise. The price of a high quality VLOM deep well handpump is, roughly, \$500-\$800, while well drilling can cost anywhere from a few hundred dollars to over \$10,000, depending on the depth of the well, soil conditions, the drilling equipment used, labour costs, and the degree of community participation (Carter and Ball 2002). In hardrock regions of India (where it is naturally more expensive to drill), Talbot (1997) estimates that an India Mark II pump, of 5" diameter, drilled to a depth of 60 m and cased to 10m would cost about \$1300. [37] For shallower bores upto 30m the cost of a pump unit is only \$170 (1996 \$). In neighbouring Pakistan, competition among producers of a smaller and local version of the Afridev has brought down capital costs of the pump unit from \$320 to \$130 in 10 years (WSP 2000).

Handpumps and wells are a suitable technology for any rural or peri-urban location where the groundwater is not contaminated and the water table is not lower than about 60 metres. Because of high population densities, lack of sanitation and industrial activity, peri-urban groundwater in many, but not all, cases is too contaminated for a handpump to provide safe water. Aquifer levels are also dropping as water is withdrawn for municipal and industrial use, and as the natural recharge area is reduced through paving over. In some areas, however, there are several layers of groundwater, the deeper of which is usually less contaminated. So residents using a shallow-well pump to draw water from a polluted near-surface aquifer would benefit from additional investment to tap their deep aquifer. Many sites also simply have broken handpumps that could be replaced – the Government of India's own report in 1994 estimated that 22% of handpumps needed repair, and 12% were totally defunct (cited in WSP 1999a). Finally, as with standpipes, walking times and waiting times are a daily burden on (mostly) rural women and girls (Ahmed 2000). The UNICEF standards of one water point for 250 people is probably not adequate for most communities (as we argue in our conclusion), and in any case is not met where populations have risen over time but the number of water collection points has not.

Groundwater depletion and aquifer pollution (from natural sources, e.g. arsenic, or human ones e.g. agricultural and faecal contamination) are the main threats to sustainable water extraction for basic domestic needs. In most locations, groundwater extraction for domestic consumption alone will not deplete the local aquifer. Unfortunately, groundwater withdrawal for irrigation is almost totally unregulated, even in developed countries, and aquifer overdraft in India is effectively promoted by state governments through energy subsidies for pumping. With increasing industrial activity and agricultural chemical use, aquifer contamination is increasing, with little prospect of near-term regulatory or management intervention. Despite these problems, thousands of villages remain where inexpensive handpumps and working wells are urgently needed.

Setting aside the aquifer depletion problem for now, India's handpump infrastructure can be revitalized if the systems are convenient to access, if they can be repaired and maintained without delays, and if the costs of new installations and maintenance can (at least partially) be recovered. Two innovative efforts from two different states offer some insights into how these goals might be achieved.

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[37] The cost of drilling in hardrock has been brought down to about \$20 per metre in India – this is probably the lowest figure in the world.

1. *Swajal Project; Uttar Pradesh* (WSP 2001b)

The World Bank assisted Swajal Project is a US$ 63 million effort, to cover 1,200 villages with a population of 1.2 million in 19 districts in the Hill and Bundelkhand regions of Uttar Pradesh. The main goals are to provide water through a combination of technologies (piped water, handpumps, rainwater harvesting and open wells); to introduce sanitation and composting; and to increase environmental and health education. All the projects under this scheme require 10% of the capital costs and 100% of the operating costs to be paid by the users. Village water and sanitation committees are elected, are empowered to operate the project bank account, and to make decisions about technology choice and the contracting of goods and services. The committees work closely with their facilitating NGOs and their Project Management Units, which are autonomous and registered at the state level. Swajal is an ongoing project so it is too early to evaluate its overall effectiveness and sustainability. An interim report from the village of Laxmipur relates how the water committee visited private firms that had submitted competing bids for the construction of a tubewell with an overhead storage tank. Another report from Khankatiya – a hill village in Pithorgarh – shows how the village committee, which had decided that they needed a gravity flow water system, found a skilled mason from a distant village to construct the reservoir. The Uttar Pradesh Jal Nigam (the official water agency) plays little role in Swajal, but the UP state government has supported it in principle and through allocating funds.

The Swajal Project is not a handpump project as such – it covers too wide an area to use any one means of water delivery – but we note that villages that do use handpumps contract for an average of eight handpumps per village. A crude per-capita calculation reveals that 125 – 150 people share a handpump (that is, the water points are almost twice as dense as UNICEF standards). Waiting times, walking times, and free-rider induced neglect are all likely to be reduced with smaller user groups, making these community-level schemes more expensive in the short run but potentially more sustainable in the long run. We return to this point later in the paper.

2. *Samaj Pragati Sahayog*; *Madhya Pradesh* (SPS 1999)

Samaj Pragati Sahayog (SPS) is based in Dewas district, Madhya Pradesh, a drought-prone and heavily *adivasi* region.[38] In 1993, a survey found that 70% of the area's handpumps were in disrepair, and that government-trained mechanics were unwilling to travel to these remote villages to carry out repair and maintenance activities. SPS sent 4 tribal men to Tilonia in Rajasthan (which has a nationally respected Social Work and Research Centre) to be trained in handpump repair and maintenance. Upon their return, they formed a core team of mechanics, repaired the handpumps in 14 villages (previously declared 'irreparable' by government mechanics) and trained others through SPS-organized handpump workshops and camps. By 1997, over 50 *adivasis,* including 11 women, had been trained to repair handpumps. They worked in 14 hand-pump 'circles', each circle comprising 2 – 3 *panchayats*, with a trained mechanic in every circle. Each circle today is self-reliant in parts and tools, and all handpumps are working. This has ensured a basic supply of safe drinking water.

The SPS model is very different from the Swajal model in that formal cost-sharing arrangements do not exist between the government and the user groups. Nevertheless, it

[38] *Adivasis* are India's indigenous peoples. They are commonly referred to as 'tribals' but many scholars prefer the term *adivasi* (literally: 'first residents')

exemplifies the principle of cost-sharing in the form of labour from the users, organization from the facilitating NGO, and a small cash grant and legal recognition from the Madhya Pradesh government. The government has officially turned over the responsibility of handpump maintenance to the circles, and it was the government that suggested expanding out from the original 14 villages to the 90 villages that are now served by the circles.

The Madhya Pradesh effort is small, while the Swajal Programme of Uttar Pradesh is much more ambitious. What they have in common is that the relevant NGOs or donors partnered in some fashion with the local governments in question – instead of trying to bypass the government altogether – which could be essential for scaling up successful pilot efforts (World Bank 2004; Chapter 2). This makes Swajal and SPS potential models for replication in other communities that face similar problems but have the capacity to self-provision.

A note on handpump history

We have seen that approximately a third of India's handpumps are either defunct or in need of repair – a depressing statistic that is a regular feature of the literature on the failures of government water policy. But it is worth mentioning that, when looked at through the lens of history, the largely publicly-funded handpump programme has been a phenomenal success. Access to safe water increased from less than 10 per cent in 1966 to 31 per cent in 1980 to 82 per cent in 1996 (Talbot 1997). This remarkable achievement was a result of NGOs experimenting with technologies of drilling boreholes and developing pumps strong enough for community (rather than family) use; of the Government of India generating demand so that private companies stepped in to produce and improve the handpumps and spare parts; of training GoI engineers and mechanics to use and repair these new technologies; of UNICEF's sustained support at the level of national policy as well as on-the-ground implementation; and of NGOs continuing to work with rural communities. For instance, the 'India Mark II' model was designed by an NGO in Maharashtra, modified and improved by an engineering company with UNICEF funding, and launched as a massive effort by the GoI's Rural Water Supply programme.

Of course, today it is clear that the state-led maintenance system has broken down and that the handpump programme needs some mode of cost-sharing to remain viable. It is also clear that declining water tables and water quality pose the most serious threats to the handpump network. As Talbot (1997) reminds his readers, "The India experience has taught us that every problem has a solution; but that each solution creates another set of problems." Nevertheless, the history of India's handpump programme is a history of multi-institution coordination towards a single goal that remains instructive in the light of today's problems.

III.4 Water augmentation mechanisms

A *water augmentation mechanism* is a method by which water that would normally run off into rivers or seas, and so would not be accessible for drinking or agriculture, is captured and stored so that it can be used. Augmentation methods include storing water in underground tanks for use in the dry season; collecting rainwater on the rooftops of homes, schools etc; and watershed-scale rainwater harvesting which can directly be tapped or can recharge the surrounding aquifer. Of these methods, watershed-scale rainwater harvesting has received the most attention in the literature and on the ground in India, and is part of official water policy in at least five states. We focus this section on this option.

Rainwater harvesting

The simplest and most common method of watershed-scale rainwater harvesting is the construction of a checkdam across a seasonal drainage. During heavy rains the ground becomes saturated and rainwater flows quickly along the surface instead of percolating into the earth,[39] flowing into drainage channels and then into streams, rivers, and ultimately the ocean. A checkdam built across a drainage channel prevents the water from flowing downstream, creating a small reservoir. The water in this reservoir has two uses -- directly as surface water for watering animals or for bathing, washing, or, with protection and disinfection, drinking. The water in the reservoir also seeps into the ground, recharging the local aquifer, to be tapped over the rest of the year. Maintenance of a checkdam and reservoir is relatively simple, the major task being periodic silt removal.

Watershed RWH on its own is not a complete supply solution. A surface reservoir is subject to biological contamination as is any pond and will need protection and treatment to be safe for drinking. Rainwater harvesting provides a reliably clean water source most easily and inexpensively when it is used to recharge an aquifer that a community can tap via an existing well. Many locations in India suffer from aquifer depletion, most often as a result of irrigated agriculture. In such locations, a well and handpump are often already in place, and a well-sited aquifer recharge project can make those wells useful again. An important benefit of watershed RWH is that it can provide additional water for livestock watering, and potentially for agriculture. A rural community thus gets water for productive activities important to the sustainability of its lifestyle, rather than just a subsistence water supply. But one problem with RWH in such settings (as with pump projects in general) is that, unless groundwater extraction by agriculture is regulated, there is a significant risk that the recharge project will just be supplying water to farmers, and not to the villagers that need the drinking water.

The capital and start-up costs of RWH are hard to generalize. The major cost is in checkdam construction, and the size of the dam needed to catch a given volume of water will vary substantially with topography, and with whether the goal is just drinking water or additional productive activity. Local availability of construction materials, equipment, and construction expertise also influence the cost. So do the arrangements for construction labour – certain communities donate labour while other pay wages in cash and/or food. In the publicly-funded Gujarat program mentioned below, the average checkdam construction cost was about US $3200, and the average reservoir retained about 15 million litres of water. So, very roughly, the cost per litre of harvested water was $.00023 per litre, or 23 cents per thousand litres -- approximately two orders of magnitude less than the costs cited for rooftop harvesting systems (Shingi and Asopa 2002). At this rate, catching enough water to give one person 20 litres per day for one year would cost only $1.69 (though to make sure that enough recharged water makes it to wells where it can be withdrawn and used, more water would need to be harvested, so costs will be higher). Another set of costs was provided by

[39] This is why rainwater harvesting is necessary where topography permits, and why wells alone are not enough. The soil cannot store the moisture when the rain falls over a few days in heavy torrents – especially if there is a hardrock layer a few meters below the ground. This rainfall and bedrock combination is common in India's drylands. In addition, where groundwater levels are depleted or polluted, harvested rainwater is a cleaner, more accessible source of water and of shallow aquifer recharge (Shah et al 1998).

Sanjit Roy,[40] from RWH efforts in Rajasthan and Sikkim. These systems store rainwater (for drinking only) in underground tanks that are treated with chlorine and fitted with handpumps. The labour component in Rajasthan comes to $0.03 / litre in rocky soils and even less in sandy soils. The water is sold (by tanker and at the pump itself) for an average price of $0.02 / litre. The Sikkim structure – with the tank carved into the hillside -- has a storage capacity of 160,000 litres and a total per litre cost of $0.03.[41]These costs are only for the investment in the checkdam, and do not include well re-boring, handpump replacement, capacity building, NGO facilitation, etc. that may additionally be necessary.

Despite impressive results from many RWH efforts, and the near-zealous advocacy of its many proponents, RWH cannot be implemented in every town and village. The lower reaches of watersheds are better catchment areas for harvesting rain than the upper reaches in general (Kerr, Pangare and Pangare 2003). Uncertain subsurface hydrology makes it difficult to predict the rate, direction, and extent of the movement of water underground. It is therefore difficult to predict the annual yield of a watershed rainwater harvesting project, in terms of the accessible groundwater that it generates. Small checkdams are simple engineering structures and can be built from earth, rocks, masonry or concrete. Larger checkdams introduce a series of complications -- the engineering is more complex, and the danger of collapse more substantial. Further, because water rights are poorly defined (or simply defined as being the property of the state), large checkdams that produce large reservoirs can generate conflict with the state, other water authorities and downstream water users. We shall re-visit this point later in the paper.

Major NGOs and environmental organizations such as Samaj Pragati Sahayog (Madhya Pradesh), Centre for Science and the Environment (Delhi), Barefoot College and GRAVIS (both in Rajasthan) and Utthan (Gujarat) have been active in promoting and implementing RWH for many years. Government programmes in several Indian states have also led to the construction of large numbers of watershed RWH structures. The state government of Gujarat in 2000-1 funded a cost-sharing program whereby farming village residents, with NGO assistance, constructed more than 10,000 checkdams in less than a year to recharge agricultural and domestic wells (Shingi and Asopa 2002). Several NGO efforts have focused on developing community capacity and resource mobilization, without any connection to the state water authorities. However, as RWH goes to scale, it is essential to work with relevant water agencies or Irrigation Departments – for reasons of property right allocations, third party effects of numerous (though individually small) hydrological interventions, resource mobilization, and overall integration into mainstream water policy. We present an example which is NGO-led, but state government-partnered, as a model for advancing access to water through RWH, where conditions permit.

Samaj Pragati Sahayog (SPS) is based in Bagli *tehsil* in Dewas, Madhya Pradesh. It has pioneered efforts to provide water, and also year-round employment, through decentralized

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[40] Sanjit 'Bunker' Roy of Tilonia, Rajasthan, is a nationally known rainwater harvesting promoter and facilitator, who runs an innovative village-based programme of extension and outreach in the fields of health, education, rainwater harvesting, handpump repair, veterinary care etc. (www.barefootcollege.org)

[41] Cost breakdown from Barefoot College Training Campus, Sikkim. Costs were unsubsidized, and included material costs of cement, sand, iron rods, bamboo etc as well as labour, transport and sales taxes.

rural water systems and watershed protection.[42] In addition to the hand-pump project mentioned above, SPS has facilitated rainwater harvesting and water storage through earthen *bunding* and terracing structures. Central and Western India have seen repeated failures of the monsoon and severe drought conditions over the last decade. Rainfall deficits have led to a severe shortage of drinking water for people and water for livestock. To drought-proof villages against future lean years, SPS-organized teams of *adivasis* constructed protected ponds to hold rainwater and to recharge the local aquifers. They organized labour sharing and cost sharing schedules (most labour was paid the minimum wage, with less than 10% of it 'donated', and the financial costs were shared by donors, community members as well as the Madhya Pradesh state government). The teams also designed and implemented rules of water allocation that were transparent and (apparently) perceived to be equitable. In short, the water system was run on the common-pool resource model, which is not a feature shared by most (community-level) piped or handpump systems.

Today, after 10 years of work in the area, trained teams of *adivasis* frequently plan, choose the sites, and design the RWH structures for new projects (not necessarily initiated by SPS). The team accompanies SPS's technical experts from village to village, planning the project, explaining to the local people its purpose and mobilizing them to participate in the process. SPS has spread its work to over 100, 000 hectares in 4 Indian states, in most cases with financial and technical support from the relevant government agencies. SPS's cost estimate for a system of 100 rainwater ponds and 8 earthen *bunds,* for 7000 people in 15 villages, is approximately $ 300,000 (in 2002 US dollars). 10% of this sum goes to administration, training, education and community organization. The remaining 90% goes into the works. This is many times more than the number calculated for the hypothetical 20 lpcd water harvesting cost for the Gujarat checkdam project, because *much more* than 20 lpcd are being collected to recharge the aquifer. We note that the average cost of checkdam construction, about $3000, was roughly consistent across both projects.[43]

In a country such as India there can be no single blueprint for scaling up innovative water supply delivery and financing mechanisms. The SPS model of indirectly forging technical and financial partnerships between poor communities and their local governments is a way of delivering services in which the government does not provide the service, but pays a more efficient provider to do so. Morris (2004) argues that most private providers and NGOs enter the field of water and sanitation to 'compensate' for state failure, but some innovations can in fact be precursors of larger social changes. This was true of the Anand dairy cooperative which became the seed for Operation Flood. SPS's watershed development and SEWA's micro-banks, which have grown through partnerships with international financing and local governments, but have retained their focus on community needs and community autonomy, may have similar potential to be 'leverage points' (Morris 2004).

[42] It is quite normal for RWH projects to have multiple goals (drinking water, livestock maintenance, emergency irrigation and employment) – this is a feature that makes cost comparisons with purely drinking water systems impossible. While these multiple goals increase the costs per litre of water harvested, arguably they also increase community commitment and sustainability.

[43] Nivedita Banerji and Mihir Shah of SPS; personal communication.

III.5 Water treatment mechanisms

If water exists but is not safe to drink then it needs secondary and tertiary treatment – but treatment of water to make it potable has not been given the same attention as making a minimum quantity of water available. Where it is not possible (for reasons of cost or political resistance) to address the environmental source of contamination, on-site treatment is necessary. As a rule, the implementation of water treatment has been less successful than the development of water supply projects. Water supply is an obvious necessity for life, but water treatment could involve substantial changes in behaviour to achieve often difficult-to-perceive benefits. Water agency staff are typically better trained in managing repairs and delivery schedules than in water treatment options (as noted by the Sukthankar Committee 2003; p 9 above). And community capacity building and education for water treatment projects is, if anything, more important than that for water supply efforts.

In this section we focus on particle removing techniques and disinfection. Particle removal (settling and filtration) is the first step towards drinking water acceptability, and many disinfection methods will not work if the water is too turbid. Disinfection is next in importance – the WHO is clear in its recommendations that microbiological quality of water should be given priority over the chemical quality of the water when the health budget does not permit both (Gadgil 1998). Good sanitation practices and adequate methods to dispose of human and animal waste are, of course, inextricably tied to microbiological quality. We do not discuss methods of chemical removal, such as arsenic or fluoride treatment, because most of the relatively inexpensive treatments, that could conceivably go to scale in rural and peri-urban areas, are still in the field-testing phase.[44]

Particle removal techniques

Well-tested low-cost filtration approaches include sand filters and ceramic filters, both of which have been used for hundreds of years. Slow sand filters incorporate both biological and physical filtration properties. The BioSand filter developed by the Center for Affordable Water and Sanitation Technology in Calgary (www.cawst.org) is a household sand filter unit designed to be produced in developing countries. 20,000 BioSand filters have been installed worldwide.[45] Costs vary between $15-$30 per household unit. Flow rates are high, on the order of 30 l/hour. The BioSand (or any sand filter) has not gained traction in India, but the Dhan Foundation based in Tamil Nadu has just begun to promote these devices.

Ceramic filters, locally produced from clay using indigenous pottery techniques, provide a physical barrier that prepares the water for disinfection, and may even be sufficient to disinfect water alone. Ceramic filters such as the Terafil from Orissa, and the colloidal silver enhanced filters (Filtron) developed in Guatemala, may cost only $5 - $10 for a household unit. They are less durable than sand filters (their lifespan is 1 – 5 years) and they have low flow rates (1 – 2 litres per hour) (Murcott and Lukacs 2002; Sobsey 2002). But they are easy

[44] The focus of most research and action in this area is now on arsenic removal in rural Bangladesh and West Bengal, India. Several arsenic treatment technologies for developing country application, including co-precipitation, ion exchange and activated alumina filtration are now being field-tested. The household-based 2 Kolshi model of Bangladesh is under extensive testing. Another option is to bypass the groundwater altogether with rainwater harvesting or protected pond systems. Many foundations, research groups, and multilateral organizations are working on research and field testing in this critical area (WHO 2001; Murcott and Lukacs 2002).

[45] The specific countries are Haiti, Uganda, Honduras, Guatemala, Mexico, and the Dominican Republic.

to use, and are easy to produce (and therefore a local supply chain can be maintained). International Development Enterprises (www.ideorg.org) has piloted a 1000-household effort to test and promote a locally-produced Filtron in Cambodia.

As of today, the thrust of NGO-led and commercially produced filtration techniques for developing countries is on point-of-use (household) devices.[46] Both the BioSand and the Filtron are point-of-use filters, designed to be combined with "an overall water delivery network and intensive educational efforts aimed at improving water hygiene in marginalized communities throughout the world."[47] This makes them cheap, but it is generally harder to cross-subsidize the poorest with, and to ensure the rapid adoption of, household-level treatments. The intensive education advocated for the proper and continued use of point-of-use devices is uncommon except for 'pilot' projects. Regular cleaning and maintenance activities (that ceramic filters may need) are often inconvenient.[48] A comprehensive survey of household preferences in Bangladesh indicated a strong preference for centralized filtering and arsenic removal systems over household filtering technologies (Ahmad et al 2002). Finally, the effectiveness of these filters depends on the quality of the source water in the first place, so where the water is really turbid or coliform organism counts are really high, sand and ceramic filters will be of limited value.

Disinfection techniques

Boiling and chlorination

Boiling water is a widely used, simple and reliable way to disinfect water. At sea level, boiling water for one minute will effectively disinfect even turbid water. But energy costs of boiling water for the poor (who do not have access to, for instance, efficient gas stoves), are very high. In a typical biomass cookstove, boiling water for an entire family just for drinking will more than double the family's daily fuel needs.

Chlorine is the most widely-used chemical disinfectant in both the developed and developing worlds. The amount of chlorine required for effective disinfection varies widely with water characteristics including pH, temperature, particulate concentration, and common chemicals. Thus it can be difficult to determine the dose required (overdosing has health dangers and makes the water taste unpleasant). In-home disinfection with chlorine tablets has all the advantages and disadvantages of point-of-use treatments discussed above. Community water system treatments, in contrast, do not need such extensive education but do need trained operators to administer the dose and test the water source. Chlorine degrades over time (over weeks or months, depending on how it has been stored); and maintaining a supply chain can be difficult in rural areas. However, the Barefoot College initiated RWH efforts have used chlorine effectively to disinfect their community-level water storage. As a point-of-use example, the Centers for Disease Control (USA) have developed and tested the

[46] Community-based slow sand filters are being tested in India by the CLEANIndia campaign (http://www.cleanindia.org/jalpur_system1.htm). Improved slow sand filters (Jal-TARA), capable of removing both particles and most pathogenic bacteria, and with a yield of 2000 – 3000 litres per day, have been installed in schools, temples and villages. The Jal-TARA is very much a pilot project, and details on its use and costs are not readily available.

[47] Quoted from the literature of Potters for Peace (www.potpaz.org/pfpfilters.htm).

[48] The inconvenience of daily treatment coupled with the inability of crude filtration methods to reduce many diarrhoeas could be alternative reasons for the findings of Jalan, Somanathan and Chaudhuri (2003), cited above in Section II.1.

common-salt based Safe Water System. By 2000, there were 1 million users of the SWS in 15 countries, with the supply chain funded and maintained by international donors, multinational companies, NGOs, Ministries of Health and of Water, and door-to-door salesmen and kiosk operators (Lukacs 2003).[49]

Ultraviolet light disinfection

Ultraviolet (UV) light with wavelength in the 240 – 280 nanometre range damages the DNA of micro-organisms and is thus an effective water disinfectant. Compared to chlorine disinfection, its disadvantages are that it imparts no residual protection to the treated water, and needs a source of (grid or PV) electricity for the UV lamp. Its advantages are that it is scale neutral with respect to cost, needs a very short contact time with the raw water (a few seconds rather than 30 – 60 minutes) and over-dosing is not possible (Gadgil 1998).

Recent innovations for low-cost community-scale UV disinfection have been extensively field-tested and are in use in Mexico, the Philippines and Uganda. A 40 watt UV lamp in a unit such as Water Health International's *UVWaterWorks* disinfects water at a rate of 15 litres per minute (www.waterhealth.com) – high enough to serve a community of about 2000. Energy requirements for UV disinfection are thus three to four orders of magnitude less than that for boiling. With grid electricity, the cost of disinfection is approximately $0.10 per 10 litres of water, including the amortized cost of capital as well as all annual costs. Although per-litre operating costs for UV systems are lower than those for chlorine disinfection, the capital cost is higher – about $1,500 for a basic *UVWaterWorks* unit in the USA, and less for locally-manufactured alternatives.[50] So the costs must be spread over many community members. UV disinfection could be an especially good option for peri-urban areas where populations are dense and the water quality inadequate. Small-scale vendors operating kiosks using UV systems could provide a safer alternative to existing vended, handpump, or standpipe supplies.

Burch and Thomas (1998) have estimated the average operating costs of different in-home and small community-scale water disinfection methods in developing countries. Their cost comparisons indicate that a filter plus chlorine-treated plant would cost $0.07 per m^3; a filter plus grid-powered UV would cost $0.03; a filter plus PV-powered UV water would cost $0.15 per m^3; chlorine for home treatment without prior filtration would cost $0.09; and boiling with purchased fuel $20.83. (All costs are in 1998 US dollars, and indicate orders of magnitude rather than precise costs).

We now discuss a case study of rural water purification using UV from the state of Guerrero in Mexico.[51] The arrangement between the private producer (WaterHealth Mexico), local and

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[49] As expected with these individual units, the CDC cautions: "Maintaining long-term use of the SWS requires sufficient resources to continue project activities such as social marketing, promotion and product distribution." (www.cdc.gov/safewater)

[50] This particular design is expensive because it is fail-safe and almost zero-maintenance – less expensive but less reliable UV designs, for community use as well as individual use, do exist and are being field-tested.

[51] Unlike the other studies in this paper, there is no official documentation on the Guerrero case. All the information in this section comes from visits to several Guerrero sites by one of the authors (Ray) and her colleagues; data collected from the Department of Health authorities in Chilpancingo, Guerrero, by Dr. Yvonne Flores; discussions with Dr. Mario Manjarrez in the clinic of Los Mogotes, Guerrero; and a 2003 visit

also private maintenance engineer, the Department of Health in the state of Guerrero (who paid the capital costs) and the rural community-based health clinics (who perform minimal maintenance and track the health outcomes), offers an example of multi-institution coordination that could be feasible for at least some Indian states. But the Guerrero case also suggests potential problems of regulation and cost recovery that are instructive.

Guerrero, near the south central Pacific coast of Mexico, is one of its poorest states. In 1998 the Department of Health of the State of Guerrero purchased 58 community systems from a WaterHealth Mexico (WHM) and installed them in dispersed rural communities 1999/2000. The communities were largely without in-home piped water. WHM incorporated the basic *UVWaterworks* into a six-step community level drinking water treatment plant, which processes water from a protected spring or a bore well and delivers filtered and disinfected drinking water for pick-up at the village health clinic. The total capital cost – including pumps, settling tanks, filtration units, the UV system itself and the tanks which store the purified water – was just over $3000. Each installation serves 2000 – 2500 people daily. The weekly maintenance (cleaning the filters and the holding tanks) is relatively simple and is carried out by a community member, usually an employee of the health centre. Quarterly maintenance such as changing the filters, cleaning the system and minor repairs is carried out by the engineer employed by WHM. Annual maintenance (primarily checking the system thoroughly and changing the UV bulb) is also the responsibility of WHM. The Health Department pays for the maintenance costs (approximately $20 per community per year). The users themselves collect the water for free. Though no rigorous before-and-after studies of diarrhoea exist, considerable anecdotal evidence and weekly clinic records suggest that the rate of diarrhoea has fallen dramatically among children under age 5 in several (but not all) of the UV villages.

The Guerrero sites show that water community-scale water treatment systems can be installed and sustained with workable collaborations between local governments, the private sector and community members. However, three issues remain unresolved.

1. There appears to be no formal mechanism for the Health Department to *monitor and regulate* the maintenance performance of WHM and its engineers. As a result, quarterly maintenance is irregular, especially in the more remote villages.[52] Some of the Guerrero communities are pro-active in maintaining their systems, but not all communities are able or willing to do so.
2. There is no mechanism for *cost recovery* from the users. The operating costs of the UV systems are so low that they can easily be recovered. Cost-sharing may not be necessary at the 60-village scale, but will almost certainly be necessary if the state of Guerrero decides to scale the programme up.
3. Finally, many target *users live too far* from the safe water systems. The rate of use of UV water is higher where populations are densely located close to the installation sites. Access is therefore inconvenient for many households, though technically in accordance with UNICEF guidelines. The systems would undoubtedly be more effective if there were e.g. two per village rather than one – the costs of the system shared by 1000 rather than 2000

by a student team (Sharon Karlsberg, Pablo Seminario, Jason Stein and Michelle Thomas) from Haas Business School, UC Berkeley. We are grateful to all of them for sharing their unpublished data.

[52] This pattern of providing or (in this case) financing the supply mechanism but not following through on repairs and maintenance is all too common in developing country contexts (World Bank 2004; p 74).

people would still be low relative to the costs of frequent diarrhoea. Another option would be to construct a small piped network from the system, terminating in shared water collection points throughout the residential areas. This is how many rural piped water schemes in India are designed.

III.6 Some conclusions, some concerns

The literature on drinking water in India is characterized by an overall sense of policy failure and barriers to access, punctuated with numerous examples of successful 'cases'. But what is each case a case of? Cases tend to be written up as examples of what their particular authors are interested in – of community participation, of private sector participation, of appropriate technology, of willingness to pay, of equitable sharing among all users. It is therefore a challenge to answer the key question for rural and peri-urban India – i.e. *how feasible is it to scale up access to drinking water through decentralized technical and institutional options?* In more concrete terms, what are the lessons from these diverse experiences and how do we know that these are the lessons? In this section we bring together the vast but varied literature to highlight some recurring themes of relevance to an affordable, sustainable and replicable drinking water programme. We also identify themes that do not recur, but should.

Sharing the costs

Sharing the cost of a new water system or of upgrading and maintaining an existing water system is a consistent theme in the literature. Many NGO-led rainwater harvesting efforts work only in those communities that are willing to contribute up to 20% of the capital costs, in addition to 100% of the annual costs. The Prime Minister's drinking water initiative, *Swajaldhara*, has made a 10% cost contribution from the community a condition for releasing the remaining 90%. The World Bank has conducted and commissioned many willingness-to-pay studies that show that even poor people will pay for water if it is conveniently and reliably supplied.

The cost-sharing mechanisms that both communities and lenders find acceptable will vary. These mechanisms include micro-credit for infrastructure improvement (SEWA); operating costs recovered through community contributions (Swajal; Kolhapur multi-village system); and combined cash and labour contributions (SPS; Barefoot College). Some of these arrangements are variants of Public Financing of Infrastructure, or PFI, whereby the government finances essential infrastructure through providers who are more efficient than the government itself (Morris 2004). Mukhopadhayay (2004) persuasively argues that the government's existing water budget can go much further with creative PFI contracts.

Three questions remain under-explored in the literature on cost-sharing. First, how can the poorest people or the poorest regions be cross-subsidized? Targeting specific populations or specific areas is complex, and targeting methods have both direct and hidden costs for the administration and for the poor (van de Waal 1998). Few studies on rural cost recovery contain thoughtful discussions on cross-subsidization, though they admit that it is necessary (WSP 1999a; p8).[53] Second, what have been the public health impacts of specific cost-sharing

[53] One possibility is to have publicly funded community-level services (such as wells and yard taps) and recover full costs from 'private' services beyond that (meaning, no subsidies for the added cost of in-home connections) (Briscoe and Garn 1995). This rule of thumb has not been followed in many recent slum upgrading initiatives.

arrangements? With few exceptions, cost-sharing is treated as a goal in itself rather than as a means to extending access for reasons of public health. And third, are parallel efforts under way to withdraw urban subsidies over time? In a fine report on water services in India, the Water and Sanitation Program claims that, "People, including poor people, can afford and are willing to pay for safe water: if they get a reliable supply; if they get the service levels and other features they want; and if they are sure other people are paying their fair share too" (WSP 1999a; p11). This last consideration has, however, dropped out of most studies on cost-sharing and cost-recovery.

Sharing the water

Relative to the rules of cost-sharing, the rules of water-sharing have not been given much importance. Water supply connections for which users are willing to pay may not assure access for all just because cost recovery has been assured. As mentioned earlier, the more extensive the piped network for a given volume of water, the more difficult it is to maintain water pressure. The larger the number of un-metered private connections, the harder it is to ensure a minimum ration of 40 lpcd for all – especially in times of scarcity. In short, demand-led supply solutions have to take into account the near-term growth of demand, and to protect access to the national goal of 40 lpcd. But there is no evidence that they do so at present.

As for community-scale water systems – these are designed to be shared, and are therefore common-pool resources (CPRs). Yet the rich body of literature on CPRs, much of it from the irrigation sector in India itself, is all but ignored in the literature on drinking water. In the absence of guidelines for sharing water and labour (not just costs), common-pool resources become open access resources – owned by everyone and therefore no one (Ostrom 1990; Seabright 1993). Groundwater as well as public standpipes in India display this characteristic.

Empirical and theoretical work on CPR management has shown that shared resources can be used efficiently and cooperatively under certain (necessary, not sufficient) conditions. These include a small number of users, clear criteria for 'membership' in the group of users, simple rules of allocation that can be followed (and violations of which are easy to detect), and repeated interactions among the users (Wade 1988). Standpipes that serve over 300 people or borewells that serve an entire village are unlikely to fulfil these conditions. However, a water point that is shared by a small user group, living within a short distance of the source, might be easier to maintain as a CPR. It would also be possible to devise and monitor rules of water allocation during times of stress – as the participatory irrigation literature has shown (Datye and Patil 1987; Bardhan 2000). We do not assume that tubewells and standpipes that are spatially located in accordance with CPR principles will actually be maintained in good repair or will ensure water for all. However, we note that the Swajal study above showed that there were on average *eight* handpumps per village, and the Kolhapur study also emphasized the small size of the management unit. The implication here is that shared water points in rural and peri-urban India should be more densely located, certainly less than 1 km away from homes, despite the additional investment that that would require. *Effective* low-cost options are not necessarily the cheapest options.

Community-based water management is hardly a panacea. In heterogeneous user groups the resource is vulnerable to elite capture (Platteau and Gaspart 2003); proponents of CPR management often romanticize 'community' and ignore the larger political context (Mohan and Stokke 2000); and there are dangers to cementing a two-tier system where the rich are subsidised while the poor 'participate' (Jaglin 2002). However, we have seen that in rural and peri-urban areas common water sources are already the norm. Increasing the number of collection points would make them more convenient to use and potentially more amenable to sustainable management. Under conditions of water stress, a larger number of accessible water points might better ensure threshold access for all than mixed systems with in-home piped water for some plus inconveniently located shared water for the rest.

Institutional partnerships

There is remarkable consensus in the literature that governments should not be in the water provision business but should be responsible for ensuring that the poor receive a basic level of essential services (World Bank 2004). Governments should then ensure that private and NGO providers are regulated and monitored with respect to price structures and water quality, and should provide incentives for these providers to serve the poor. This new role for government translates to developing partnerships with the private sector and with civil society for water delivery. Such partnerships provide much-needed separation between the service provider and the regulator.

Public-private partnerships (PPP) have received the most attention, and have worked well in some rural and peri-urban areas (Chennai Water Board – tanker vendors; Guerrero Health Department – Water Health Mexico). Public – NGO partnerships (such as with SPS in Madhya Pradesh) are also effective and may be more committed to serving the underserved than traditional PPPs. Public – private – NGO partnerships are exemplified by SEWA's housing improvement loans[54] and the Indian handpump programme of the 1970s and 1980s. Finally, as the central government devolves responsibilities to lower levels, as the 73rd Amendment commits it to do, public – public partnerships between different levels of government (such as the Kolhapur scheme) may become increasingly common. All these mechanisms are potentially viable in the Indian context.

Two aspects of this partnership mode of operation need further consideration. First, relative to regular discussions of community capacity-building, empowerment etc, water agency staff capacity-building is under-explored in policy documents. Yet most water agencies are not geared towards decentralized and distributed services – nor are they adept at working with local populations and independent NGOs. This lack of 'capacity' may well be a binding constraint to extending access (Biswas 1996). Second, the consequences of devolving responsibility to *Panchayati Raj* institutions for water and other services are very poorly understood. Such decentralization is no guarantee of equity, efficiency or accountability – and in fact many PRIs lack the capacity to select local user groups, allocate funds and organize village level services (Litvack, Ahmad and Bird 1998). Much more empirical research and comparative institutional analysis are needed on both water agencies and Panchayati Raj institutions in order to re-organize and deploy them effectively.

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[54] SEWA is, strictly speaking, a membership-based trade union rather than an NGO.

Scaling up

Physical constraints

Decentralized water projects on the same watershed or within a single catchment area are linked by hydrology, so it is not feasible to scale them up in a decentralized way.[55] Boreholes with electric or diesel-operated pumps deplete the common aquifer unless their numbers and spacing are regulated. Rainwater harvesting is considered environmentally low-impact -- even beneficial -- because of its ability to recharge local aquifers. However, *part* of the water captured at any one site would have, if un-captured, recharged downstream aquifers or re-entered the ecosystem. The state of Rajasthan's controversial claim to harvested water in Alwar was unpopular with RWH proponents,[56] but as watershed level interventions multiply, negative third-party effects are inevitable. Preliminary water balance studies from Andhra Pradesh and Karnataka suggest that RWH interventions have already impacted water use patterns with positive consequences for some and negative consequences for others (Batchelor et al 2002). A recent review of watershed programmes finds that almost no attention has been paid so far to these unintended consequences (Joy and Paranjape 2004).

Property rights in this area remain unclear, or by default, belong to the state. We suggest that the safest way to go to scale would be regularly to monitor basin-level water balances (which, for example, the National Institute of Hydrology[57] could spearhead) as new RWH projects are implemented or boreholes are deepened. Such monitoring would help to anticipate the watershed level consequences of potentially thousands of small interventions, and to understand where small-scale technologies can deliver the greatest benefits. Water is a State subject in India, and with the passage of the 73rd Amendment, local water supplies are the jurisdiction of local level governments. But state level data hoarding and uncoordinated local decisions are not sustainable modes of operation where watershed boundaries do not coincide with political boundaries.

Context constraints

A sustainable system is one that can continue to provide 30 - 40 lpcd of safe water for the majority of its intended users into the foreseeable future. Well-intentioned pilot projects that do not survive their donors' withdrawal, and government funded 'pipes and pumps' projects[58] that languish from subsequent neglect are, by definition, not sustainable. Scaling up of sustainable technologies, institutional mechanisms and financing arrangement is critical if universal access is to be achieved within a reasonable time period. However, generic solutions are much easier to replicate than are context-sensitive solutions. The consensus that participatory and context-specific approaches are the only sustainable ones would seem to pose a problem for scaling up. Clearly not all communities today are capable of taking charge of their water supply or treatment through the 90/10 financing model, or through

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[55] This cautionary point does not apply to water treatment interventions, only to water supply interventions.

[56] See www.cseindia.org for details of the debate on who owns harvested rainwater – does it belong to the community whose labour created the reservoir or 'does the government own the rain'?

[57] NIH is India's premier institute for hydrology and water resources research. Its 6 affiliated centres conduct basin studies, flood and drought studies, water quality monitoring, hydrologic modelling, conjunctive use studies, and GIS and remote sensing modelling for groundwater assessment. It is especially known for its work on hard-rock aquifers. www.nih.ernet.in.

[58] This is the term used by the late Anil Agarwal, Centre for Science and Environment, to describe government funded water projects that focus on supply targets but ignore sustainability and community buy in.

joint water management. Nor are many water agencies capable of adapting to the social and economic contexts of their clients.

One of the more honest evaluations of the potential trade-off between scaling up and sustainability is presented in Davis and Iyer (2002). The authors argue that though there are numerous successful rural water supply projects, they do not go to scale because of human and financial resource constraints; failure to incorporate the goal of scaling up into the design of the pilot; resistance to scaling up by key stakeholders; and cherry-picking the site of a typical pilot so that many real world problems do not have to be confronted. They conclude – and we concur -- that a set of detailed case studies, focusing on strategies to overcome real world barriers, would be extremely helpful in bridging the gap between scaling up and sustainability.

If faced with a choice between sustainability of water interventions and scaling up of possibly unsustainable models, we would have to side with sustainability as the more important goal. It may therefore be some time before universal access in rural and peri-urban India becomes a reality.

Concluding remarks

Despite achievements in improving access to safer sources of water in the 1980s and 1990s, the current system of household water provision in India is unable to provide convenient and safe access to drinking water for a large sector of the population. Urban water delivery is characterized by irregular delivery and pressure, provided by inefficient and heavily subsidized municipal boards which are unable to maintain and expand the existing system. The situation is somewhat worse in peri-urban and rural areas with declining water availability, groundwater depletion and poor maintenance of existing infrastructure. Substantial reform is needed in order to cater for existing needs, and to meet increasing demand for water fuelled by both population and income growth. We have already discussed potential avenues for reform in urban and rural areas, and here will only comment on a couple of implications for further research and policy.

A major barrier to research and the design of appropriate policies is the lack of reliable, up-to-date and publicly accessible information on many aspects of the Indian water system. Baseline information is necessary in order to be able to evaluate various reforms in progress, and in order to allow for benchmarking against Government targets, other states and nearby countries. A lack of transparency over the true costs of underpriced and inefficient municipal systems dampens public support for the major reforms needed. Incomplete and difficult-to-find information on groundwater withdrawals makes rural drinking water interventions unsustainable. In this paper we have attempted to lay out the current state of knowledge available from public sources in India, and in doing so, have revealed many areas where more information is clearly needed. While efforts are underway to carry out some benchmarking of financial performance of several large utilities, regular and comparable data needs to be made available on, inter alia, water quality, subsidization, metering and broken meters, groundwater levels, handpump maintenance, and other such information.

The past few years have seen some experimentation with private sector involvement in the urban water sector and an expansion of decentralized community-based systems in rural areas. We have provided examples of the types of reform efforts underway, but insufficient time has passed to evaluate even the short term effects of many of these projects, while longer term issues such as sustainability require even more time to analyse. Further research is needed to study the effects of efforts underway, and to delve deeper into the institutional conditions and political circumstances which allowed these limited reforms to take place.

The past few years have also seen many innovative technical and institutional solutions to scarce drinking water or unsafe drinking water. Protecting the quality and sustainability of harvested rainwater, allocating and monitoring access to community-based water systems, and developing effective collaborations among local water agencies, NGOs, the private sector and communities are all areas that deserve serious research support and study. Forbes (2003) argues that, in a developing country with limited research resources, research priorities should be guided by what is most useful and appropriable within the country of origin. In particular he argues that some topics are critical to the well-being of developing country citizens, but are of relatively little relevance to richer countries, so developing countries cannot free ride on the international research 'commons'. They have to pursue those research areas themselves. Most of our suggestions for investigation and data collection in India's drinking water sector fulfil these criteria.

Finally, while our focus has been on drinking water delivery, over 90 percent of fresh water in India goes to agriculture. Long-term expansion and sustainability of access to drinking water will therefore require conservation and reallocation from the agricultural to the domestic sector. Many of the issues discussed here in terms of cost recovery, institutional coordination and common resources policy will also have relevance in research and policy reform in this area.

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Table 1: Source of Household Drinking Water

Percentage of Households Receiving their Drinking Water from each source

	All India		*Urban*		*Rural*		*Small City/Town*		*Large Cities*	
Source of drinking water	1992-93	1998-99	1992-93	1998-99	1992-93	1998-99	1992-93	1998-99	1992-93	1998-99
Piped into residence/yard/plot	18.4	21.0	48.1	51.6	7.1	9.3	43.3	45.3	57.6	69.1
Public tap	14.8	17.6	21.5	22.7	12.2	15.7	20.7	24.9	23.1	16.9
Handpump in residence/yard/plot	13.6	15.4	9.6	9.9	15.1	17.5	12.1	11.7	4.6	4.9
Public handpump	21.6	23.8	8.5	8.3	26.5	29.7	8.5	8.9	8.5	6.5
Private Wells	7.2	7.4	4.7	3.8	8.2	8.7	6.3	4.7	1.6	1.5
Well in residence/yard/plot		1.2		0.7		1.4		0.8		0.4
Open well		6.2		3.1		7.4		3.9		1.1
Public Wells	18.6	11.4	4.6	2.2	23.9	14.8	5.5	2.9	2.7	0.4
Public covered well		1.0		0.3		1.2		0.4		0.1
Public open well		10.4		1.9		13.6		2.5		0.3
Spring	0.7	0.5	0.1	0.1	0.9	0.7	0.1	0.1	0.0	0.1
River, stream	1.9	1.2	0.5	0.1	2.5	1.6	0.7	0.1	0.3	0.0
Pond, lake	1.2	0.8	0.3	0.3	1.5	1.0	0.4	0.4	0.1	0.0
Dam	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Rainwater	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Tanker truck	0.4	0.2	1.0	0.3	0.1	0.1	0.9	0.4	1.2	0.2
Other	1.6	0.5	1.1	0.7	1.8	0.5	1.4	0.7	0.5	0.5
Water from improved source (excluding wells)	68.3	77.9	87.7	92.5	60.9	72.3	84.7	90.8	93.7	97.3
Water from improved source (including wells in residence and covered wells)[1]	71.0	80.0	89.2	93.5	64.1	74.9	86.5	92.0	94.6	97.8

Source: Population weighted values calculated from the National Family Health Survey

Urban areas consist of large cities, small cities and towns.

1. 1992-93 figures calculated assuming that wells in residence constitute same proportion of private wells as in 1998-99, and that public covered wells constitute the same proportion of public wells as in 1998-99.

Table 2: Source of Drinking Water by State 1998-99

Percentage of Households Receiving their Drinking Water from each source

	URBAN AREAS						RURAL AREAS					
STATE	Piped Water	Public Tap	Private handpump	Public handpump	Wells	Springs, rivers, streams & ponds	Piped Water	Public Tap	Private handpump	Public handpump	Wells	Springs, rivers, streams & ponds
Andhra Pradesh	43.8	42.9	1.9	6.8	3.3	0.0	9.3	30.7	2.5	30.4	22.9	3.5
Assam	35.9	11.8	30.0	4.8	16.9	0.2	3.3	3.8	29.0	21.5	30.4	11.7
Bihar	26.4	8.3	35.4	15.0	14.2	0.3	2.8	1.6	37.8	32.0	23.5	1.6
Goa	62.9	12.1	0.2	0.5	23.9	0.2	33.5	18.5	0.0	0.0	41.3	6.6
Gujarat	75.6	14.0	2.8	3.6	0.9	0.1	37.8	17.9	2.9	17.3	17.4	3.8
Haryana	63.7	8.1	22.5	5.2	0.5	0.0	11.2	24.5	24.5	22.4	17.0	0.1
Himachal Pradesh	71.3	19.4	1.6	3.2	4.4	0.2	26.6	39.1	1.4	8.0	18.6	5.7
Jammu	87.9	8.3	0.8	0.5	0.7	1.8	27.4	19.7	10.1	5.2	11.8	25.2
Karnataka	55.6	35.1	2.0	3.5	3.8	0.1	10.4	44.7	1.7	25.0	16.2	1.9
Kerala	17.8	19.8	1.3	0.9	60.0	0.0	3.6	7.8	1.4	0.8	83.6	1.1
Madhya Pradesh	43.8	28.9	4.8	13.6	8.1	0.1	5.8	5.1	2.6	40.6	42.0	3.8
Maharashtra	68.9	26.2	0.3	1.6	2.3	0.0	22.5	24.8	1.4	21.6	26.1	2.5
Manipur	35.5	27.7	0.9	2.0	1.9	28.0	8.3	23.7	1.4	7.5	4.6	54.2
Meghalaya	40.8	42.6	0.4	0.4	10.6	5.2	8.2	19.1	3.7	0.8	34.0	33.8
Mizoram	47.6	25.3	0.3	1.4	11.4	12.9	1.5	46.0	0.0	2.7	22.0	26.9
Nagaland	26.6	9.8	3.6	1.2	39.6	19.2	14.1	26.0	0.1	0.1	22.4	37.0
Orissa	21.0	25.9	5.7	28.5	17.6	1.1	0.9	3.0	5.2	54.3	27.8	8.7
Punjab	67.6	2.0	29.6	0.7	0.2	0.0	16.4	5.3	72.2	4.5	1.3	0.1
Rajasthan	78.5	10.8	1.9	4.3	2.8	0.8	16.0	12.4	3.9	28.8	32.5	4.6
Sikkim	89.6	2.4	0.6	0.6	0.0	6.7	79.9	2.4	0.8	0.0	0.5	15.7
Tamil Nadhu	35.8	37.2	5.3	10.3	6.9	2.1	9.1	55.7	1.9	16.4	13.3	3.3
West Bengal	36.0	30.0	6.5	19.6	6.6	0.0	5.1	5.4	19.1	58.6	9.9	0.5
Uttar Pradesh	38.8	4.1	39.6	15.6	1.7	0.1	2.8	2.7	46.1	30.6	15.7	2.0
New Delhi	78.7	8.9	8.6	2.5	0.2	0.0	65.3	10.3	18.8	5.1	0.5	0.0
Arunachal Pradesh	50.6	25.3	8.6	10.3	1.1	1.1	16.8	48.3	7.5	5.4	9.6	12.2
Tripura	25.1	26.7	28.3	8.8	11.2	0.0	4.1	18.0	8.5	24.6	35.8	6.0

Source: Own Calculations from National Family Health Survey 1998-99

Table 3: Access to Piped Water by Asset Deciles
Percentage with Access by relative asset levels

Location-specific Asset Decile	*All India*	*Urban*	*Rural*	*Small Cities & Towns*	*Large Cities*
1	2.8	15.9	2.4	12.3	26.4
2	3.0	31.0	5.5	23.4	42.1
3	5.8	34.9	3.2	28.4	50.2
4	8.9	43.3	4.6	35.6	60.2
5	13.9	53.7	6.9	45.4	66.3
6	19.1	60.5	10.3	48.7	78.3
7	29.5	68.1	13.1	60.0	85.1
8	40.8	77.1	19.4	66.8	86.5
9	54.2	81.2	22.9	74.9	90.0
10	71.3	83.7	35.7	78.3	88.6

Notes: Asset Deciles Based on First Principal Component for location
Source: NFHS 1998-99

Table 4: Time taken to get to Water Sources 1998-99
for households without water on their premises

	Percentage of Households in	
Time taken	Urban	Rural
5 minutes or less	34.3	25.5
6-10 minutes	25.7	26.7
11-20 minutes	18.8	22.4
20 minutes or more	21.2	25.5

Source: Own calculations from NFHS 1998-99

Table 5: Methods of Purifying Water 1998-99
percentage of households using given method

Purification Method	*All India*	*Urban*	*Rural*	*Small Cities & Towns*	*Large Cities*
Strain with cloth	18.5	25.5	15.9	23.3	32.0
Alum	1.3	1.4	1.2	1.4	1.3
Water filter	5.9	15.2	2.5	14.2	17.9
Boil	8.1	13.6	6.1	12.3	17.4
Electronic purifier	0.4	1.1	0.1	0.7	2.2
Nothing	68.5	49.9	75.3	53.4	39.6
Other	0.7	0.6	0.8	0.6	0.7

Source: Own calculations from NFHS 1998-99

Table 6: Indicators of Irregular Supply and Wastage

City	Source	year	Hours per day of water supply	Unaccounted for water (%)	Metering (%)	Staff per 1000 connections	Cost recovery (% of operating costs)	Accounts receivables (months)
Bangladore	4	2002-03	4	34-44	100	8	95	
Calcutta/Kolkata	5	2004	9		5			
	4	2002-03	6 to 7	30-40	very low	14	15	
	1	1997	10	50	0	17.1	19	1.5
	2	1993		36				
Chennai	6	2001			<5			
	1	1997	4	20	1	25.9	106	5.8
Delhi	1	1997	4	26	73	21.4	68	4.5
	3	1995	5					
	2	1993		30				
Mumbai	1	1997	5	18	67	33.3	93	19.7
	2	1993		24				
Hyderabad	4	2002-03	0.5 to 4	33		13	66	
Comparison cities								
Lahore	1	1997	17	40	24	5.7	141	7
Kathmandu	1	1997	6	40	83	15	139	4.5
Bangkok	1	1997	24	38	100	4.6	112	2
Beijing	1	1997	24	8	100	27.2	77	0.1
Asian-Pacific average	1	1997	19	35	83	11.8	95	4

Notes: cost recovery is annual billing as percentage of operation and maintenance costs

Sources:
1: Asian Development Bank (1997)
2. Zérah (2000) reports of Asian Development Bank 1993 figures
3. Zérah (2000) reports of her own 1995 survey.
4. WSP (2002)
5. Own communication with Kolkata Municipal Corporation
6. Brocklehurst, Pandurangi and Ramanathan (2002)

Table 7: Water Tariffs in Several Large Indian Cities

	Hyderabad 1993		Hyderabad 2003-04		Bangladore 2003-04	
	Consumption	Rate	Consumption	Rate	Consumption	Rate
	Slab (Kl/month)	(Rs/Kl or Rs)	Slab (Kl/month)	(Rs/Kl or Rs)	Slab (Kl/month)	(Rs/Kl or Rs)
Metered Connections:	Up to 15	40 (flat rate)	Up to 30	6	Up to 15	6
	15-25	3	30-200	10	15-25	8
	25-500	5	200-500	25	25-50	12
	over 500	10	over 500	25 on all units	50-75	30
					over 75	36
Minimum monthly tariff				90		90
Unmetered connections	all	120 (flat rate)	15mm pipe	90 (flat rate)		
			20mm pipe	270 (flat rate)		
			25mm pipe	600 (flat rate)		
			40mm	1500 (flat rate)		
			50mm +	3200 (flat rate)		

	Delhi	1995-96	1997-98	2003-04	Chennai 2003-04	
	Consumption	Rate	Rate	Rate	Consumption	Rate
	Slab (Kl/month)	(Rs/Kl or Rs)	(Rs/Kl or Rs)	(Rs/Kl or Rs)	Slab (Kl/month)	(Rs/Kl or Rs)
Metered Connections:	Up to 10	0.46	0.53	0.53	Up to 10	2.5
	10-20	0.46	1.50	1.50	10-15	10
	20-30	0.91	2.25	2.25	16-25	15
	over 30	0.91	4.50	4.50	over 25	25
Minimum monthly tariff			30	30		50
Unmetered connections	all	9.75 (flat rate)	30 (flat rate)	30 (flat rate)	all	50 (flat rate)

Notes:
Flat rates are monthly rates in Rs. $1US = Rs 43 (April, 2004)
Sources:
Hyderabad 1993 rates are from Saleth and Dinar (1997) and 2003-04 rates are from
Hyderabad Metropolitian Water Supply and Sewerage Board (MWSSB), http://www.hyderabadwater.gov.in/
Bangladore rates from Bangladore Water Supply and Sewerage Board (BWSSB), http://www.bwssb.org/
Chennai rates from Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), http://www.chennaimetrowater.com/
Delhi 1995-96 and 1997-98 rates are from Zérah (2000, p. 74) and include 30 percent and 50 percent surcharges
Delhi 2003-04 rates from Delhi Jal Board (DJB), http://www.delhijalboard.com [accessed April 2004]

Table 8: Comparison of Metered Prices of First 50 Kl 2003-04

Kl per month	Hyderabad	Bangalore	Chennai	Delhi
10	90	90	50	30
20	120	130	150	30
30	180	230	350	42.8
40	280	350	600	87.8
50	380	470	850	132.8

source: own calculations from block and minimum tariffs in Table 7.

Figure 1: Access to Piped Water by Per Capita State Domestic Product