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Shashi Kolavalli
K V Raju

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PROTECTING DRINKING WATER SOURCES: A SUB-BASIN VIEW

Shashi Kolavalli*
K V Raju**

Ensuring universal access to safe drinking water is one of the more difficult development challenges for India as conflicting demands from various sectors commonly exceed water availability in many regions. Although nearly all the habitations have been provided with 'safe' sources, access is limited, as drinking water sources under pressure from other demands are inadequate. Depletion of groundwater aquifers and water pollution threaten continued availability of drinking water. The prevailing institutions do not adequately protect drinking water, although policies accord the highest priority to meeting human and livestock needs. The recent introduction of drinking water protection legislation in two states could help if implemented.

Providing safe drinking water for the population is one of the more difficult social development challenges for India. Poor health conditions and the bulk of the infant deaths in the country can be attributed to limited access to safe drinking water: nearly a million children die of diarrhoea diseases annually as a result of drinking unsafe water and living under unhygienic conditions (UNICEF). An estimated 45 million people are affected by poor water quality caused by pollution, excess fluoride, arsenic, iron and ingress of salt water. Close to 90 per cent of the habitations in the country are estimated to have safe drinking water facilities, but only a smaller percentage of the population is likely to have year-round access to safe drinking water. Improving access to drinking water will be particularly challenging, as inter-sectoral conflicts for water are increasing in the country.

Water conflicts – arising from conflicting demands for water that can be met only through more efficient use of water in one of more uses, or one use being forsaken for another – have arisen in some parts of the country. By 2025, nearly a third of the country's population is expected to face absolute water scarcity – defined as not having sufficient water to maintain 1990 levels of per capita food production from irrigated agriculture and also meet domestic and industrial sector needs (Seckler et al. 1998). Water withdrawals are estimated to increase by only about

* Consultant, AFTM1 division, The World Bank, Washington D.C. Email: skolavalli@worldbank.org

** Professor, Ecological Economics Unit, Institute for Social and Economic Change, Bangalore, India. Email: kvraju@isec.ac.in.

15 per cent between 1990 and 2025 in India, but because of regional differences in availability, some areas will face scarcity (Seckler et al 1998; Iyer 2001). Water is expected to become scarce in 11 of 20 major river basins in the country (World Bank 1998b). Attempts to meet the growing urban water demands from sources away from the urban areas, for example, are likely to lead to inter-sectoral water conflicts (Saleth & Dinar 1997).

Water crisis in India is manifesting itself in the form of depletion of groundwater aquifers and water pollution (Seckler et al. 1998; World Bank 1998b). Groundwater extraction in India is estimated to exceed recharge by a factor of two or more. Receding aquifers dry up surface sources, affecting fresh water supplies, as groundwater flows keep rivers from drying up when water is scarce. Water pollution is also extensive with domestic sewage, industrial effluents and agricultural runoff being the main sources of pollution.[1] Aquifer drawdown and pollution are likely to threaten food production growth and availability of safe drinking water.

How we manage conflicting water demands through technological and institutional innovations will have a bearing on our ability to ensure adequate availability of safe drinking water. Although policies accord the highest priority in the use of water resources to meeting drinking water needs, the domestic sector may not fare well in the competition for water in the absence of effective mechanisms to operationalize the policies. How water is utilized for various purposes is guided by institutions – customs, policies, laws and markets that dictate who can use water and how. Water scarcity can be averted by introducing institutions to encourage more efficient use in different sectors, and facilitating transfers from one use to another, as needed (Gleick 1993). Both technological and institutional innovations are required to do this effectively. But institutional innovations are more important, as appropriate institutions provide the necessary incentives for technical ingenuity (Homer-Dixon 1995). Institutions also need to evolve as resource conditions change (Saleth and Dinar 1999).

The deficiencies in institutions are central to poor management of water in India (e.g., Saleth 1996). They relate to both the absence of incentives to conserve water in various uses, and the lack of effective mechanisms to achieve inter-sectoral allocations that are consistent with social objectives. The lack of incentives to use water efficiently in agriculture – the dominant water user – is well known: surface irrigation systems do not offer incentives for conservation (e.g., World Bank 1998b); groundwater controls are ineffective and inequitable (e.g., Dhawan 1989); and groundwater markets may promote efficiency and equity, but encourage aquifer depletion (Shah 1993). The challenge, therefore, is to facilitate the development of institutions that encourage conservation in all uses, and, more importantly from the drinking water perspective, achieve inter-sectoral use patterns that are consistent with social objectives, one of which must be to provide universal access to safe drinking water.

The objective of this paper is to examine whether the existing water institutions ensure adequate availability of drinking water. The answer may be somewhat obvious given the widespread drinking water shortages, but we go beyond the obvious to examine the range within which existing institutions work to protect drinking water from being diverted to other uses, and identify difficulties in operationalizing policies that seek to protect drinking water. We do so by reviewing the literature and using information from a 2001 rapid case study of the Ghataprabha sub-basin in Karnataka.[2] We distinguish between ensuring availability of adequate water to meet the drinking water needs and organizing its supply – the utility dimension that is the primary concern of drinking water programmes. The paper deals with the first. Although, building and maintaining drinking infrastructure is often considered to be the more challenging aspect of improving access to drinking water, without protection of drinking water sources, the viability of organized water systems would be threatened (World Bank 1998c).

We begin with a brief discussion of the national commitment to meeting the drinking water needs. Then, we present the case study, beginning with a description of the area, followed by water availability in the sub-basin, various organizations engaged in water management, water utilization and the institutions that guide water utilization. Finally, we summarize what can be learned from the case study with supporting evidence from the rest of the country, and draw some implications for protecting drinking water.

National Commitment and Coverage

The supply of safe drinking water is one of the basic services identified to achieve acceptable levels of social consumption and minimum standard of living. The level of access to be provided is defined in terms of per capita availability, proximity of sources to users, and water quality (GOI 1999).[3] In terms of quantity, the objective is to supply 40 litres per capita per day (lpcd) to rural residents, and from 70 to 125 lpcd – depending on the presence of sewage systems – in urban areas. Consumers are expected to share the costs when supplies exceed the minimum access levels. Water supplies are also expected to broadly correspond to standards of service that users are willing to maintain, operate and finance. New drinking water supply projects that aim to increase supply beyond 40 lpcd are expected to recover from users at least 10 per cent of the capital costs (GOI 1997).

In 1997, there were an estimated 61,724 habitations in the country without any safe source of drinking water, 378,000 which were "partially covered" and 151,000 habitations with quality problems such as excess fluoride, salinity, iron and arsenic (GOI 1997). More recent assessments suggest that of the estimated 1.4 million habitations in the country, only 12 per cent are partially covered and only 22,000 or about 2 per cent were not covered (WSP 2000).[4] In about 15 per cent of the habitations, water quality is a problem. These estimates suggest that most of the habitations are 'covered' by organized systems in the sense that they have safe sources with estimated average per capita availability close to or higher than accepted levels. As it becomes evident later, 'coverage' by a safe source does not necessarily imply adequate year-round access, as there may be seasonal water shortages or disruption of services due to lack of adequate upkeep of systems.

Case Study: The Ghataprabha Sub-Basin

In Karnataka where the sub-basin is located, the government claims that no habitation in the state is without a safe drinking water source (GOK 2000).[5] However, as in the rest of the country, the population may not have year-round access to safe drinking water. About two-thirds of the state that receive less than 750 mm rain is drought prone. Drinking water supplies are becoming increasingly unreliable in semi-arid parts of the state where the sale of drinking water is common during dry seasons (KAWAD 2001).

Salient Features

The Ghataprabha sub-basin covers an area of 8,829 sq km in the Krishna basin, which traverses three states. The Ghataprabha river is one of the southern tributaries of the Krishna in its upper reaches: it rises from the Western Ghats in Maharashtra and flows east into Karnataka. In Karnataka, it flows 216 km through Belgaum district past Bagalkot to join Krishna in Bijapur district. About 80 per cent of the sub-basin is in Karnataka in the districts of Belgaum, Bijapur and Bagalkot. The case study focuses on the area in Karnataka in which the bulk of the water in the sub-basin is utilized.

Agriculture – which is largely dependent on inadequate and unreliable rainfall – is the main occupation of the people in the sub-basin. The average rainfall is around 600 mm in bulk of the sub-basin. Only about 28 per cent of the culturable area is irrigated, with sugarcane planted on nearly a third of the irrigated area. Nearly 30 per cent of the population is estimated to be poor. And, about a fourth of the population was urban in 1990.

Multiple Organizations

A plethora of organizations, under several ministries, develop water resources for various uses and also monitor their status. The Water

Resources Department (WRD) in the Ministry of Water Resources is responsible for major and medium irrigation systems that irrigate more than 2,000 hectares.[6] The Department of Minor Irrigation – also housed in WRD, but under the direction of the Ministry of Minor Irrigation (MI) – and Groundwater Department (GWD) under the Ministry of Mines and Geology are responsible for systems that irrigate smaller areas – primarily river lift systems or groundwater. The WRD controls the use of surface sources, particularly the rivers. Various local governments control the tanks.[7] The WRD is organized along hydrological boundaries: staff managing parts of an irrigation system in different administrative units report to a single authority responsible for the system. The MI and the GWD, on the other hand, are organized along administrative boundaries. Organizations such as the National Water Development Agency (NWDA) and National Institute of Hydrology (NIH) and the Central Groundwater Board (CGWB) are engaged in monitoring and research.

Several state organizations share the responsibility for developing drinking water supplies. The center provides substantial resources. The Ministry of Rural Development and Panchayat Raj (RDPR) at the state level, Zilla Parishads (ZP) at district levels, and gram or town panchayats at habitation levels organize drinking water for the rural population. The ZPs build rural water and sanitation systems, with technical support from the Rural Development Engineering Departments (RDED). After the introduction of the Panchayat Raj Act of 1993, the operation and maintenance of rural water systems – 'mini supply systems' and borewells – has become the statutory responsibility of gram panchayats (GP).

The Karnataka Urban Water Supply and Drainage Board (KUWS&DB), under the Ministry of Urban Development and Municipalities, builds urban water systems. Their mandate is to hand over the systems to local governments after an initial period of maintenance. But they often continue to operate the systems as wholesalers to civic bodies, as many local governments may not be prepared to take over.

Water pollution is monitored and controlled by yet another group of organizations. The state pollution control board enforces pollution control regulations; the GWD, the CGWB, and the RDEDs monitor groundwater quality.

Water Availability

The Ghataprabha and its tributaries are the major sources of surface water in this sub-basin. Water is utilized through the Ghataprabha Irrigation System (GIS), a series of 94 barrages across rivers, nearly 40 river-lift systems and an estimated 193 tanks. The GIS comprises a dam across the river Ghataprabha at Hidkal close to Belgaum, the largest city in the sub-basin, and a weir across one of its tributaries 20 km downstream. Two main canals distribute the water: the Left Bank Canal (LBC) is designed to irrigate about 162,000 ha, and the right bank canal (RBC), which is under construction, is expected to irrigate 156,000 ha. When the system was designed, it was assumed that the drinking and industrial needs would be met without significantly affecting irrigation commitments.

Private irrigation wells and public drinking water wells extract groundwater. The NWDA – which assumes that drinking water and industrial requirements are usually met with 22 per cent of available water resources – estimates that nearly half of the replinishable groundwater is still available for use, making it possible to nearly double the current level of groundwater irrigation.

Water Utilization and Institutions

The water in this sub-basin is used to irrigate crops, produce power and meet industrial, domestic, and environmental needs. In 1990, the estimated shares of various uses of water in the Krishna basin were as follows: 96.3 per cent, irrigation; 2.9 per cent, domestic use; and less than 1 per cent for industrial use (CPCB 1990). When the GIS was built, the priorities for using water were in the following order: drinking, flow irrigation, lift irrigation and industrial uses.

Irrigation: Crops are irrigated with water from three sources: the GIS, water lifted from the rivers, and groundwater. Less than "designed" area is irrigated in the LBC, although some of the water designated for use in the RBC is utilized.[8] Hundreds of pumps to lift water stored behind four weirs, built in recent years downstream of the GIS, irrigate sugarcane during summer, when canal water is not supplied. Additionally, an estimated 22,000 wells in the command irrigate 45,000 ha. As in canal irrigation systems elsewhere, farmers lack incentives to use water effectively, as they pay a fixed area based fee. The farmers also pay a fixed charge for electricity used for lifting surface and groundwater. Therefore, the availability of power and water are the only factors that constrain water use.

Industrial use: Industrial water use in the entire Krishna basin was estimated to be only about a third of the domestic water use in 1990. Water using industries in the sub-basin include many in sugarcane processing – 9 sugar factories and 3 distilleries – numerous small industries, and two large non-agro industries – an aluminum plant and a cement factory.

Urban water supply systems are designed to meet both drinking water and industrial needs. The KUWS&DB supplies water to the two large industries identified above. In the recently built system to supply water to two small towns – Hukkeri and Sankeswar – from the GIS, about 10 per cent of the capacity has been designated for future industrial use.

The urban industries are given the same priority as urban residents, at least in developing supply systems. However, when water is scarce, the industries may be denied water to meet the drinking water needs.

Rural industries, which are encouraged to develop their own sources, usually draw water from surface sources, for which they are required to obtain permission from the WRD and also pay a fee.[9] Permission is granted only for a few years.[10] However, they can withdraw groundwater without seeking any approvals, adding to existing pressures from agriculture. The industries often depend more on groundwater during summer when agricultural demands are higher, and the availability of drinking water is most threatened. The industries are charged more than other users for surface water,[11] but they face similar incentives with regard to using groundwater.

Power generation: Water use for power generation is non-consumptive, as the same water is used for irrigation or drinking. There are three hydropower plants in the sub-basin: a public plant generating 30 MW and two small private units with combined generating capacity of 4. 84 MW. Water supply to them is coordinated such that the water can be utilized downstream for other purposes. The power generators pay the WRD royalty on the power generated. The private plants pay a higher royalty compared with the public one (Rs. 0.32 vs. Rs 0.0025 per KWH).

Drinking: Groundwater is the predominant drinking water source in the sub-basin: tubewells or open wells serve as drinking water sources in nearly all the surveyed villages; surface sources are used in only 2 of 47 villages. Over the years, the communities have moved from using surface to groundwater sources; and, within groundwater, from open wells to tubewells. In 1985, 38 per cent of the villages used open wells, and an additional 30 per cent used tanks and rivers, in addition to open wells. Only 6 per cent reported open wells being their only source in 2001. Decline in the quality of surface sources is one of the reasons for this shift: more than one half of the villages indicated that surface water bodies have become unsuitable for domestic and livestock consumption. In addition, in large villages, groundwater sources are no longer adequate, which has made them dependent on surface water pumped from faraway sources, usually larger rivers.

The urban centers rely more on surface sources than groundwater for the reasons mentioned above. As they overgrow their sources – usually tanks and small reservoirs – they become dependent on flows of larger rivers and surface irrigation systems. The city of Belgaum with a population of nearly 500,000, for example, has its own source of nearly 9.5 million gallons per day (mgd) – storage created behind a barrage across Markandeya river nearly 20 km from the city. In summers, water availability may reduce to 6 mgd, but, at 130 lpcd the city now requires

12 to 14 mgd. Their supplies are now augmented by 3 mgd from the GIS.[12] The city also maintains 18 open wells and 542 borewells to withdraw an estimated 1 mgd. Most of the hotels, apartments complexes, and smaller industries in the outskirts of the city also depend on groundwater supplied by private vendors who employ an estimated 200 tankers in the city.

Poor quality of groundwater and extraction costs also push cities towards surface sources. The experience of Bagalkot, a city at the tail end of the Ghataprabha River is illustrative. In summer 2000 when the river dried up for about 2 months, the city drew water from nearly 30 borewells it had, and built additional 65 wells to meet its requirements. Though groundwater was adequate to meet their needs, the users who attributed increase in health problems such as joint aches to high levels of calcium in groundwater were unhappy. The city also prefers river flows, as it can save on power: pumping surface water requires about 120 HP compared with nearly 500 HP for groundwater. To secure supplies from the river during the dry season, the city has built a barrage high enough to hold two months water supply.

In both urban and rural areas, water charges have not kept up with supply costs. In the urban areas, domestic connections are charged Rs. 45 per month regardless of the costs incurred.[13] Moreover, the charges are not volumetric, and only a portion of the connections is private – 27,000 of 47,000 households in Belgaum have private connections, for example – further reducing opportunities for cost recovery. Nearly 80 per cent of the fees in Belgaum are recovered, but recovery is poorer in rural areas. In newly built village systems, cost recovery has not even begun. In the recently built system for Hukkeri and Sankeshwar, for example, unpaid electricity charges had accumulated to nearly Rs 12 million.

Access: Though 'coverage' may be universal, access is not year-round. Among the surveyed villages, all but one had a 'safe' drinking water source, and supplies were also regular: nearly one-half normally receive water for less than 3 hours daily; a third for more than 3 hours and the balance, round the clock. Though 85 per cent of the villages indicated that their supplies were adequate, nearly 40 per cent indicated experiencing seasonal shortages – in villages with both high and low estimated per capita availability. In parts of Jamkandi, a taluk in which groundwater is pumped up from 450 feet, borewells that usually yield 8,000 lph reduce to only 2,000 to 3,000 lph in summers. Seasonal shortages force people to depend on traditional unsafe sources in 10 to 20 per cent of the Karnataka villages with World Bank supported drinking water systems (Paramshivam 2001).

The key informants attributed seasonal shortages to increased groundwater irrigation and reduced rainfall, all suggesting that groundwater depletion was the source of the problem. The officials estimate that private well operations affect nearly 10 per cent of the drinking water systems in the sub-basin. The district officials in Bagalkot for example, report that nearly 20 per cent of the 600 hand pumps in 97 villages can no longer lift water; the wells are up to 140 feet deep, but water tables are estimated to go down to about 250 feet in dry seasons. Annually, 8 to 10 per cent of the borewells are declared as "defunct," and 5 per cent as 'permanent failures.'

As noted already, declining quality of groundwater is also a limitation to access. About 15 per cent of the villages reported quality being unacceptable. In about a third of the habitations in the state, drinking water is contaminated to varying degrees with fluoride, brackishness, nitrates and iron (GOK 2001). Information on groundwater quality is sparse, as the RDED responsible for monitoring quality does not have adequate resources. Declining water availability and quality problems are exacerbated by poor operation and maintenance of drinking water systems: for example, nearly 30 per cent of the 4,800 hand pumps in Belgaum district were reported to be not working.

Urban residents seem to receive more water on average, but the frequency and duration of supplies suggest that their access is more limited than the average quantities suggest. In many of the urban centers, residents receive water for only a few hours once in several days.[14] In Belgaum, supplies last for 2 to 3 hours on alternative days, which may be changed to 1 to 2 hours every third day in summer. In Gokak, where the average supply is 100 lpcd, the households receive water for about an hour on alternate days. In Bagalkot, another city in which average supply is 100 lpcd, the residents receive water once in two days. The residents' access in terms of being able to have adequate quantities when needed is dependent on their ability to invest in infrastructure to capture water when it becomes available and store it.

Environmental use: The release of untreated sewage into the rivers is a common practice in the sub-basin. The absence of sanitation and sewage treatment appears to be a greater threat to maintaining water quality than industry-caused pollution. None of the industries in the sub-basin appear to be polluting water sources, at least according to the office of the state pollution control board.[15] The local PCB office indicated that it had 'served notices' on several city and town authorities for releasing untreated sewage into rivers, but was reluctant to reveal the exact number or identify the towns. The notices appear to have had little effect on city administrations, as holding cities and towns accountable appears to be more difficult than making private companies change their behaviour: measures such as denying utilities that potentially make private companies take notice are not effective against public bodies representing towns and cities.

Urban centers are estimated to typically release as sewage nearly 80 per cent of the water they consume. As the urban centers in the sub-basin do not have sewage treatment facilities, Belgaum, Gokak and Bagalkot together release approximately 50,000 kl of untreated sewage daily into rivers and streams. Belgaum releases sewage directly into a perennial stream that has now turned into a sewer drain along its 30 km course. Where Gokak releases sewage into the Ghataprabha river, only raw sewage may flow for about 2 months in summer when the river is usually dry. The absence of sanitation facilities in rural areas is also a threat to water quality. In less than a third of the villages surveyed, were there any households with toilets – usually less than 20 per cent of the households do. Only in less than 10 per cent of the total villages did more than a third of the households have toilets. As noted earlier, a significant portion of the villages indicated that water bodies had been polluted primarily from poor sanitation practices.

Status of Water Resources

There are signs of water crisis – demands exceeding supplies and conflicts arising between various uses requiring reallocation – in the sub-basin. New demands are being made on water in the multipurpose systems. Groundwater tables are declining, and pollution is shrinking water sources suitable for drinking.

The GIS will be under pressure to reallocate water from agriculture to meet urban water needs. Belgaum, Mudhol, Gokak, Bagalkot, and perhaps Chickodi are some cities looking to meet their increasing requirements from the Ghataprabha River.[16] Water is now released from the GIS for non-agricultural purposes only during the non-summer months. If new demands are to be met particularly during summer, greater sacrifices will have to be made by the agricultural users.[17] Conflicts between urban users and farmers who need to irrigate sugarcane during summer have already begun. In the summer of 2000, when water was released from the GIS to supply water to Bagalkot, the farmers downstream raised their barrages to block the flow to irrigate their sugarcane. Senior politicians and administrators had to intervene to persuade the farmers to let the water flow downstream.

The groundwater situation is also worsening. Although the estimated usage and recharge suggest that there is room for further development, water tables are going down.[18] Between 1987 and 1997, the total number of wells declined from 22,502 (21,698 dugwells and 863 tubewells) to 21,819 (9,121 dugwells and 12,698 tubewells). Nearly half of the dug wells were replaced by deeper tubewells.

The available information suggests that water quality in the Ghataprabha has deteriorated substantially. Bacterial contamination is high, with MPN counts of nearly 900 per 1,000 ml (Pawar 2000).[19] High levels of contamination throughout its length are primarily due to disposal of untreated sewage into the river (CPCB 1990).

Water shortages have brought attention to increasing groundwater recharge, but the scope for increasing water availability is limited. The government of Karnataka has established guidelines for artificial recharge of drinking water sources in Karnataka (GOK, 2000). Nearly 20 per cent of the drinking water project funds can now be utilized to 'protect or enhance supplies' through regulation, prevention of quality degradation, recharge of aquifers, watershed development, forestation and rainwater harvesting. But at least under semi-arid conditions, the potential to augment water supplies may be limited (KAWAD 2001). Studies conducted in a few watersheds in northern Karnataka show that the present demand for domestic water supply and sanitation and for livestock ranges from 3.2 to 11.6 per cent of recharge. The current withdrawals for agriculture and domestic use are estimated to be already fairly close to annual recharge, suggesting that there may not be sufficient water to meet the increasing needs for drinking and also sustain the intensity of agriculture.

Institutional Challenges

The water use patterns in the Gahataprabha sub-basin demonstrate the nature of conflicts that are likely to emerge, the need for institutions to encourage sustainable use and facilitate inter-sectoral allocations that are consistent with the social objectives. The prevailing institutions are not adequately protecting drinking water sources from pressures from competing uses.

Threats to Drinking Water

The availability of water itself is a limitation to providing access to drinking water. Where availability is limited, the mere provision of drinking water supplying infrastructure – the development of a 'safe' source – does not ensure year-round access. According to the Rajiv Gandhi Drinking Water Mission, a third of the groundwater-based drinking water systems experience seasonal water shortages caused by aquifer depletion (GOI-WB 1998c). In a survey of communities in Maharashtra and Karnataka that had been given new drinking water systems, nearly 50 per cent reported that adequate water was not available in dry seasons (World Bank 1998d). In about 20,000 of the 55,000 habitations in the state of Karnataka, for example, the supply of water is not adequate during the hot season (GOK 2001).

The principal threat to drinking water availability comes from groundwater depletion, as groundwater is the source for nearly 85 per cent of the rural population served by public drinking water systems, and nearly half of the urban and industrial requirements are also met from groundwater (World Bank 1998c). Groundwater of good quality is the preferred source for drinking water systems – particularly for small rural habitations – because of low cost of operation and maintenance (GOK 2000). A safe groundwater-based drinking water system can be developed in a day or two, as all that is entailed is the digging of a well. For surface sources, on the other hand, water filtering has to be provided for, which often raises the costs several fold, and takes more time to complete. One of the important means of ensuring adequate availability of drinking water, therefore, is maintaining groundwater extraction to sustainable levels and maintaining water quality (World Bank 1998c)

However, urbanization and growth of rural habitations that exceed the capacity of wells to provide adequate water will increase dependence on surface sources, as it is more feasible to organize large supplies from surface sources than from groundwater. More than 80 per cent of medium sized towns fully or partially depend on surface sources, and only 16 per cent of towns depend on groundwater alone (CPCB 2000). Feasibility and extraction costs apart, groundwater in many areas may not be of acceptable quality. Nearly 66 million people in India are estimated to be consuming groundwater with unsafe levels of fluoride (van der Hoek 2001). Nearly 30 million people in the eastern states are estimated to be at risk of consuming water with higher than acceptable arsenic levels. Almost 50 per cent of the groundwater used in and around Delhi is contaminated with fluoride and nitrates (Down to Earth 1998). Therefore, both increase in population and decline in groundwater quality are likely to increase dependence on surface sources for drinking water. However, this dependence will be limited to organized drinking water systems. Direct use of surface sources is likely to decline. The national family health survey indicates that only about 3 per cent of the households in 1998–99 made use of surface sources compared with 11 per cent of the households in 1992–93 (IIPS-ORC Macro 2000).

Water quality decline – which becomes evident as scarcity worsens – is as much a threat as water scarcity (World Bank 1998; Iyer 2001). Inadequate sanitation, industrial pollution, and the practice of chemical input-based intensive agriculture threaten quality (Ramachandraiah 2001). Poor sanitation and absence of sewage treatment contribute to water pollution in both rural and urban areas. Even in a relatively water-abundant state such as Kerala, safe drinking water availability is threatened by the absence of adequate sanitation (Hindu 1998). It is estimated that nearly 2.9 million of the 5.5 million households in Kerala are estimated that they do not have safe sanitation. In 1990, only 7 per cent of the Karnataka population had access to sanitation. Though access to safe sanitation is higher in urban areas, disposal of sewage without treatment is widespread: only about 66 per cent of the population in medium sized (class II) towns, for example, have sewage facilities (CPCB 2000). Less than 5 per cent of the wastewater generated in the country is treated before it is disposed off. Almost all the major rivers in the country do not meet the safety standards for drinking and bathing because of bacterial contamination (CPCB 2000).

Chemical contamination of water by industrial effluents and non-point pollution by agriculture is also a major threat to maintaining water quality. Drinking water sources are contaminated by industrial effluents even in rural Punjab (Tiwana and Singh 1996). Water pollution is extensive in industrialized regions such as south and central Gujarat (Indian Express 1999). Agriculture also presents less intensive but extensive contamination of groundwater with nitrates, trace metals and organic compounds. The Yamuna river flows, an important water source for New Delhi for example, contain unsafe levels of pesticide residues (Down to Earth 1998).

Inter-sectoral Transfer Institutions

Water used for one purpose is appropriated for another – in what may be called inter-sectoral transfer or reallocation – through different means in surface and groundwater. Quite often, the nature of transfers may not be clear. In some cases, new users are added on to existing sources, resulting in congestion that may reduce water availability to one or more users, but all or some of the users may be able to meet their needs by using water more effectively. In other cases, one or more uses are displaced by one or more other uses, resulting in an inter-sectoral transfer.

In the case of groundwater, land ownership, the ability to prospect for water and to build appropriate extraction infrastructure – a well of suitable depth and suitable pump – and the ability to pay for water determine access. The rights of landowners – whether they are agriculturalists, industrialists, house owners or water vendors – to groundwater below their land enable them to access groundwater by making the necessary investments. To the extent that current extraction from a distinct aquifer is below recharge, new entrants may not affect current users, and there may not be any transfer from one use to another. But as increasing investments push extraction beyond recharge – making groundwater harder to capture – the uses with superior prospecting and infrastructure-building capabilities begin to deprive other uses. The resources that the states bring to building drinking water systems may match or often surpass private resources, but positive externalities from prospecting prevent drinking water systems from maintaining their edge. Private wells are apparently built near productive drinking water wells to tap the same aquifer.

Apart from access through land ownership, groundwater is also accessible through markets. Many well owners – agriculturists and others – sell water from their wells to other agriculturists, urban residents or industries (eg., Shah 2000). The sales may be prompted by the availability of more than what one needs or the opportunity to earn higher returns, as in the case of agriculturists selling to households and industries. These transactions in most cases require transport, usually organized by the sellers, as in the case of water supplies to other agriculturists and urban residents, and usually by the buyers in the case of industries. Through these transactions, groundwater usually moves towards higher valued uses, guided by willingness to pay. Groundwater use outcomes emerging from access determined by ability to invest and willingness to pay may proximate what could be achieved by private ownership of groundwater, at least within limited spaces defined by transport costs.

Inter-sectoral transfer of surface water sources, particularly those publicly controlled, on the other hand, takes place largely through administrative mechanisms. Local organizations in some regions exercise control over how surface sources such as tanks are used. Farmers' use of river flows, although subject to control may be as weak as control over groundwater extraction. However, greater control is feasible over water captured and stored in public systems, which is allocated to various uses guided by established priorities that are moderated by local political priorities. The national and all state policies place the highest priority on drinking water. The GOK's recently approved water policy, for example, prioritizes in the following order: drinking water, agriculture, aquaculture, agro-industries, non-agro industries, and finally, navigation.

There are difficulties in operationalizing the priorities through administrative mechanisms, although they may represent values collectively held as to how water should be utilized. First, real control is exercised only over water captured in public systems. Second, administrative mechanisms are less clear as to how water should be allocated to various uses at the margin. For example, if agriculture has higher priority over industries, how much of agricultural needs should be met before meeting industrial needs. The political process that moderates the "across the board" priorities may, to some extent, take into consideration relative values in different uses, thus bringing allocation close to what may be achieved through markets. With regard to drinking water, however, the allocation decision may be more clear in the sense that meeting certain basic needs have priority over all other uses.

Administrative processes also have undesirable effects. One, enforcing priorities often involves involuntary appropriation from users.[20] Two, a strategy that the states follow to avoid appropriation is not to grant rights that are deemed permanent in any sense, so that administrative reallocations can be made periodically. The rights of all users then become subject to periodic review and some users risk dilution of their rights. Even if these processes can achieve value-based allocations, the problems with administrative/political allocations are probably high transaction costs, and most definitely, greater uncertainty for lower priority users.

As drinking water requirements usually make up only a small portion of water available, significant tradeoffs between various uses do not usually occur in large systems. However, explicit tradeoffs are made if necessary, usually in smaller systems. In systems in arid regions such as Gujarat – Meshwo and Phophal are two examples – drinking water needs are met before irrigating crops (Kolavalli et al. 1994). National policy also gives explicit consideration to meeting human needs in the design of multipurpose water projects.

The denial of one use by another takes place through ineffective public control – in the absence of private property rights – in the case of use of water bodies to discharge wastes. The Comptroller and Auditor General of India reports that Water (Prevention and Control of Pollution) Act of 1974 is weakly implemented (TOI 2001). In Haryana and Karnataka, for example, from a fourth to a third of the industrial units function without permission. Industrial pollution of drinking water sources attracts little political attention, as it is often the poor who are most affected (DfID 2001). The affected communities often have to seek redress through the judiciary, but relief may come only after irreversible damage is done (Down to Earth 1997). Community action seems essential to protect water quality. One of the important factors that influence pollution control decision of firms is pressure from communities and NGOs (Pargal et al 1997).

A reasonable conclusion may be that surface drinking water sources are better protected than groundwater sources, as inter-sectoral allocations of surface water are driven, to some extent, by public priorities. The absence of access to drinking water now attracts as much public attention as starvation. Groundwater sources, which provide drinking water to the bulk of the rural population, however, are not adequately protected. Equally threatening for sustaining drinking water supplies is ineffective control of pollution of both surface and groundwater.

Improving Water Governance

Ensuring drinking water availability is closely tied to the larger challenge of improving water management, an important objective of which is also to maintain quality. The challenge is to develop a set of institutions that encourage conservation in all uses - conservation will ease pressure from all uses - and facilitate allocation of water among various uses that reflect social preferences, particularly enabling meeting of human requirements as a fundamental right.

Policies that create market-like conditions for water are recommended for improving water use efficiency and minimizing conflicts between various sectors (e.g., Rosegrant and Gazmuri 1997). Though appealing to policy analysts, market-like mechanisms are hard to establish, as they do not work without clear and tradable property rights, but some suggest that it is feasible to establish such rights in India (e.g., Saleth 1996). Though it may be feasible in canal irrigation systems — assuming that irrigation bureaucracies' reluctance to become downwardly accountable could be overcome — it still leaves groundwater unaffected. Even if we had information on better information on groundwater, whether we can agree on a basis for allocating rights to groundwater is not clear. In any case, all that would have to wait until we have better information, and technological and institutional developments have reduced transaction costs involved in assigning, monitoring and enforcing private rights. Even if we could assign rights, 'optimal allocation' may not be achieved through market mechanisms alone, as water can be used again and again for different purposes as it flows through river basins, which leads to potential externalities (Perry ét al 1999).

Another limitation with market mechanisms is that they alone may not lead to socially desirable outcomes, as economic efficiency — driven by willingness to pay — alone may not be what societies want to achieve (Perry et al 1999). Two competing values relevant for water allocating institutions are that water is a basic need that should be met regardless of the ability to pay, and that water should be treated as an economic good and willingness to pay for it should dictate its allocation among users and uses (Perry et al 1998). Institutions with different values are appropriate at different levels of water use. A balance also has to be struck between achieving market efficiency and social equity in allocating water between sectors (DFID 2001). While it may be useful to employ market institutions to achieve higher values within sectors and between some sectors, non-market institutions are required to ensure availability of water, although a portion of the population may have the capability to access drinking water through markets.

The thrust of reforms in the water sector has been on improving efficiency, principally in agriculture. The strategies focus on decentralization of water distribution decisions to lower levels in publicly managed surface irrigation systems (Saleth and Dinar 1999), and on enhanced community and state controls and 'management' rather than 'development' to bring groundwater extraction more in line with its sustainable use (e.g., Moench 1994; World Bank 1998a). The reforms have been more effective in surface systems. However, both do not deal in any significant way with inter-sectoral transfers. Improving efficiency in agriculture alone is not adequate to protect drinking water sources and fairly allocate water to various sectors (DFID 2001).

New Measures

Grassroots level institutions are necessary to manage conflict between rural water supply and agricultural water use or water pollution (World

Bank 1998b). The lack of adequate information on aquifer conditions, divergence between resource and community boundaries, and high monitoring costs — even if they are less than what they would be under more centralized control — make local control infeasible. Introducing control over groundwater extraction has been one of the difficult aspects of bringing about sustainable use of water resources. However, it will be the principal challenge to protecting drinking water resources, in the short to medium term. There appears to be greater political commitment — egged by the World Bank supported drinking water programs — to protect drinking water sources.

The governments of Karnataka and Maharashtra have now introduced groundwater control measures to protect drinking water sources. The Karnataka Groundwater Act of 1999 prohibits the sinking of wells within a distance of 500 metres from a public drinking water source, without the permission of an appropriate authority. The authority is empowered to even prevent extraction from existing wells by declaring any area as water scarce. An entire watershed can also be declared as being over-exploited, thus preventing well sinking or operation of any existing wells that may affect drinking water wells.

These protective measures offer greater potential to be successful than any general control on groundwater use. The success will depend on who the 'appropriate authority,' is, and the extent to which well interferences can be identified. Unlike the general controls on groundwater extraction, this act may not affect everyone: only those whose wells interfere with drinking water wells will be affected. Given that everyone benefits from drinking water, there may be greater political will to implement the act. Additionally, affected well owners are compensated.

Protection of water quality, however, continues to be neglected. Improving sanitation is likely to be critical. Sanitation often receives less priority than drinking water supply, and it is often treated as something that should follow provision of drinking water. However, improving sanitation may be essential for improving access to safe drinking water, as the absence of sanitation accounts for a more widespread contamination of water resources than other pollution sources. The sanitation strategies, however, remain poorly designed, as they focus on subsidies, educating people on the health benefits, and fiats that require public individuals to have toilets, without adequately addressing factors such as local notions of cleanliness, caste anxieties about sharing and cleaning of toilets, the need for technical solutions to reduce water requirement that may be very relevant for poor sanitation and public hygiene in India.

Notes

1 About 75 per cent of the wastewater is produced by the domestic sector. Only 25 per cent of class I cities – those with population greater than 100,000 – have wastewater collection, treatment and disposal facilities. And, less than 10 per cent of the 241 smaller towns have wastewater collection systems. Some 20 per cent of the wastewater generated in Class I cities and only 2 per cent of all wastewater generated in Class II towns is treated. According to Central Statistical Organisation, about 75.7 million people living in cities and 563.6 million people living in rural areas did not have access to toilets of any type in 1993. As a result, huge quantity of organic wastes find its way into water bodies (IGIDR).

2 The sub-basin represents semi-arid conditions in the southern states where inter-sectoral conflicts are likely to become more apparent in the future. The case study involved discussion with various organizations engaged in managing different aspects of water. In addition, we collected information from key informants on access to drinking water and status of water resources in a sample of 47 villages in the sub-basin. Utilizing the list of villages obtained from district officials and the estimated drinking water availability, we categorized the villages into two groups: those that receive less than 20 lpcd, and those that receive more. A five per cent sample was drawn from each group for each taluk. Within taluks, villages with various levels of proximity to the Ghataprabha River were chosen to capture geographical diversity.

3 Adequate access incorporates the following: 1) 40 lpcd for human beings; 2) additional 30 lpcd for cattle in drought prone areas; 3) one hand pump or stand post for every 250 persons; 4) a water source within the habitation or within 100 metres elevation difference in the hills; 5) "safe" defined as free from bacterial contamination and chemical contamination viz. fluoride, iron, arsenic, nitrate, brackishness in excess or beyond permissible limits.

4 The priorities for expanding access to drinking water are to first provide water even at less than desired levels to all the habitations, then focus on areas with quality problems, and finally to achieve the desired level of supply to everyone. More specifically: 1) to cover "not covered areas"; 2) to fully cover partially covered areas in which habitations get less than 10 lpcd; 3) to cover all habitations with water quality problems; 4) to bring up access to 40 lpcd; 5) to provide water supply facilities for the SC, ST and landless agricultural labourers; and 6) to provide safe drinking water in every rural primary school.

5 Habitations are defined as having at least 50 families/individuals. Coverage may not be complete in districts in which populations tend to be dispersed, living on farmsteads. Karnataka aims to supply rural residents with 55 lpcd and urban residents with 70 to 135 lpcd.

6 In recent years, autonomous organizations such as KNNL (Krishna Neeravari Nigam Limited) and KBJNL (Krishna Bhagya Jal Nigam Limited) have been established to manage water resources in various basins or sub-basins.

7 JSYS (Jala Samvardhane Yojana Sangha) has been established to rehabilitate and hand over tanks that are controlled by the government.

8 Nearly 148,000 ha are irrigated in the LBC using 30 per cent more than the water allocated.

9 The sugar companies, which require nearly 0.75 kl/MT of capacity, use both surface and groundwater. The factories are typically permitted to draw more water during the crushing season in summer. The Athani Farmers Sugar Factory Ltd. for example, is permitted to draw from the Krishna river 158,300 gallons per day (gpd) from October 15 to May 15, and 114,300 gpd from May 16 to October 14.

10 Two sugar companies, for example, have permission to draw water from the river for only 4 years.

11 The charge are Rs. 3,200 per mcft (Rs. 90.56 per m^3).

12 The KNNL permits KUWS&DB to draw 28.3 million m^3 per year from the GIS. The contract stipulates that water should not be demanded from February 1 to June 15 and that the KUWS&DB should make its own arrangements for storing water during summer. Urban centers that receive water from multipurpose systems pay Rs. 375 per mcft (Rs. 10.61 per million m^3).

13 Non-domestic connections are charged Rs. 90 per month; and commercial connections Rs. 180 per month.

14 Intended supply is 120 lpcd in Belgaum and 70 lpcd in other towns.

15 All economic enterprises are required to obtain permission from the Pollution Control Board (PCB) to begin their operations. The PCB permits operations only if the required investments are made, and subsequently, it monitors the industries to see whether they are complying with the standards governing release of effluents. Compliance is brought about through legal action and denial of essential services such as power supply.

16 Gokak currently draws water downstream of the power plant in addition to drawing water from nearly 40 borewells. The city is building a new system to draw additional water from the river.

17 Though the quantity required for drinking is small, evaporation and transmission losses through dry riverbeds during summers will be high.

18 Within the Ghataprabha command, waterlogging and salinity are endemic.

19 Water for human consumption should usually have zero count of faecal coliform and less than 500 for bathing.

20 Markets or opportunities to negotiate, on the other hand, could facilitate voluntary transfer from one use to another, without opposition from existing users (Easter et al 1999; Bruns & Meinzen-Dick 1999)

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INSTITUTE FOR SOCIAL AND ECONOMIC CHANGE
Prof. V. K. R. V. Rao Road, Nagarbhavi, Bangalore - 560 072, India
Phone : 0091-80 - 3215468, 3215519, 3215592 ; Fax: 0091-80 - 3217008
Grams: ECOSOCI, Bangalore - 560 040
E-mail:kvraju@isec.ac.in, Web:http://www.isec.ac.in