Urbanization and Intersectoral Competition for Water

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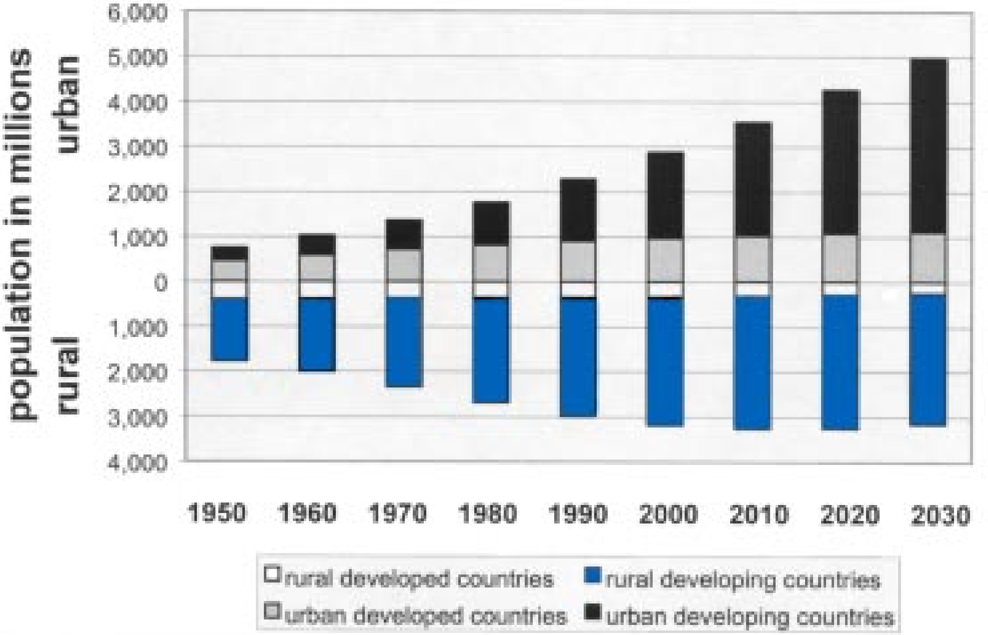
Introduction

One of the most dramatic demographic trends in the latter half of the 20th century was the urbanization of populations in both developing and industrialized countries—a trend likely to continue in the first half of the 21st century. Worldwide, cities added more than 2 billion people from 1950 to 2000, and they are expected to add more than 2 billion more from 2000 to 2025 (see Figure 1). As much as 95 percent of these increases is anticipated to come in developing countries, especially Asia and Africa. Whereas the populations of Europe, the Americas, and Oceania were by 1994 over 70 percent urbanized, Asia and Africa were only 34 percent urban. But these continents are projected to

Figure 1. Urban and Rural Populations in Millions, 1950-2030



Source: data from FAO STAT: http://apps.fao.org be 54-55 percent urbanized by 2025 (United Nations Population Division, 1996). And while the rate of global urban growth is now actually declining (from 2.6 to 2.2 percent per year worldwide, and 3.8 to 2.9 percent in developing countries), the sheer number of people being added to cities will continue to grow rapidly. There are already 411 cities with more than a million people, and 19 megacities with over 10 million (Catley-Carlson, 2000).

Such concentrations of humanity pose enormous challenges to the social, political, and physical environment—challenges that apply not only to cities but rural areas as well. Countries that are urbanizing later are going through the process at a compressed pace, which makes it even more difficult to keep up. Perhaps the greatest two challenges imposed on natural resources by rapid urbanization lie in (1) the distribution of limited water supplies, and (2) the disposal of water-borne wastes. A closer look reveals that meeting urban water needs also has serious economic, social, and political dimensions.

Urban water demand comes both from: (a) the concentration in cities of people, who need water to survive; and (b) urban economic activity. Meeting the water demands of growing cities requires not only large quantities of high-quality water for domestic use, but also large volumes of water for industrial production. Although agriculture is still the largest user of water—accounting for an estimated 72 percent of water withdrawals worldwide and over 90 percent in low-income developing countries (Rosegrant & Ringler, 1998)—municipal and industrial demands are growing much faster (see Table 1). For example, urban water demand in China is projected to grow 60 percent over the next ten years, from 50 to 80 billion cubic meters (BCM); and Chinese *industrial* water demand will increase 62 percent, from 127 to 206 BCM (Nyberg & Rozelle, 1999, page 85). In India, the current domestic water use of about 25 BCM is expected to more than double by 2025 to 52 BCM,; while current water demand by Indian industry and energy generation of about 67 BCM is projected to increase to 228 BCM by 2025. Thus, Indian domestic and industrial water withdrawals will more than double over the next 25 years, accounting for 27 percent of total withdrawals for the country by 2025 (compared to 17 percent in the mid-1990s) (World Bank, 1998).

Table 1. Estimated Global Water Use in the 20th Century

Sector	*1900*	*1950*	*1995*
Agricultural use			
Withdrawal	513	1,124	2,504
Consumption	321	856	1,753
Industrial Use			
Withdrawal	22	182	752
Consumption	5	14	83
Municipal Use			
Withdrawal	44	53	344
Consumption	5	14	50
Reservoirs (evaporation)	0	11	188
Total			
Withdrawal	579	1,365	3,788
Consumption	331	894	2,074

Source: Shiklomanov (1999).

Currently, the world overall has sufficient water to meet municipal and industrial demands, which represent a small fraction of available water supplies (especially compared to agricultural water use) both globally and in most developing countries (Shiklomonov, 1999). But it is not enough to have sufficient quantities of water at a global or macro level. Water must be supplied *where* it is needed, *when* it is needed, and at a sufficient *quality*. It is these characteristics that both pose the greatest challenge to urban water supply and generate the greatest competition between water-use sectors.

This article examines the implications of urbanization for intersectoral competition over water, not only in technical or economic terms, but also in terms of political and social dynamics as well as the possibilities to meet the water needs of growing cities. It begins by looking at the water needs of each sector in urban and rural areas—the quantity, timing, and quality of water demand. It then treats (a) the intersectoral linkages in water quantity and quality, (b) the resulting competition and opportunities for cooperation posed by these linkages, and (c) the values of water in different uses. A closer look at the identity of the users provides insights on how competition for water is likely to play out in different settings. (However, this competition is not necessarily a zero-sum game.) The article identifies promising technical and institutional options for supply and demand management to provide adequate water services. It concludes by exploring the implications contemporary urban dynamics pose for future water policy.

Water Uses in Urban and Rural Areas

The major sectors of human water use are: (a) domestic consumption; (b) industrial production; (c) agricultural production (including livestock); and (d) recreational uses. Although domestic and industrial uses are usually associated with urban demand (and agriculture with rural demand), a closer look indicates that *all* of these uses cut across rural, peri-urban, and urban divisions.

Domestic Water Consumption

Most societies and national policies accord highest priority to water for direct human consumption, including drinking, cooking, bathing, and cleaning. Lack of access to sufficient water for drinking and bathing increases the spread of many water-borne and water-washed diseases, especially diarrheal and skin diseases. Furthermore, domestic water should be of good quality. Both bacterial and chemical contamination can also cause disease (Van der Hoek, 2001).

Defining basic human needs for water is difficult. Gleick (1999) estimates an average need of five liters/capita/day for drinking, plus 10 for food preparation, 15 for bathing, and 20 for basic hygiene and sanitation—making a total of 50 liters/capita/day. However, domestic water demand is not simply a multiple of the population size. Per capita demand increases with urbanization and rising incomes. Rural water supply systems in India, for example, use a norm of 40 liters/capita/day for domestic use without household piped connections, where it is assumed that other water sources can be used for bathing and washing clothes. Urban areas with piped water supply but no underground sewerage in India use 70 liters/capita/day, while India's urban areas with underground sewerage use 125 liters/capita/day, as in most major cities (MIDS, 1995). These norms refer to basic levels; water demand can rise even further with rising incomes. Residential use in Europe, for example, averages around 200 liters/capita/day, and in the United States, 400 liters/capita/day (Cosgrove & Rijsberman, 2000). By Indian standards, a population of one million people would require: 14.6 million cubic meters per year delivered to the end-users for domestic water supply in rural areas; 25.5 million cubic meters for piped urban supplies but no sewerage; and 45.6 million cubic meters for sewerage. The same one million population in the United States would require 146 million cubic meters (plus transit losses).

Despite the recognized importance of domestic water supplies, an estimated 1.1 billion people worldwide do not have access to an adequate quantity or quality of domestic water. At least 2.2 million die annually of diarrheal diseases alone (WHO & UNICEF, 2000). This problem cuts across rural and urban divides. In rural areas, women and children often walk several kilometers to collect water. But urban dwellers are not necessarily better off. Both Lagos and Abidjan have average municipal water supplies of only 40-45 liters/capita/day for their entire populations. Nairobi has a mere 17.7 liters/capita/day, and Lome and Accra supply less than 10 liters (UNCHS, 1998). Even in cities with high average domestic water consumption, many people—especially those living in slums and peri-urban areas—do not receive an adequate share of the municipal supplies. A study in nine East African cities recorded a decrease from the late 1960s to the late 1990s in both (a) the proportion of households with piped water at their homes, and (b) the availability of water in the municipal systems. For those without household pipe connections, collection time for travel and queuing tripled from less than half an hour to more than an hour and a half per day, with private kiosks having the highest collection times (Thompson et al., 2000).

Industrial Water Use

Beyond domestic water needs, water is an input into the economic development process. Industrial production requires water, although the exact amount varies depending on the industry and the technology used. Because of the clustering of factories in cities, industrial demand forms a significant amount of urban water demand. However, a growing number of factories in rural areas also demand water. Industries not only require water for the manufacturing process itself but also for cooling or cleaning. This allows for the possibility of recycling water in factories.

Agricultural Water Use.

Agriculture is the largest water-consumption sector worldwide, especially in developing countries. Irrigation has been and will continue to be critical to achieving food security. Worldwide, irrigated agriculture contributes nearly 40 percent of total food production on 17 percent of the global cultivated area. Irrigated production supplies over 60 percent of the food in India and nearly 70 percent of the grain in China (Rosegrant & Ringler, 1998). Controlled water supplies were critical to the dramatic yield increases of the Green Revolution period of the 1960s-1980s, which allowed per capita food consumption to go up in developing countries (especially in Asia) despite increases in overall population. The increased food production needed to supply the growing urban and rural populations of the future will likely require even more irrigation: the International Water Management Institute (IWMI) estimates that 17 percent more water will be needed for irrigation by 2025 to meet food demand (IWMI, 2000).

Many irrigation systems appear to use water inefficiently, so that crop production itself consumes a relatively low fraction of the water diverted. For example, with surface water applications, only one- to two-thirds of the water applied at the field level goes directly for crop growth, with the rest seeping away or evaporating. Consequently, it appears that either increasing irrigation efficiency or reducing water losses (such as through new irrigation technology or management practices) would free up significant water for other uses, especially municipal and industrial uses. However, this process is not as simple as it seems: unused water from irrigating one field often becomes a source of water further downstream. Thus, overall basin-level efficiencies are generally much higher than they seem, leaving less "unused" water than is assumed (Seckler, 1996).

Within the agricultural sector, crop production receives the greatest attention, but fish and livestock also require water. Animals (including fish) consume a relatively small volume of water in comparison to crop consumption and can produce a very high value of output (Bakker et al., 1999). Moreover, as worldwide demand for animal products increases, the importance of supplying water for aquaculture and livestock is also likely to increase.

In terms of water quality, agricultural production does not require its water supplies to be as clean as those for domestic use. However, crop production is very sensitive to salinity levels and to some industrial pollutants. Treated sewage can actually provide nutrients to crops, but the danger from contamination depends on how and where the crops are used in the food chain (e.g., vegetables that are eaten fresh are most susceptible, followed by grain and tree crops; danger of contamination is least for fiber or fuel crops). Furthermore, continuous use of recycled sewage can lead to build-up of salts that make the soil unproductive. Meanwhile, agrochemicals in the runoff from irrigation systems can become a significant source of water pollution. Fertilizer runoff can cause eutrophication (excess algae growth) of water bodies, and pesticide residues can be toxic for fish and human consumption.

Although agriculture is a predominantly rural activity, urban agriculture is also significant. An estimated 800 million people worldwide take part in urban agriculture, with 150 million full-time farmers (UNDP, 1996). Gardens in cities and peri-urban areas contribute significantly to incomes, food security, and nutritional quality of diets, especially for the poor. Livestock production (including dairy) is also a significant source of income and micronutrients, while trees contribute to food, fuel, and air quality as they improve the overall urban environment (Smit & Nasr, 1992). All of this activity requires water drawn from municipal systems, local wells, water harvesting, or recycled wastewater.

Providing water for utilitarian purposes (production and domestic consumption) alone is not enough; people also demand water for recreational and aesthetic purposes. Ornamental gardens, lawns, swimming pools, and golf courses may not be considered "essential" water uses, but demand for such uses rises with income levels. They thus need to be included in long-term plans for water supplies or managing water demand.

In sum, stereotypical images of "thirsty cities" that equate (a) urban demand with "drinking water" or factories, and (b) rural water supply with irrigation do not adequately portray the water uses in each area. Rural areas also need domestic water supply; and with rural industrialization, factories are increasingly drawing water (and discharging wastes) in rural areas. Nor should the water uses of urban agriculture and landscaping be overlooked.

Intersectoral Linkages in Water Quantity and Quality

As long as there is unused water, meeting cities' growing water requirements poses primarily a technical and financial challenge. However, when water becomes scarce worldwide, meeting the demands of urban areas for drinking, industrial, and other uses will necessitate shifting regional water resources from rural to urban consumers. This need creates rural-urban and sectoral competition over the allocation of water resources.

Water use, however, is not simply a matter of withdrawal. Two other critical elements to consider when evaluating any form of water use are (a) the return flows it generates, and (b) the waste those return flows add to the hydrologic system. Although agricultural use also involves drainage back to rivers and aquifers, the proportion of the water returned as wastewater in urban areas is much higher. The sewage or industrial effluents discharged in urban situations have a high potential for polluting the surface or ground water—affecting the quality and therefore future potential uses for the water. Discharge of wastewater after municipal or industrial use can impose a negative externality (a social cost) on the next user: the wastewater will have to be treated to minimize the pollution and maximize its utility.

This dynamic results in important intersectoral linkages in both water *quantity* and *quality*. Although the former has received greater attention in most water policies, water *quality* linkages are becoming increasingly critical. In both cases, the intersectoral linkages and possible conflicts that may emerge have to be managed by appropriate institutions, preferably at the basin level.

Water quantity linkages

The hydrological cycle provides periodic rainfall or snowfall to replenish the flow in the rivers and streams and augment the groundwater table. Water is therefore a renewable natural resource that can be utilized in a sustainable manner provided long term "use" does not exceed natural replenishment. The total available water resources in a given basin or region is fixed, however, and has to be shared among many users.

The International Water Management Institute (IWMI) distinguishes between *open* basins, which have enough water to accommodate new users, and *closed* basins, where all available supplies are allocated to existing uses (Seckler, 1996). More and more water basins, even in once water-abundant areas, are becoming "closed": increasing the water available for one use in a basin requires removing that water from other uses (including nature) or from other basins.

The timing of water demand causes further complications. Much agricultural water use is seasonal. By contrast, municipal and industrial water demands are year-round. In climates where rainfall or runoff are seasonal, supplying water in the dry season requires storage, generally in the form of groundwater reserves or surface reservoirs. Stored water is the most valuable (for agriculture as well as domestic and industrial uses), but also the scarcest.

Unlike irrigation, where crops consume large volumes of water through evapotranspiration (evaporation from the soil and transpiration by the growing plants), municipal and industrial uses return 70 percent or more as wastewater. In some cities and towns where individual homeowners or industries supplementally tap the local ground water, they may actually return a greater volume of wastewater than the amount of water they received from the public supply system. Storm water runoff from the streets also mixes with sewage in some urban settings. Much of this water can be recycled as it moves through the basin, provided it is treated to remove harmful wastes. However, over 40 percent of cities with a population over 500,000 are located on coasts (WRI, 1996), which reduces the scope for reuse. Unless these cities take special measures to recycle water (e.g., through industrial recycling or use of treated sewage for peri-urban agriculture), their wastewater is discharged into the sea and lost.

Water quality linkages

The quality of available water in rivers, lakes, and the sea diminishes with the return of wastewater, although the level of quality and potential future uses depend on the wastewater's origins. Municipal wastewater or sewage contains organic compounds, nitrogen, and solids that have to be removed through sewage treatment. Untreated sewage pollutes the water bodies into which it is discharged and could endanger public health and aquatic ecosystems. (The nutrients contained in sewage could be profitably utilized for urban agriculture such as tree crops or fodder.) Unfortunately, the sewage also contains various urban wastes from gasoline stations, photo shops, laboratories, and small industries. These can contribute heavy metals and other toxic compounds that are not suitable for agriculture.

Industry could use sufficiently-treated sewage. Since sewage is discharged continuously throughout the year, wastewater is a reliable source of water for industry. For example, some of the large industries in Chennai (Madras) India that experienced severe water shortage problems in the 1980s (due to heavy reliance on ground water) collaborated with the local water agency to use partly treated sewage. The industries (a refinery and a fertilizer plant) set up treatment facilities to purchase and treat the sewage adequately so that it could be used not only for cooling but also for manufacturing pro-

Simply appropriating water from existing rural uses for transfer to cities and industries will cause rural resentment.

cesses. These industries have subsequently used sewage successfully for nearly a decade—a win-win solution that saves the water agency the cost of treatment and actually (a) brings revenue from selling the sewage, (b) reduces pollution, and (c) provides the industries with a reliable source of water.

Industrial effluents can also pollute water bodies or ground water, rendering the water unsuitable for other economic or ecological uses. The return flow from industries that consume large quantities of water for processing can restore a river's quantity of flow to its original level but also seriously impair its quality. Users downstream from such industries either cannot use the water or have to commit resources for treating the water to restore it to usable quality. The intersectoral impact is even greater where the effluent is discharged upstream of a dam. During the dry season when the dam is closed, the effluent accumulates in the reservoir, contaminating the surface water and even percolating to the groundwater table (Appasamy, 2000). In some cases, the effluents also flow directly on to agricultural land, affecting soil and ground water while also possibly contaminating drinking water wells. Additionally, the effluents may seriously harm the quality or usability of agricultural land and drinking water wells in the region, forcing farmers and consumers to abandon them (Appasamy, 2000; Kurnia, Avianto, & Bruns, 2000).

Disposal of partly-treated or untreated effluents on land is often recommended in semi-arid regions of developing countries as a source of irrigation. Israel meets over 70 percent of irrigation with wastewater reuse, and it is estimated that over 500,000 hectares in Latin America are irrigated with untreated watewater, with half of that land in Mexico (see Scott, Zarazúa, & Levine, 2000). This technique is supposed to be a win-win solution that avoids creating pollution while providing farmers with water. Unfortunately, the technique promotes the buildup of salts and other toxins in ground water and soils, ultimately stunting crops. The negative impact may take time to manifest itself, by which time the water table is so contaminated that it may take years before the process can be reversed.

Fisheries and other aquatic ecosystems are particularly sensitive to water quality and can be seriously affected when industrial effluents are discharged into water bodies. The harm may travel up the food chain when other aquatic life or people eat the affected fish. Similarly, livestock require water for drinking and fodder, and milk is especially susceptible to poor quality water or contaminated fodder.

Economic Values of Water in Different Uses

When water scarcity arises, governments generally allocate water resources among sectors by assigning priorities and setting quantitative limits for each user. Economists have argued strongly for using market mechanisms (such as tradable water rights) or pricing instead as the instrument for allocation. The International Conference on Water and the Environment (ICWE, 1992) agreed upon the principle known as the Dublin Statement (which was subsequently affirmed at several other international forums, such as the 2000 Second World Water Forum) that water must be treated as an “economic good” on account of its relative scarcity. Though this has not been widely applied in practice, there is growing attention to economic aspects in water allocation (Dinar, 2000). There are several ways of estimating the economic value of water, either based on: (a) the value in production, actual water prices, or users’ willingness to pay; or (b) the cost of recycling or alternative water sources. However, it is important to recognize that there are two components to water costs: the cost of delivering the water, and the value of the resource itself. Water does not reach the end-user without infrastructure to collect it and deliver it to the user. The net benefit of water is the value (in use) less the cost of delivering the water.

Agriculture

Since water is an input into agricultural production, it is possible to compute the value of water to that production process. An irrigated plot yields much greater returns than does an unirrigated plot, with the difference in returns indicating the value of water to agriculture. But these conventional approaches to valuing irrigation water neglect the value of other overlapping water uses that are generally found in irrigation systems, especially in developing countries. The value of fish production, livestock, homestead gardens, domestic use and other enterprises that draw water from the irrigation system can be substantial. Because they are difficult to measure, however, they are often overlooked.

Industry

In the case of industrial water use, instead of estimating the value through the production route, researchers could determine how much industry would be willing to pay or actually pays for the water. For industries that recycle water, the cost of recycling a unit of water could also be estimated (Bhatia, Cestti, & Winpenny, 1995). All these methods reflect the upper bound that industry sets on the value of water.

Households

In the case of households, researchers can carry out "willingness-to-pay" surveys to estimate the value of water. Where private markets for water exist, the scarcity value of water can also be observed in the marketplace. As in the case of irrigation, the cost of supplying the water must be deducted to estimate the net value of water for both industrial and domestic use.

Nature

Finally, the market (or "revealed preference") cannot reveal the value of water for ecological services, because such services are by nature public goods and valuable to future generations as well as our own. In this case, the measure of willingness to pay (e.g. for protecting a wetland or other aquatic ecosystems) also does not capture important non-economic factors, such as preservation of biodiversity or even aesthetics. Because of the difficulties in valuing ecological services and deciding who should pay for them, it may be preferable to allocate water for these purposes quantitatively, without debating their value vis-à-vis other sectors. Such a decision may have opportunity costs in the sense that the water set aside cannot be used for other purposes. On the other hand, it may be possible for certain uses to coexist. For example, aquaculture and capture fisheries can operate in the reservoirs and canals of irrigation systems in some cases, but in other cases excessive use of agricultural pesticides can compromise fisheries. Each case is location-specific and has to be examined independently.

In practice, the monetary value of water in the industrial or domestic sector is generally much higher than in the agricultural sector, as increases in food production over the past 20 years have led to a decline in real food prices (especially for wheat and rice, the major crops grown under irrigation in many developing countries). This dynamic does not mean that other sectors are more important than agriculture: growing populations will have to eat as well as drink. However, if the market alone allocated water, non-agricultural requirements would be met first. Societies, on the other hand, may wish to place equal or greater value on agriculture, since: (a) food is a basic need, (b) agriculture is vital to rural livelihoods, and (c) issues of future food security or equity may not be adequately captured by economic measures.

Arguments For Pricing

Within the agricultural sector, it is useful to compare the marginal value of water for different crops. In many cases in both developing and industrialized countries, irrigation water has been heavily subsidized for farmers as a government policy to increase food production and gain the political support of rural populations in countries from the United States to India. Even when farmers are charged for water, charges are rarely based on the amount of water used (largely because of technical difficulties and the cost of measuring and collecting volumetric charges). As a result, farmers have no incentive to economize their water use, and may choose to grow water-intensive crops like rice or sugarcane even in water-scarce areas. If the technical and managerial obstacles could be overcome, pricing irrigation water to reflect its real value would lead to more rational cropping-decisions by farmers.

The same principle applies to households, which tend to waste water. It is often suggested that pricing would force water conservation and reduce non-essential uses such as ornamental gardening or swimming pools. Yet water may not have high price elasticity. In developing countries, those who use water for these purposes are rarely deterred by increased prices for publicly supplied water; in practice, they purchase water from private suppliers at far higher prices. Where price increases have reduced water use, the conservation effect decreases over time as people adjust to the new prices (UNCHS, 1996). If conservation is the purpose, quantitative restrictions may be more appropriate.

But there are other reasons for pricing domestic water at a higher price that is closer to

Map 1. India

Source: *The Times Atlas of the World* (1999) the value the water holds for other uses. First, increasing cost recovery would provide funds for continued investment in and operation of water-supply systems (as well as for acquiring the water). Currently, many cities lose 40 to 60 percent in the form of unaccounted water (Wegelin-Schuringa, 1999). If water were priced realistically, cities would realize that their mismanagement is costing them a valuable resource (or, conversely, that they could double revenues by eliminating water loss).

Water valuation aids policymakers in making both allocation as well as pricing decisions. Pricing of water is important not only for making optimal use of the resource, but also to ensure the financial sustainability of the water agency—be it for irrigation, industry, or household use. There is a growing literature on the political economy of water pricing (e.g., Dinar, 2000), spurred by the resistance of interest groups (such as agriculture) to proposed reforms to current free or subsidized water supplies. Given the strain on public budgets, water agencies will face a difficult choice in the long run: either allow the infrastructure to deteriorate, or make the politically unpopular decision to price water efficiently for all sectors.

It is a myth that the poor will not pay for water. Many surveys indicate that poor people are willing to pay for water if they are guaranteed a reliable supply (Wegelin-Schuringa, 1999). And the poor currently pay for water when they purchase from vendors or if they have to spend time collecting the water from standposts and other sources.

But although water clearly has an economic value, pricing water is controversial because, unlike other commodities, water is essential for all forms of life—and therefore should not be denied because the user cannot afford to pay or because Mother Nature cannot express preference in the marketplace. It becomes necessary, therefore, to ensure a “lifeline” quantity not only for human beings, but also for livestock, fish, and all living ecosystems. In other words, the allocation mechanism must make provision for ecosystem uses, apart from purely anthropogenic uses. Beyond this baseline, water pricing can be useful to manage demand and make resources available to pay for adequate water services for all.

It is also important to value the waste-disposal services that rivers and lakes provide in assimilating effluents, thereby cleaning water flows. Analysts can value these services in terms of the cost of effluent treatment that would have been incurred in the absence of the water body. Of course, waste should not be exempted from treatment prior to its discharge into the water body. In practice, however, discharges are rarely treated. Analysts estimate that 90 percent of sewage in developing countries is discharged directly into water bodies without treatment; hence rivers, lakes, and coastal bodies in these regions have become severely polluted (WRI, 1996). In tropical countries (where rainfall is seasonal) there is the added problem that those rivers that only have seasonal flows have no capacity to receive even treated effluents in the dry seasons.

Water Users and Power Relations

Despite the Dublin Statement and a number of other international declarations that water should be treated as an economic good, the allocation and provision of water to different uses rarely follow strictly economic values and criteria. Rather, social and political factors exert a major influence on these decisions. Because water supply is so vital to life as well as to livelihoods, its provision is critical for social stability and political legitimacy of governments. Thus, intersectoral competition for water cannot be understood without looking more closely at (a) the users and other stakeholders, (b) their power relations, and (c) the strategies they employ to secure their water demands.

Box 1: Water Quantity, Quality, and Influence in Tiruppur, South India

The town of Tiruppur in South India exemplifies many of the dilemmas that developing countries face when a secondary city or town rapidly industrializes. Tiruppur's rapid expansion of population—from 235,000 in 1991 to 340,000 in 2001, with a predicted increase to 490,000 in 2011—has resulted in an increased need in the city for both water supply and underground sewage. Much of this population increase is drawn by the hosiery industry, which has grown rapidly due to the opening up of export markets. This industry employs over 200,000 people in the Tiruppur area and generates millions of dollars of exports. There are 702 bleaching and dyeing units in the area that require large quantities of water to operate.

Tiruppur has intersectoral competition over both quantity and quality of water. Water for the city's industries has been largely obtained by pumping local groundwater, which is being depleted. Some farmers have begun selling water to the city and industries—but while these farmers find selling water more profitable than using it on their own farms, surrounding wells are drying up because of the increased extraction.

The effects of increased industrial water demand on Tiruppur's water quality are even more serious. The effluents discharged by the local hosiery industry's bleaching and dying units have polluted the river and local ground water in the urban area. Residents have to rely on water brought from more distant sources. The effluents have also affected the city's irrigation tanks as well as a new reservoir downstream from Tiruppur. All of these are now unfit for both irrigation and fisheries, amounting to losses of $1 million for which the farmers and fishers were not compensated.

In collaboration with industry, a number of funding agencies are financing a 55 km pipeline to bring water from a local river to supply water for Tiruppur's municipality, industries, and wayside villages. Proponents of the project propose that its investment costs will be recovered through user charges. The implementation of the project will reduce the exploitation of ground water, but will still result in the discharge of effluents. The pipeline has been opposed by farmers' organizations and community groups.

Government pressure on the hosiery industry to recycle its effluents could have reduced both the water requirement and the downstream pollution problem. (Indeed, water scarcity has already reduced water-use per kg of cloth from 226.5 liters in 1980 to 144.8 liters in 2000.) However, there has not been effective coordination between Tiruppur's Public Works Department (which deals primarily with irrigation and water quantity) and the Pollution Control Board (which deals with industries and water quality). Farmers and local NGOs filed a petition with the Indian High Court, asking that local industries be required to treat their waste. As a result, most of the factories constructed individual or collective treatment units, and the remaining 164 industrial units were shut down for non-compliance. However, the treatment units still do not meet standards, and the factories are still able to exert considerable influence on local policymakers because of their importance to local employment and export revenues.

Source: Appasamy (2000).

Domestic Water Supply Users

At one level, domestic water supplies are the most cross-cutting type of water use. Rich and poor, urban and rural households alike need water for drinking, cooking, washing, and bathing. Women typically bear the greatest responsibility for domestic water use (and the greatest cost when it is not provided), but both men and women obviously need drinking and bathing water.

This universal human need for water is recognized in the primacy given to domestic water supplies in many government policies, religious statements on water, and local norms. The new South African water law is perhaps the clearest example of government law giving priority to basic domestic use (South Africa, 1997), but the importance of domestic use is also seen in Nepal's Water Resources Act of 1992 (Pradhan & Meinzen-Dick, 2001). Islamic law and hadiths stress the importance of providing water to guests, and extend the "right of thirst" for animals and plants as well (Farouqui, Biswas & Bino, 2001; Wescoat, 1995). In the Christian Bible, Matthew 25:40 relates that on judgment day, giving water to those who thirst will be one of the defining criteria for separating those who are to go to the kingdom of heaven from those who are to be cast out. In Hinduism, offering drinking water benefits the donor (Manu: IV:229). On the other hand, at least in one reported case in the hills of Nepal, it is believed that the persons who prevent others from gaining access to drinking water, even if the source is on private land, would go to hell (Upreti, 2000).

In principle, therefore, few begrudge allocating water for urban domestic use, especially since many rural families have members living in the cities. Rural opposition to transferring water for urban domestic use often comes from a perception that the cities will get a higher level of service, or that urban residents will use the water for non-essential purposes. For example, in the Lower Bhavani area of South India, when water from an irrigation reservoir was reallocated to Coimbatore city, many farmers did not oppose the transfer itself, because they recognized the importance of drinking water and because many had relatives living in the city. However, villages along the way protested that they did not have piped domestic water supply, so during the 1990s they were also given connections. As a result, the original allocation for domestic supply to the city had to be increased to supply the villages as well.

The universal human need for domestic water does not imply that everyone receives equal service. The differences lie not only between urban and rural situations but also between different types of cities and between classes within each area. The water problems of megacities often receive the greatest attention and resources from national governments and external donors; these cities are more likely to have exhausted locally-available water supplies and to have polluted their surroundings. However, only 15 percent of urban populations live in cities over 5 million; 60 percent live in cities and towns of less than a million (People and the Planet, 1996). Secondary cities and towns face problems in providing water similar to those of large cities, but they have fewer financial and political resources to address them.

At first glance, it may seem that rural and urban water interests are at odds with each other; but when we look closely at the household level, this characterization is revealed as not fully accurate. First, many rural households have family members in the cities, and thus can identify to some extent with urban water needs. Meanwhile, neither all rural nor all urban households have the same access to water. While a few rural households have their own tubewells close to the house or have access to piped water, other rural residents may (a) travel long distances to collect water, and (b) have problems with water quality. The differences in water access within cities are even more marked. Slum areas are often either not served by municipal supplies or have standpipes rather than household connections and no sewerage. Only 18 percent of low-income urban residents in developing countries have household pipe connections from the municipal water supply system, compared to 80 percent of high-income residents in these countries (WRI, 1996).

Industrial Users

Many governments give lip service to the priority of domestic water supply and may even list irrigation as the priority user in their water policy; but industrial uses generally prevail thanks to economic and political influence (see Box 1; for an example from Indonesia, see Kurnia, Avianto, & Bruns, 2000). This is seen not only in a society's water-allocation policy, but also in its degree of regulation over pollution. However, while large factories may have the greatest economic influence over policy decisions and their enforcement, they are easier to regulate than small factories: a large factory's supply and discharge occur at a single point, while many small and dispersed factories take water through a variety of legal, semi-legal, and illegal means and often discharge wastes with minimal treatment. And although many developing countries encourage rural industrialization in an attempt to prevent overcrowding of urban areas, the economies of agglomeration often make urban industrial production more efficient and easier to regulate. Indeed, discharge of effluent from rural factories has had very negative effects on agricultural production, e.g. in Indonesia and India (see Box 1).

Since factories employ so many people, it is not just industrialists who have an interest in securing water for factories. Even farm families often have family members employed in factories and therefore experience divided interests regarding industrial water use (Kurnia, Avianto, & Bruns, 2000). Also, the importance of generating exports and revenue for the government often leads to policies that favor industrial interests.

Farmers

Just as domestic and industrial users are not homogeneous and cut across rural and urban boundaries, farmers also differ greatly in wealth, influence, and ability to secure alternative water supplies and livelihoods. This makes it difficult to determine in advance how competition for water between agriculture and other sectors will play out. Those farmers who grow water-intensive or low-value crops may be able to switch to water-saving crops or technologies and still reap profits. Farmers who possess recognized senior water rights (those rights of longest-standing and with greatest legal backing) may be protected from water transfers or receive adequate compensation for such transfers. But many other farmers either lack the resources to change technologies or do not receive any compensation. Drought-related reallocations around Mendota, California from 1987-92 resulted in a 26 percent decrease in the number of farms. While larger farmers were better placed to cope with water losses, 70 percent of the Mendota area's small farms went out of business (Rosegrant & Ringler, 1998).

It is not only farmers' livelihoods that depend on water supplies: the entire rural economy of a region may be affected, including the tax base. Thus, "third-party effects" of intersectoral water transfers include not only the physical or hydrological consequences of water transfers, but also economic and livelihood effects. Moreover, even urban residents are stakeholders in ensuring stable agricultural production for food security.

Nature

Ecosystems (including wetlands, rivers, and discharges into the sea) require water just as critically as humans do. Demands to reserve water for nature generally increase with national income levels. Although local populations are most directly affected, national and even international environmental groups (e.g. the International Union for the Conservation of Nature (IUCN) and Green Cross International) advocate reserving water for nature (IUCN, 2000). Legislation such as South Africa's water law (South Africa, 1997), court cases such as the application of the Public Trust Doctrine to limit water abstractions in the United States (Ingram & Oggins, 1992; Koehler, 1995), and international treaties such as the Ramsar Convention on Wetlands (UNESCO, 1994), all strengthen the bargaining power of nature advocacy groups to protect water supplies from further anthropogenic use. As ecosystem uses become recognized, there is less and less “unused” water available for growing urban demands, further increasing competition for existing water supplies.

Options for Meeting Urban Water Needs

There are three broad strategies for reconciling growing demands for urban water with the constraints on the quantity and quality available: (1) increasing supplies through new sources; (2) reallocation from other sectors; or (3) managing urban demand. Each of these calls for a combination of technical and institutional measures.

New Sources to Increase Water Supplies for Cities

The options for increasing water supplies through new sources include: (a) building new dams and water-control structures, (b) inter-basin transfers, (c) non-conventional sources such as desalination, and (d) water harvesting. As noted above, most urban uses require year-round access to water. In climates with seasonal rainfall (as in many developing countries), ensuring such supplies generally requires stored water. Ground water and reservoirs therefore play the largest role in supplying municipal water.

Ground water: Foster (1999) estimates that one billion urban dwellers in Asia and 150 million in Latin America rely on ground water for their domestic water supply. However, overextraction of ground water in and around cities has caused falling water tables. Cities such as Mexico City and Bangkok both face subsidence of the land itself as their aquifers are depleted and compacted, while almost all coastal cities face saltwater intrusion because of aquifer depletion (WRI, 1996). Moreover, contamination of aquifers through seepage from various wastes has reduced the quality of ground water, especially at shallow levels. Thus, groundwater storage has a limited capacity to meet even existing urban water demands.

Surface storage: Once a popular solution to rising water demands, new dams and reservoir building have become increasingly expensive in financial, environmental, and political terms. Almost all the best sites for such construction are already exploited; the environmental costs of submerging forests and wildlife are increasingly being recognized; and opposition to such environmental damage and the submergence of villages chronically provokes political opposition. Thus, cities often turn to water stored behind existing dams built for irrigation or hydropower.

Inter-basin transfers: Bringing in water from other areas represents another possibility to meet growing urban demands in water-short basins. Such projects often involve high-cost canals or pipes to transport the water, especially where the water must travel a long distance. Moreover, taking water from one basin may harm the environment, and the pipes or canals may have to cut through forests, agricultural land, or habitations—causing environmental or land acquisition problems. Increasingly, communities that lie in the path of such canals or pipes demand a share of the water, either for drinking or for irrigation.

Non-conventional sources: Desalination is expensive and energy-intensive under existing technology. Even after desalination, pumping water from the sea to its destination poses an additional cost. Thus, desalination is unlikely to be used on any large scale, except in very water-scarce and energy-rich countries (as in the Middle East).

Water harvesting: There are various forms of water harvesting that capture and store runoff during the rainy season, ranging in scale from a household rooftop to those that cover a sub-watershed of several square kilometers—capturing water either in storage tanks, the soil profile, or recharging ground water (see Agarwal, Narain, & Khurana 2001; Kerr & Pangare 2001). These generally small-scale technologies are receiving attention from governments, NGOs, and donors because they are seen as environmentally friendly ways of increasing the availability of water

Water harvesting is especially important in monsoon climates with rapid runoff over a few months. The greatest emphasis has been placed on rural water harvesting, either for direct irrigation use or for recharging water tables. There is some debate whether this technique increases the water available for cities: critics claim that rural water harvesting reduces downstream flows, while proponents claim that effective harvesting can recharge water tables and bring seasonal rivers "back to life"—thus benefiting cities as well (Agarwal, 2000). Urban water harvesting certainly offers more direct possibilities to improve water availability in cities. As with rural water harvesting, rainwater and runoff can be either stored and used directly, or used to recharge the ground water. A growing number of cities, including Chennai and parts of Delhi, are requiring the inclusion of water-harvesting structures in all new buildings.

Reuse and recycling: As noted above, many forms of water use do not consume most of the water they withdraw. Much is eventually returned to the hydrologic system, though at a reduced water quality. Wastewater can be reused and recycled at various levels from the household to the city. "Grey water" from sinks or showers is often used for home gardens or can be diverted to soak pits to recharge the ground water. Treatment and recycling of wastewater for non-potable uses can be taken up in large buildings. Several cities have attempted to use treated sewage for urban agriculture or for industry, though there are concerns with the accumulation of salts and heavy metals that can harm the soil or human health (Flynn, 1999; Scott, Zarazúa, & Levine, 20001). Industries that recycle their wastewater simultaneously reduce their water requirement as well as the effluent discharged.

Reallocating Water from Agriculture to Cities

Although there is some capacity for tapping unexploited water sources to meet rising urban demands, these sources are becoming more difficult and expensive to access. Thus, supplying more water for cities will require taking water from another use. Increasingly, water is shifted from irrigation because: (a) it uses the most water worldwide, especially in developing countries; and (b) the estimated economic value of water in agricultural production is low relative to domestic and industrial use.

It is often argued that even a small percentage of water saved from agriculture could meet most urban demands (e.g., Rogers, Bouhia, & Kalbermatten, 2000). While this is true at an aggregate level, timing and location cause significant complications. Whereas much irrigation use is seasonal, non-agricultural requirements are year-round, necessitating storage. It is also usually not feasible for all farmers to save a small amount of water to transfer to cities; rather, those farmers near the cities usually become the major source of water transfers.

In many cases, water is simply expropriated from agriculture to meet other sectoral demands, as was done in the Bhavani basin in India or the Angat basin in the Philippines during a drought year. Such expropriations can cause political unrest as well as loss of income to others in rural communities and an erosion of the rural tax base. Further rural-to-urban migration might also be a consequence, as livelihoods and water dry up in rural areas. On the other hand, many farmers are often willing to share their water supply if they will be compensated. A myriad of cases—especially in the western United States, Chile, and Mexico—indicate considerable scope for negotiated transfers with mutual gain (for a review, see Rosegrant & Ringler, 1998). Under some of these arrangements, cities can pay for investments in rural irrigation water conservation and then use the "saved" water; they can also pay farmers to not irrigate some of their land or buy outright rural water rights. Much of the success of these arrangements hinges on the extent to which the customary water rights of irrigators are recognized and alternative livelihoods are available. Even if the government has not conferred clear water rights to farmers, farmers who have been irrigating for a number of years generally feel ownership over the water; and such transfers do threaten their asset base and livelihoods (Bruns & Meinzen-Dick, 2000).

Tradable property rights for farmers (if recognized by the state) allow farmers to voluntarily transfer water to other users. This option offers the potential to protect farmers' interests while still providing an incentive for conservation and the transfer of water to higher-value (or higher-paying) uses (Rosegrant & Binswanger, 1994). However, such water markets will require (a) physical infrastructure for the transfers, (b) effective information systems, and (c) effective mechanisms for dealing with the consequences of such transfers for third parties. Reviewing the evidence on intersectoral water transfers, Rosegrant & Ringler (1998) concluded that outcomes are generally positive on rural communities under the following conditions:

Stereotypical images of "thirsty cities" that equate (a) urban demand with "drinking water" or factories, and (b) rural water supply with irrigation do not adequately portray the water uses in each area.

- farmers have secure water rights;
- farmers receive substantial compensation for transfers;
- farmers can sell only part of their water (and stay in farming);
- there are effective institutions to deal with third-party effects (including negative effects on the rural tax base and economy); and
- there are flexible tools (such as leases and options contracts) rather than just expropriation or outright sale of water to urban interests.

Managing Urban Water Demands

Increasing water supplies is not the only option for dealing with growing urban water use. There is also considerable scope for reducing water *demands* through physical and institutional mechanisms. In this regard, it is important to distinguish between (a) basic water *needs* for human and environmental uses, and (b) *wants* for water for additional goods and services (Lundqvist & Gleick, 1997). Reducing non-essential wants and wastage can reduce water demand substantially, reducing pressure on all water resources. While the following examples discuss urban water uses, the same principles can also apply to the rural sector as it attempts to conserve water in irrigation.

Given the high cost of transporting water from distant sources (as well as the opportunity cost of reallocating water from existing uses such as agriculture), urban water agencies are increasingly looking at ways to use the existing supplies more efficiently. Many cities in developing countries have "unaccounted-for water" (UFW) of 50 percent or more because of leakages, theft, or other problems in the distribution system. Reducing UFW and improving the physical efficiency of main supply and household plumbing will increase available water.

Leak detection: Leaks often occur at joints or at house-service connections due to corrosion or other structural problems. Mexico City alone loses an estimated 12 cubic meters per second because of leaks (Urban Age, 1999), amounting to 378 million cubic meters per year. Apart from the financial loss to water agencies, leakage affects the level of service to consumers. Moreover, contamination of protected water may occur if the leaking points are not repaired. Upon detection of leaks, water agencies may need to replace old pipes and take other remedial measures, but the water savings will make up for the cost of leak detection and preventive maintenance within one to two years (not counting the improvements in water quality that result).

Stopping water theft and illegal connections: Some UFW is not lost in leaks but is tapped and used illegally. Given the difficulty of tracking down unmetered connections, water agencies will need to work with communities in order to account for and recover some of the costs of illegal connections. If water is becoming scarce, the agency may have to consider an alternative institutional system such as a group tap, community tap, or vending kiosk (Wegelin-Schuringa, 1999). New pre-pay meters such as those being used in South Africa may provide a suitable technology for low-income areas, because the tokens can be bought in small increments (rather than larger monthly payments) and do not require regular meter reading and bill preparation.

In-house improvements: Water agencies may wish to provide water audit services (similar to energy audits) to increase the efficiency of water use at the household or institutional level. Because flush toilets use a large portion of domestic water use, introduction of nine- or six-liter flush toilets or dual flush toilets can save considerable amounts (e.g., 15 percent of total residential use in Israel) (UNCHS, 1996). By replacing 350,000 old toilets, Mexico City's water conservation program saved enough water to supply an additional 250,000 residents (Gleick, 2001). Water-saving washing machines and shower and faucet regulators can also save significant amounts. Incorporating such technologies into housing codes will generally increase adoption rates. Similarly, industries can do much to conserve water: recycling water from cooling, steam, and heating systems as well as seal water; pressure and flow regulators and valves; the use of lower quality water for some purposes; and air cooling.

Pricing urban water: The pricing structure for water is often blamed for inefficient water use. In most developing countries, farmers and households either do not pay a unit cost for water use or pay a low charge; both policies provide little incentive for water conservation. User charges, effluent charges, or tradable water rights can provide an impetus for conservation. However, pricing alone has a limited effect in inducing household conservation, because water charges form a small portion of family income, especially for the wealthier households that consume most water. Dramatic increases in water charges can reduce consumption, but as noted above the effect declines over time as people adjust to the new prices unless the price increases are accompanied by other measures, especially education campaigns (UNCHS, 1996). Nevertheless, all water-use sectors—agriculture, industry, and domestic—should pay prices that reflect at least the average cost of supply.

Education measures: Water conservation requires behavioral change as much as anything. Getting people to adopt such changes requires awareness and understanding on the part of the general public. Public information campaigns through the media and direct consultation with user groups can provide information on water scarcity as well as water conservation methods, habits, and measures to conserve water. School programs to educate young people about water conservation as well as sanitation can pay rich dividends in the long run. The public can become involved in water conservation through community organizations and other initiatives. In Chennai, the local water agency has formulated a Citizens' Charter as the first step in involving the users in water conservation efforts.

Decentralized systems: Many centralized city services do not provide uniform water and wastewater services to the poor communities they serve. For example, depending on the location and infrastructure available in formal and informal settlements, a city's water agency may provide special services through tanker trucks, stand posts, or kiosks, and will have to decide whether or not to charge for these services. Low-income communities may wish to have their own community-managed systems, either to improve services (by having them under their own control) or to reduce their costs. Urban authorities need to legally recognize and work with these community-managed systems to improve performance for all. For peri-urban and suburban communities, decentralized water and wastewater systems may be more appropriate; it is not clear that there are economies of scale in extending water services from a centralized system to these outlying areas. Again, local governments of these communities may prefer to manage their own systems.

Pollution control: Most countries have passed pollution-control laws that require polluting industries and municipalities to treat wastewater to prescribed effluent standards. However, implementation and enforcement of the laws is often more problematic.

Municipalities may not have the necessary resources to build sewage treatment plants without financial assistance from higher levels of government. If the municipal systems cannot handle heavy loads of effluents, industries will have to invest in either individual or common treatment plants or will have to pre-treat their wastes if they are not to overload the capacity of publicly-owned treatment plants. But in developing countries, industries have shown reluctance to undertake the capital cost of treatment without some subsidy and an even greater reluctance to operate the plants properly due to the costs of chemicals, power, and trained personnel.

Effluent charges based on the quality and the quantity of the effluent discharged into public systems or waterways can provide an incentive to industry to conserve water as well as to reduce pollution. Industries may treat their wastes up to a point and then pay for the balance as a tax. Some countries, such as China, Colombia, and the Philippines, have been experimenting with varying degrees of success with effluent charges. Marketable permits for pollution—similar to tradable water rights—have also been suggested but have not yet been employed in the case of water pollution in developing countries (Hoag & Hughes-Popp, 2000). In general, economic conservation and pollution-control instruments function best when coupled with stricter regulation and enforcement.

This regulatory process can be aided by involving the local community. Public disclosure of information on pollution could motivate polluters to reduce their effluents. "Green" ratings of industries can pressure polluters to comply with environmental regulations: consumers may boycott these industries' products, while their investors may worry about regulatory penalties or liability settlements. Stock prices may also reflect the green performance of polluting industries, which in turn affects their credit rating and ultimately the cost of borrowing. Indonesia's Program for Pollution Control, Evaluation and Rating (PROPER) was effective because public disclosure of emissions combined external pressure with improvements in plant managers' own awareness of pollution levels and opportunities to improve their performance (Afsah, Blackman, & Ratunanda, 2000). Again, economic or normative sanctions work best when combined with education about what can be done and how to do it.

Whether or not industries can be pressured into treating their effluents, municipalities may need financial assistance to meet water quality standards. In India, the Ganga Action Plan and the National River Action Plan provide substantial resources to towns and cities to control pollution entering the major rivers of the country. Under these plans, sewage and storm water outfalls are diverted to a chain of sewage-treatment plants to treat the wastes before discharge into the waterways. Thus, both the carrot and the stick may be needed for a comprehensive program to improve water quality in both urban and rural areas.

Water boards and basin organizations: Traditionally, water quantity and water quality have been managed by different institutions at the regional and local levels. There is growing recognition that this separation is an artificial disciplinary boundary and does not reflect the fact that water is a unitary resource. Quantity and quality are irrevocably linked in both nature and in the minds of average users. If there is sufficient quantity, contaminants can be diluted to make the quality acceptable; and if the quality is too bad, it can make water quantities unusable. Future institutions must be able to simultaneously examine and manage water resources from both the quantity and quality perspectives. Basin organizations were initiated with the Ruhr basin in Germany, and have been adopted in a number of European countries, especially France. The Murray-Darling Basin Organization in Australia was one of the first river basin organizations to devise appropriate water-quality management measures, which have been used as indicators of the improvements in water quality. Other countries (e.g. Indonesia, Brazil, Mexico, Venezuela, Bulgaria, Poland, Ukraine, and India) are working to establish similar bodies for integrated development and management of each river basin (UNDDSMS, 1996). If these river boards are to be effective, they must have sufficient representation of all users in order to make decisions on the intersectoral linkages of water quantity and quality.

Financing: All these efforts require the provision of not just water but infrastructure. The scale of necessary investments is massive. The Global Water Partnership estimated in 2000 that developing countries would require US$13 billion of investment per year for drinking water, $17 billion for sanitation, $70 billion for municipal waste water treatment, and $30 billion for industrial effluent treatment—a total of $130 billion per year, compared to current investment levels of $35 billion (Global Water Partnership, 2000). Financing agencies such as the World Bank are setting up urban infrastructure funds in some countries to facilitate this process. Cost recovery is becoming increasingly important to donors as a means to improve both financial sustainability and demand management. However, even with these efficiencies, the public sector will not be able to invest enough. To meet the gap between what is needed and what public sector and international financial institutions are prepared to provide, private-sector participation is increasingly sought either directly from national and multinational corporations or through the domestic and international capital markets (World Water Commission, 2000; International Conference on Freshwater, 2001). Mobilizing resources from the capital markets may be done by issuing bonds backed by government agencies; but in other cases, private-sector firms are directly involved through water concessions or a range of contracts for building, operating, or maintaining water supply systems. For example, Ondeo, a subsidiary of the French multinational corporation SUEZ, is involved in water supply in major cities in Argentina, Morocco, Indonesia, Philippines, Chile, and South Africa (ONDEO, 2001). But involvement of private firms requires appropriate pricing and regulation to balance out the interests of the company in cost recovery with the interests of consumers and political stability.

Conclusions

The process of urbanization that shaped the latter half of the 20th century will continue in the 21st—not only in megacities, but also in towns and secondary cities. Of all the challenges posed by the dramatic growth of cities, none will continue to have greater impact on the quality of human life or the environment than (a) the provision of water, and (b) the treatment of waterborne wastes.

Water is essential for life and livelihoods in both rural and urban areas. Considerable amounts of water are necessary to produce food for both rural and urban populations, and globally the water needed for irrigation is likely to increase in the next 25 years. Secure rural livelihoods are also critical to prevent excessive urbanization, and much of the stability of rural production and employment depends on safe and secure water supplies. At the same time, urbanization is an engine of economic growth in developing countries, with great potential to reduce poverty. To realize this potential, cities also need water for industries and to ensure a decent quality of life for all their citizens.

The traditional result has been intersectoral competition over quantity and quality of water. But there are also possibilities for mutual gain. A closer look at types of water uses shows that domestic, agricultural, and industrial demands for water are all found in both rural and urban areas (although in different concentrations). Simply appropriating water from existing rural uses for transfer to cities and industries will cause rural resentment. Negotiated approaches that allow farmers to voluntarily reduce water use and profit from water transfer to cities are likely to cause less resistance and less loss of livelihoods in rural areas.

Both economic progress and government stability depend on meeting the water needs of rural, urban, and peri-urban areas. Meeting these needs will require substantial investments in urban infrastructure for water supply, treatment, and disposal. At the same time, very few muncipalities will be able to meet unchecked urban water demands. Therefore, demand management will also be necessary. Water pricing, which has received considerable attention as a means of demand management, may not be very effective without complementary regulations, education campaigns, leak detection, retrofitting, recycling, and other technical improvements.

Providing water in an efficient, equitable and sustainable manner to both urban and rural areas in the 21st century poses as much of an institutional as a technical challenge. The ad hoc and sectoral approaches of the past do not adequately address the interrelated nature of urban water use. To meet urban water needs, water institutions must expand their vision in at least two directions: (1) to extend services to low income communities and peri-urban areas, and (2) to protect the quality of surface and ground water. But this expansion will require a move from centralized decision-making to the consistent involvement of many different types of stakeholders. If water transfers from agricultural use are to be accomplished with minimal negative impact on rural livelihoods, decision-makers and administrative officials must develop negotiation processes and capacity.

Although vital and challenging, water quantity issues are also only part of the story. Much more attention must be given to water quality. This includes: (a) technical innovation in water-quality monitoring and wastewater treatment, (b) financing of municipal and industrial-water treatment plants, and (c) institutions to monitor and enforce water quality standards. As in the case of water conservation, public education can play a major role.

Finally, dealing with the water needs of the poor (who constitute almost one-third of the global urban population) will require far greater efforts. Such efforts must go beyond conventional engineering approaches to include a wider range of options for water supply and sanitation. Addressing these needs also requires rethinking institutional approaches to incorporate community organizations in decision-making as well as implementation.

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Note

[1] Abderrahman (2000) reports a cost of $0.70-$.90 per cubic meter for desalination plants in Saudi Arabia, with a further cost of $.20 per cubic meter to pump water over 460km and 620 meters of elevation to Riyadh.

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