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Water Resource Policies and the Urban Poor: Innovative Approaches and Policy Imperatives

Ramesh Bhatia and Malin Falkenmark

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Introduction

Improved management of water resources is a key environmental and economic concern for many developing countries. The quality of both surface water and groundwater is being degraded rapidly, and large quantities of water are allocated to low-value uses in irrigation. Inefficiencies in the domestic and industrial sectors are of increasing concern, and subsidies for irrigation and domestic use cause budget deficits and limit funds for rehabilitation and new investment. Most developing countries lack regulations and incentives for internalizing the externalities that arise when one user affects the quantity and quality of water available to another. Industrial water tariffs are based on average-cost pricing rather than marginal-cost pricing and ignore the opportunity cost of water. Similarly, the costs of damage caused by pollution of surface water and groundwater are ignored in setting water tariffs. Both water use and pollution are excessive.

In urban areas of developing countries, quantity and quality constraints raise the costs of supplies: the unit cost of water from the "next project" is often two to three times the cost of a unit from the "current project." Increasing unit costs imply that, for a given level of resources, those who are unserved or poorly served will be the poor at the end of the line. Many of the urban poor suffer health problems and high mortality rates because they must depend on unreliable public supplies or use surface and groundwater that is contaminated by microbes, organic chemicals, and heavy-metal contaminants. The poor in periurban areas must either pay a high percentage of their income for water or reduce their consumption. They also suffer when employment in small enterprises is reduced because these units cannot provide funds for self-provisioning of water supply.

Estimates demonstrate that ***the provision of water supply in urban areas of developing countries will require investment of $11-14 billion per year for the next 30 years.*** These requirements are double the amounts estimated to have been available for urban water supply during the International Drinking Water Supply and Sanitation Decade (IDWSSD, the Water Decade, 1981-1990). Sector funding of the magnitude needed is not likely to be available, and provision of services to the needy, especially the poor in periurban areas, will suffer further neglect.

In addition to mobilizing additional funds, it is necessary to encourage conservation in households, industry, and agriculture so that additional water supplies will not incur added costs for transport and treatment of water. Regulatory policies and economic incentives can and do produce significant savings in household water use and reductions in industrial use. There is compelling evidence that improved policies have major impact. In a number of cases in developed and developing countries, regulation combined with pricing and tariff policies has resulted in 20-30 percent savings of water (section V). Section VI contains discussion of the implications of these savings for the urban poor.

These savings are important in providing immediate relief to those presently unserved, but they are short-term solutions. In the long term, there is a need for a change from the present subsectoral, piecemeal approach to an analytical framework that incorporates the economic and environmental links among user sectors (section VII). A new appreciation of upstream-downstream links in the river basin is required on the part of the scientific community, decision makers, and policy analysts.

Objectives

The objectives of this paper are:

☞ To **analyze the key issues** affecting the use of water resources in developing countries.

- ☞ To **identify key policy instruments** (institutional changes, regulatory measures, and economic incentives) and provide evidence from developed and developing countries where these instruments have encouraged conservation and recycling of water in industries and households.

- ☞ To **propose a new approach and an analytical framework** that incorporates the economic and environmental links among user sectors.

Symptoms of a Malfunctioning Sector

The water resource sector in developing countries is characterized by misallocation among alternative uses and waste in each use. Large quantities of water (over 80 percent) have been allocated to irrigation, where benefits are low. Excessive use in irrigated agriculture continues even though water available for urban areas has declined.

Further, water use in agriculture has received large subsidies, and revenues cover only around 10 percent of operation and maintenance (O & M) and capital costs. In the municipal and industrial (M & I) sector, prices are based on average rather than marginal costs. They do not reflect economic costs and ignore the opportunity cost of water. Low prices encourage wasting of water by households, industries, and commercial establishments.

Additional water supplies for urban areas often have to be transported over long distances—over 100 kilometers in many cases—and the cost of supplies of acceptable quality can double or triple. For given levels of investment for urban water supplies, rising costs have meant that the number of persons served does not keep pace with urban population growth, and the number who are unserved continues to rise.

Since the poor are often at the end of the line in receiving water services, they continue to depend on traditional sources of supply. Access to traditional sources tends to decline over time, and these supplies become increasingly contaminated from poor sanitation and industrial effluent. The poor must purchase water to meet basic needs and thus bear the brunt of high costs and contaminated supplies that result from inefficient management of water resources. The impact of inefficient use of water in user sectors on the urban poor are explored in detail below.

Inefficient Use of Water Resources

Allocation of water resources among alternative uses is usually inefficient in developing countries, and waste is rampant. Such mismanagement has major implications for economic performance, through both fiscal and real sector linkages. The principal fiscal link is through huge subsidies—billions of dollars, as discussed below—that contribute to ubiquitous national budget deficits. The real sector linkages arise because water resources are not used efficiently. The worst problem is allocation of large quantities of water to low-value irrigation use, and there are allocative problems within the M & I sector.

Waste

Water used in irrigated agriculture accounts for over 80 percent of total withdrawals in developing countries. Such water is characteristically high volume, low quality, and low value. Only a small fraction of water diverted in most large systems in developing countries is available for plant use, typically 25-30 percent, compared to 60-70 percent in advanced systems.[1] The remainder seeps or evaporates from unlined or obstructed canals and distribution systems.[2]

Farmers at the ends of distribution systems in large projects usually experience water shortages during critical growth periods, and such shortages reduce crop yields and encourage costly investments in groundwater extraction. In the urban water-supply sector, there is tremendous waste of water in distribution systems, homes, commercial establishments, and public facilities.

The average level of unaccounted-for water (UFW)[3] in Bank-supported projects is about 36 percent.[4] Cairo, Mexico City, Barranquilla, Lima, and Jakarta commonly experience UFW levels as high as 60 percent, compared to 10-15 percent in well-managed systems. Although a part of the UFW is unreported water use by public agencies or unauthorized private use, sometimes by the poor, a large portion of UFW is simply leakage into the soil. In the case of Jakarta, for example, water loss by leakage has been reported as 41 percent of total production.[5] Studies in Indonesia show that such losses can be reduced by 48 percent cost-effectively.[6]

Subsidies

According to one estimate, an equivalent of $250 billion (in current prices) has already been spent to create irrigation capacity in developing countries.[7] A significant portion of public investment in agriculture goes to irrigation in these countries. In Mexico, irrigation projects have taken 80 percent of agricultural investments since 1940; in India, irrigation investments of over $2 billion amount to about 30 percent of total public investments; and in Pakistan, the current five-year plan allocates 10 percent of the total public-investment budget to irrigation. Development assistance agencies have also been heavy investors: irrigation accounted for 28 percent of all World Bank agricultural lending in the 1980s, and the total of commitments by all aid agencies exceeded $2 billion per year.

Public irrigation investments have become an enormous drain on government budgets because cost recovery has fallen short of even modest targets. In Indonesia, Korea, India, Pakistan, the Philippines, and Bangladesh, irrigation receipts were less than the costs of O & M (20-90 percent).[8] Using a moderate estimate of capital costs in these countries, in 1984 actual receipts averaged less than 10 percent of the full costs of irrigation services. Average implied subsidies were 90 percent of total costs of irrigation.[9]

In Mexico, assumed cost recovery from users of public irrigation systems created at the cost of $16 billion (1981 prices) averages only around 11 percent of capital and O & M costs. In Pakistan, gross public revenues from irrigation services in 1984 were approximately PRs 1 billion, compared to outlays for O & M of irrigation works of PRs 2 billion and annualized capital charges on past irrigation investments of PRs 5.9 billion. In India in 1988-89, current revenues from water charges were Rs 1.1 billion compared to Rs 15 billion on current expenditures for large and medium-size irrigation projects. Annual irrigation subsidies were of the order of $0.6 billion in Pakistan and $1.2 billion in India. Estimated irrigation subsidies in Egypt are over $5 billion per year.[10]

Irrigation subsidies in developing countries have been justified on a number of grounds.[11] Some of these arguments may have merit, but there is need to raise irrigation charges as a means of "benefit recovery" rather than cost recovery since current charges are invariably less than 6-8 percent of additional benefits from irrigation. Given the fact that farmers with irrigation are relatively prosperous, there may be valid arguments for subsidies at the margin, but that is no defense of high subsidies in irrigation.

In economic terms, the performance of large public irrigation systems has fallen short of expectations. Performance measures such as acres irrigated, yield increase, and efficiency in water use are typically less than projected when investments were made and less than attained by private irrigators who operate more controlled decentralized systems. In Mexico, a World Bank survey found that farmers in irrigation districts continued to plant low-yield varieties of maize and harvested only 2.5 tons per hectare.[12] In India, production on canal-irrigated land averages only 2-2.5 tons of food grains per hectare, much better than dry lands, but much less than the 5-6 tons achieved with private tubewell irrigation.[13]

Investments in Urban Water Supply Systems

In developing countries, the average shares of industry and households in total water withdrawals are approximately 10 percent and 5 percent, respectively.[14] However, in some river basins where metropolitan cities are located, the share of industrial and domestic uses is 18-30 percent. For example, in Beijing and Tianjin, the respective shares of industrial and domestic uses was 44 percent and 36 percent in 1984; in Indonesia's Jabotabek region (including Jakarta) the share was 17 percent in 1987; the estimated share of industrial and household use in the Subernarekha river basin, which includes the steel-manufacturing city of Jamshedpur in eastern India, was 30 percent in 1990.

Due to rapid urbanization and industrialization, water demand for household, commercial, and industrial uses in urban areas has been increasing rapidly, and the share of industrial and domestic demands is estimated to rise in the future. These trends have caused conflicts in water use between agriculture and municipal uses. The phenomenal growth in demand for water for domestic, commercial, and industrial use in Pune, Bombay, Hyderabad, Madras, and

Vizag has required water to be transported over long distances.[15] In the Jabotabek region of Indonesia the share of water for drinking and industrial uses is estimated to increase from 17 percent in 1985 to 38 percent in 2015.[16] This increase, from 0.7 billion cubic meters in 1985 to 2 billion cubic meters in 2015, will mean that there will be a deficit of the order of 18 percent in the total estimated requirements of water in 2015 if demand is not curtailed. In Beijing and Tianjin, the demand for water for domestic and industrial uses is expected to increase by 90 percent and 150 percent, respectively, between 1984 and 2000, accounting for about 65 percent and 80 percent, respectively, of total available supplies. This will lead to shortfalls of about 20 percent and 45 percent, respectively, of projected demand.[17]

Public-sector investments in municipal and industrial water supplies constitute a significant and rising component of overall investment in water resources. Investments in municipal water supplies are typically 5-6 percent of total public investment. Since incremental costs of supplies are rising rapidly, these investments will not keep pace with the rising populations in urban areas.

As in the case of irrigation, the sales revenue in the urban water supply sector also falls short of the cost of providing supplies. Based on data from projects initiated between 1966 and 1981, the incremental cost was estimated to be around $0.49 (1988 prices) per cubic meter, compared to the effective price of slightly over $0.17 per cubic meter (assuming average UFW to be 35 percent), or only about a third of the incremental cost of producing the water.[18] Here, as in irrigation, pricing policies are not being used for demand management or for allocation of scarce water resources.

The Water Decade of the 1980s made significant progress in extending water supply services in urban areas, and more than 368 million persons received new, adequate water supplies, and coverage over the decade increased from about 77 percent to 82 percent.[19] However, urban population growth actually increased the unserved urban population by 15 percent. In 1990, there were over 300 million urban dwellers who did not have access to safe drinking water. Even if the efforts of the Water Decade continue, the number unserved will still increase to around 520 million in 2000 and 1.7 billion in 2020.

Pollution

In the absence of a policy framework that takes externalities into account, cities cause and face closely related water quantity and quality problems. Pollution of the Bogota river in Colombia is a typical example (Box 1). Surface water and groundwater supplies used by the city are often contaminated by microbiological, organic-chemical, and heavy-metal pollutants. In most cases the sources include agriculture, industries, and human settlements in the watershed, and homes and industries in the city itself.

Box 1: Pollution in the Bogota River, Colombia

Presently there is no sewage treatment, and untreated industrial and municipal wastewater flows reach the Bogota River, which discharges into the Magdalena River. A substantial portion of the flow is sewage. It has been estimated that the domestic and industrial organic pollution produce a biochemical demand for oxygen on the order of 210 and 85 tons per day, respectively. The poor quality of the water has significantly affected the communities in the lower basin as well as rural areas, which depend on the river for water supply and fishing.

The problem of pollution is even more severe since the Magdalena River is also affected by contamination of the Bogota. Because many cities and people depend on water from the Magdalena River, the risk of further pollution must be eliminated soon. Even though the flow of the Bogota River is only about 2-4 percent the flow of the Magdalena River, during some periods the Bogota River supplies up to 10 percent of the total flow of the Magdalena River at their confluence. The level of pollution of the Bogota River is such that it seriously damages the quality of the Magdalena River.

Pollution abatement of the Bogota River demands a regional approach by all agencies including all municipalities and users of the river. The different beneficial uses of the river (agriculture, water supply, and electric power generation) have implications for the level of wastewater treatment required (primary, secondary, or tertiary) and therefore affect the cost. Also, through a regional approach all beneficiaries from clean-up efforts could be included. For example, water diversion for irrigation downstream of Bogota may continue if efforts are made to clean up the river, but the question arises, "Who pays for those investments?"

A regional approach will also help address the issue of how to sustain the river flow. Fresh water reaches the Bogota River from the upper basin and from excess water from the Chingaza scheme. Water from these sources is increasingly used for water supply, which afterward is converted into sewage. However, it is planned to collect the sewage in a interceptor, and therefore the flow of the river will decrease. To sustain the Bogota River, there are plans to develop new water resources further upstream. A strategy to reduce water demand for fresh water may make additional water available to sustain the river flow.

Sources: Terence R. Lee, "Water Resources Management in Latin American and the Caribbean," 1990, pp. 63-90. Danilo Anton, "Urban Environmental and Water Supply in Latin America," Montevideo, 1990, pp. 89-94.

In Indonesia, the Ciliwung and Sunter rivers show similar symptoms. In the former, average biochemical oxygen demand (BOD) was about 15 mg/liter,[20] 150 percent higher than the norm, and in the latter, BOD was about 28 mg/liter in 1985 at the confluence with the Cipinang.[21] Moreover, at the river mouths to the Jakarta Bay, the level of BOD in some rivers exceeds the value of 90 mg/liter.[22] In the case of Ciliwung River, the water quality in the upstream area is acceptable for all purposes except drinking, but in the downstream area below Jakarta the water cannot be used for anything. The situation becomes even worse during the dry season when the flow is lower. A review of the water pollution level in selected rivers in Java shows that the level of fecal coliform is, in some cases, more than 4,000 times the conventional standards. An alarmingly high level of heavy metals has been also reported in the Cisadena river near the Tangerang Industrial Zone. In one location, the level of mercury was 100 times greater than allowable levels, and there were excessive levels of cadmium, chromium, and selenium (Box 2).[23]

Box 2: Degradation of water quality and implications for the cost of water in Indonesia

In addition to causing environmental damage, water pollution and excessive pumping have impacts on the costs of water. To improve water quality, amounts of (often costly) chemicals must be increased. For example, to treat the increasingly polluted raw water entering the Pulogadung water treatment plant in Jakarta, chlorine was increased from an average of 2.6 mg/l in 1982 to about 7 mg/l in 1984. This increase raised treatment cost by Rp 610 million per year (1985 prices) and decreased plant efficiency by 18 percent (Rp 870 million per year). The "finished" drinking water frequently was off-color and exceeded limits for concentration of ammonium, organic matter, and fecal coliform. Another negative long-term effect of high chlorine use is production of chloroform and other carcinogenic residues.

Another large cost of the high bacteriological contamination of raw water is the cost of boiling water to make it potable. The high levels of pollution and the poorly operated treatment and distribution facilities make the public water supply undrinkable unless boiled before use. For the DKI Jakarta (Jakarta special capital province) area, this cost has been estimated at Rp 96 billion (1987 prices) or $52 million per year, equivalent to 1.1 percent of the GDP generated in the DKI Jakarta. A survey conducted in Jakarta showed that a household boils about 4.4 liters of water per capita per day, whatever the source. Boiling water for between 15 and 20 minutes requires about 200 kcal per liter; kerosene, the most common fuel, provides about 8,000 kcal per liter, and its unitary economic cost is Rp 300. The cost of purifying water by boiling is therefore Rp 7.5 per liter.

Sources: Japan International Cooperation Agency, "Jakarta Water Supply Development Project," 1985, Vol. II, p. 4-20. The World Bank, "West Tarum Canal Improvement Project," Report 5429-IND, 1985, p. 35.

In Tianjin, China, only 21 percent of total wastewater is treated; the rest is dumped untreated into open bodies of water. In 1988 the Haihe River's chemical oxygen demand (COD) levels exceeded standards 85 percent of the time; chlorides, 24 percent; and volatile phenol, 5 percent of the time. Surface water and groundwater sources cannot be used for domestic purposes. The cost of treating this water is higher than the cost of transporting water from other sources.[24]

In Tunisia, the largest surface-water reservoir, Sidi Salem, provides about half of the total available resources, is suffering from eutrophication. Sewage effluent and municipal waste are dumped directly into this reservoir, and the nutrients carried by agricultural run-off reduce depth penetration of solar rays, lower oxygen levels, and increase eutrophication, which propagates parasites, viruses, and bacteria, and endangers fish, birds, and other organisms.[25]

Most of the world's pollution is generated in urban areas. This makes sanitation and controlled waste handling key issues of global concern. It raises the question whether present waste-water treatment solutions are realistic alternatives for developing-country cities.

These environmental problems give rise to two distinct health problems. The "old" problems are high rates of transmission of communicable diseases caused by use of inadequate quantities of poor-quality water. The "new" problems are the health risks arising from contamination of water sources by synthetic organic chemicals, heavy metals, pesticides, and other modern pollutants. These risks--both old and new--are particularly serious for the poor and constitute an important cause of the wide mortality differentials between the poor and the rich in cities. The recent cholera epidemic in Peru,[26] with an estimated death toll of more than a thousand and loss of exports estimated at about $400 million, is a typical case of what can happen to a country that lacks water and sanitation infrastructure and is exposed to extensive pollution.[27]

Rising Incremental Costs of Water Supply

In view of the conflicts in use of water, new supplies have to be obtained from long distances (often 50-180 km in metropolitan areas). Pipeline transportation and pumping over such distances raise investment costs significantly. The cost of water supply is rising rapidly: a unit of water from the "next project" is often two to three times the cost of a unit from the current project (Box 3 and Figure 1).

BOX 3: Increasing costs of water supply

Figure 1 shows examples where supply costs are increasing because of water resource problems. These cases illustrate that intense competition among water users creates the necessity to use high-cost, energy-consuming pumps to transport water over increasing distances. When lower-quality sources are employed, additional treatment is required to raise the water to environmental standards. Potential sources must be rejected if there has been irreversible damage to their water quality.

In the case of Amman, Jordan, when the water supply system was based on groundwater the average incremental cost (AIC) was estimated at $0.41/m³; however, chronic shortages of groundwater led to the use of surface sources and raised the AIC to $1.33/m³. The most recent projects require pumping water 1,200 m from a site about 40 km from the city. The next scheme contemplates construction of the Unit Dam and the Northern Conveyor, and the eventual cost has been estimated at $1.5/m³.

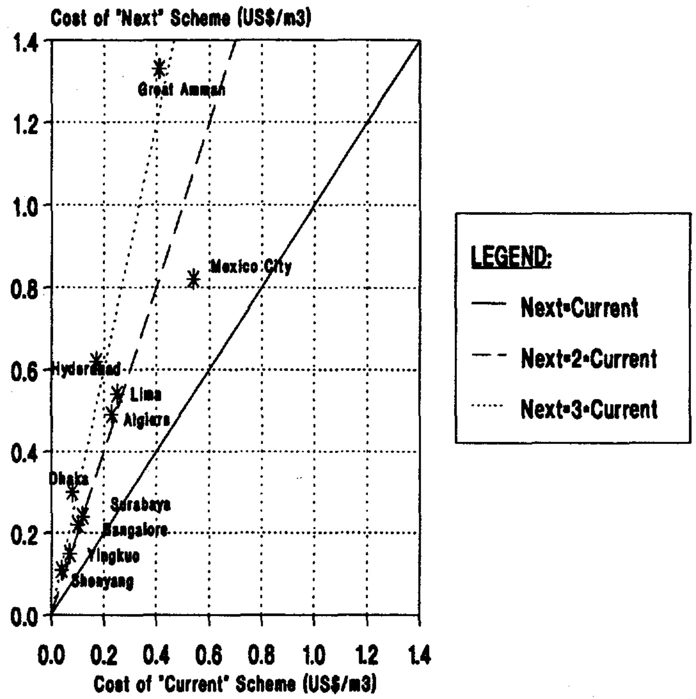
In Shenyang, China, the cost of new water supplies is anticipated to rise from $0.04 to $0.11, a nearly 200 percent increase, between 1988 and 2000. The main reason is that groundwater from the Hun valley alluvium, which is the current water source, has to be rejected as a supply of potable water because of low water quality. Water will have to be conveyed to Shenyang by gravity from a surface source 51 km from the city. In Yingkuo, the AIC of water diverted from the nearby Daliao river is about $0.16/m³. However, because of heavy pollution, this source cannot be used for domestic purpose. As a result, water is currently been supplied from the Bi Liu river at a cost of $0.30/m³.

In the case of Lima, Peru, in 1981 the AIC of a project to meet short- to medium- term needs, based in part on a surface source from the Rimac River and also on groundwater supplies, was $0.25/m³. The aquifer has been severely depleted, and groundwater sources cannot be used beyond the early nineties. In order to meet long-term urban needs, transfer of water from the Atlantic watershed is planned, with an AIC estimated at $0.53/m³.

Mexico City's water is currently pumped over an elevation of 1,000 m into the valley of Mexico from the Cutzamala river through a pipeline of about 180 km. The AIC of water from this source is $0.82/m³, almost 55 percent more than the previous source, the Mexico Valley Aquifer. The former source has been restricted because of land subsidence, lowering of the water table, and deterioration in water quality. The newly designed water supply project for the city is expected to be even more costly since it will have a longer transmission line and water will be pumped over an elevation of 2,000 m to the city.

Source: "Water Resources: Problems and Issues for the Water Supply and Sanitation Sector (Draft)," Rita Cestti, The World Bank, 1989.

Figure 1: Average Cost of Water Supply, Current Scheme vs. Next Scheme



Sources: INUWS calculations from Staff Appraisal Reports (SAR) and Feasibility Studies
Note: Prices are given in September 1988 dollars.

Public investments in municipal and industrial water supplies already constitute a rising component of overall investment in water resources, an average of about 5-6 percent of total public investment.[28] The share of public and private investments will have to increase substantially if supplies for the urban poor are to be increased along with those for households and the commercial and industrial sectors.

Plight of the Urban Poor

In 1988, over 130 million of the developing world's poorest inhabitants lived in urban areas. About two thirds live in squatter settlements: 62 million in Asia, 28 million in Latin America and 9 million in Sub-Saharan Africa.[29] Most of these people depend on traditional sources of water supplies which are getting increasingly contaminated due to human waste, industrial effluent, and agricultural pollutants. As a consequence, the poorest of the poor have to pay exorbitant prices for safe water to meet their basic needs.

A number of studies have shown that the urban poor pay very high prices for water and spend a far higher portion of their income for water than higher-income consumers. In Port-au-Prince, Haiti, the poorest households sometimes spend 20 percent of their income for water;[30] in Onitsha, Nigeria, the poor were estimated to pay 18 percent of their income for water during the dry season vs. 2-3 percent typically paid by upper-income households; in Addis Ababa, Ethiopia, and Ukunda, Kenya, the urban poor spend up to 9 percent of their income on water.[31] In Jakarta, in 1988 only 14 percent of the city's households received water through direct connections to the municipal system. Another 32 percent bought water from street vendors who charged $\$1.5$-$5.2/m^3$ depending on the distance from the public tap. In some cases households purchasing water from vendors pay 50 to 60 times more per unit of water than households connected to the municipal system (Box 4).[32]

High Costs of Water Inhibit Growth of Small Firms

In Nigeria,[33] a 1988 survey of 179 manufacturing firms showed that the public water supply system provided only 55 percent of all water used. Firms purchased 10 percent of their requirements from private tankers, and the remaining 35 percent was drawn from private boreholes. Only 10 percent of small firms (fewer than 49 employees) owned a borehole, but 75 percent of larger firms (more than 500 employees) own private borehole. It was also found that the actual unit cost (₦ 0.52/gal) for small firms (0-19 employees) was much higher than the actual cost (₦ 0.02/gal) for large firms (500-999 employees). The existing cost structure subsidizes large firms at the expense of smaller firms and inhibits the birth and growth of small firms. Further, deficiencies in the public supply have greater adverse impact on smaller firms.

BOX 4: How much do the poor in urban areas pay for water?

The problem of lack of water services hits the poor in the slum areas of the large cities in developing countries. Often the only choice for low-income households that can not afford a house connection is to buy water of substandard quality from private vendors at a relatively high price, sometimes 100 times more than that provided by public authorities. Examples are shown in the following table.

Ratio Between Prices Charged by Vendors and by Public Utilities

Country	City	Ratio	Source
Bangladesh	Dacca	12-25	1
Colombia	Cali	10	2
Ecuador	Guayaquil	20	2
Haiti	Port-au-Prince	17-100	1
Honduras	Tegucigalpa	16-34	1
Indonesia	DKI Jakarta	4-60	3
	Surabaya	20-60	1
Ivory Cost	Abidjan	5	1
Kenya	Nairobi	7-11	1
Mauritania	Nouakchott	100	2
Nigeria	Lagos	4-10	1
	Onitsha	6-38	4
Pakistan	Karachi	28-83	1
Peru	Lima	17	1
Togo	Lome	7-10	1
Turkey	Istanbul	10	1
Uganda	Kampala	4-9	1

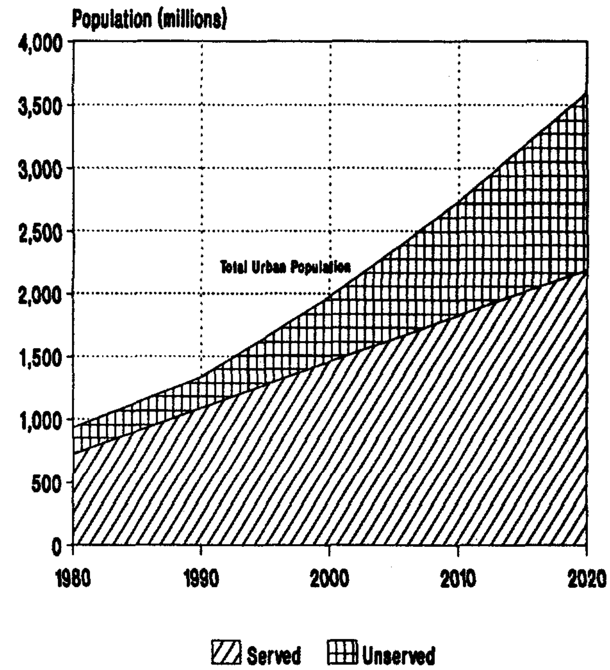
Sources: (1) "Urban Strategy Paper" (Draft), The World Bank, 1989. (2) "FY89 Sector Review Urban Development Operations," The World Bank. (3) "Indonesia: Foundations for Sustained Growth," The World Bank, 1990. (4) "Paying for Urban Services" by D. Whittington, D. Lauria, and X. Mu, 1989.

MASSIVE NEEDS IN COMING DECADES

By 2000, 2 trillion persons will live in urban areas of developing countries (compared to 1 trillion in developed countries), and there will be 45 metropolitan areas with more than 4 million population each and an aggregate total of over 400 million.[34] The urban population in less-developed countries will grow to over 3.5 billion by 2020 (Figure 2).

The Water Decade of the 1980s made significant progress[35] in extending water supply services in urban areas, and more than 360 million persons were newly provided with adequate water supplies. Coverage increased from about 77 percent in

Figure 2: Urban Population and Water Supply Coverage in Developing Countries



the decade, urban population growth was so great that there was an effective 15 percent decrease in urban coverage.

Assuming that the efforts of the Decade continue at the same scale, in 2000 the unserved urban population will be about 520 million. If, on the other hand, no urban inhabitant should remain unserved by 2000, two and a half times as many new individuals would have to be served as during the preceding decade. If, for the following 20-year period (2001-2020), for water supply were to keep pace with urban population growth would require more than twice the Decade's rates.

If investments in urban water supply (excluding rural water supply and urban sanitation) during the Decade were estimated[36] to be $6-7 billion per year, the investments required would have to be $117 billion during the 1990s to achieve 100 percent coverage of the urban population by 2000.[37] The provision of water supply services to an estimated 3.5 billion persons in urban areas of developing countries will require $340 billion during 2000-2020 (assuming that unit real costs of water supply would increase by 67 percent over the next 30 years). Even when low-cost methods of water supply are found for one third of the population, the total investments required would be of the order of $11-14 billion per year in the next three decades. These aggregate investments are about twice the investments made during 1981-1990.

As annual sector funding on the order of $11-14 billion is not likely to be available, the result will be that provision of services to the needy (periurban poor) will be neglected. Associated health implications are significant, as in the case of Peru's cholera outbreak in 1991. Hence, efforts would have to be made to increase resources both at the national and international levels. At the national level, water supply agencies would have to raise funds by providing adequate and reliable water supply so that a larger number of house connections could be given at higher tariffs. As pointed out[38] in a study of willingness to pay for water in Kerala, India, a few critical policy changes--encouraging connections by financing connection charges through higher tariffs and providing improved reliability--it is possible to raise revenues by as much as 40 percent to 100 percent.

in addition to mobilizing additional funds, it will be imperative to use existing resources most efficiently. To provide "correctives" for the current situation in the water resources sector, two things are required: First, implementation of policies that encourage conservation so that additional water supplies can be obtained without incurring additional costs for transportation, pumping, and treatment of water. However, such savings, no matter how necessary in providing immediate relief, are short-term solutions. Second and far more important, there must be a change from the present subsectoral, piecemeal approach to a framework that incorporates the economic and environmental linkages among user sectors.

OPTIONS AND INSTRUMENTS

POLICY

It is important to develop analytical approaches for policy options and related policy instruments to encourage economically efficient, equitable demand management in all user sectors and allocation of water among competing sectors. This would require encouraging investments in conservation, recycling, and reuse in both households and industries.

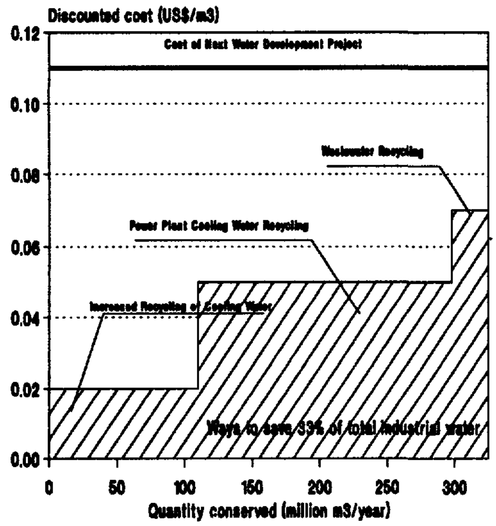
Evaluation of the costs and benefits of conserving water by improved efficiency in irrigation and reducing losses in urban water systems will encourage necessary investments for these improvements.

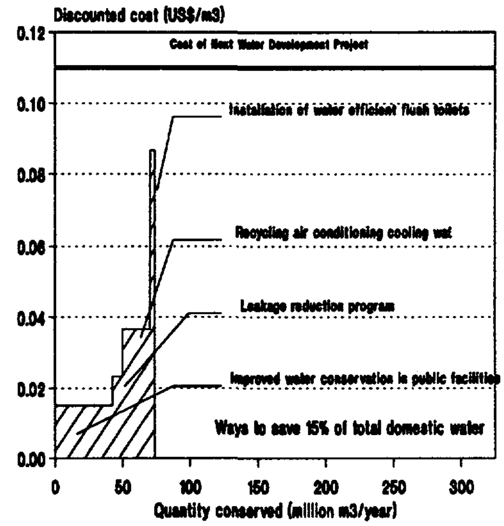
One of the most obvious ways of extending the water resource base is by conserving water and recycling it after use. However, a given measure may not be financially viable or economically appropriate. In many situations, conservation may be more cost-effective than increasing water supply. From the viewpoint of an entrepreneur, investments in water-saving processes or in recycling would be worthwhile only if the cost of water saved will be less than the cost of water supply. If water tariffs do not reflect the full costs of supply, firms and individuals will not invest in water-efficient technologies. From the viewpoint of society, improving water use efficiency will be economic only if the unit cost of water saved is less than the unit cost of water supply plus the opportunity cost of water. When comparing against supply alternatives, it is economic to implement all conservation measures whose cost of conserved water (CCW) is less than the marginal cost of new supplies (including the opportunity cost of water or economic return from alternative use of water). When a number of different conservation schemes are to be evaluated, a tabulation of the CCW for each measure will provide a supply curve for conserved water. The supply curve is a graph of the cumulative volume of water saved versus the cost of water conserved. Based on this approach and using available data, supply curves for the industrial and domestic sectors have been prepared for Beijing (Box 5).

The potential for conservation varies from one user sector to another. Hence, demand management issues must be studied for each individual sector such as household, industries and agriculture. Table 1 shows the effectiveness of various policy instruments in causing reductions in water demand.

BOX 5: The cost of saving water in Beijing

The supply curve presented below is a graph of cumulative water saving versus the discounted cost of conserved water. This analysis shows that the cheapest way of increasing water supply is through more efficient management of existing water supply systems. Domestic water demand could be reduced through leakage reduction, conservation in public facilities, and installation of water-efficient flush toilets by about 15 percent at a cost lower than the marginal cost of new water supplies. Industrial water demand could also be reduced by one third by recycling industrial water and reuse of municipal wastewater at a cost substantially lower than the cost of new supplies.





Source: M. M. Hufschmidt, J. Dixon, L. Fallon, and Z. Zhu, "Water Management Policy Options for the Beijing-Tianjin Region of China," East-West Center, Hawaii, 1987.

Table 1: Effects of Water Tariffs, Pollution Control, Water Market, and Conservation Programs on Demand for Water

Policy option or instrument	Status	Household demand	Industrial demand	Overall demand
A. Water Tariffs				
Bogor, Indonesia	Actual	30% decrease after tariff increase from $0.15 to $0.42 per cubic meter		
Fertilizer Factory, Goa, India	Actual		50% reduction in 6 yrs, from designed 22,000 cubic meters to 11,00 cubic metersper day	
B. Pollution Control and Recycling				
Tata Iron and Steel Co., TISCO, India	Projected		40% reduction through recycling of industrial effluent and sewage	
Three industries in Sao Paulo, Brazil	Actual		Effluent charge produced 40-60% reductions in unit consumption	
C. Water Market				
California	Actual			Purchased 10% of M&I demand from farmers through water bank
D. Conservation Programs				
East Bay Municipal District, California	Actual			Purchased 10% of M&I demand from farmers through water bank
Tin Plant Co., India	Projected		75% reduction through process change	
Metropollitan Water District, Southern California	Actual			50% reduction in cost of urban water by financing conservation in irrigation
Tianjin	Actual		60% reduction in unit consumption	
Beijing	Actual		17% reduction per unit of output	
Israel	Actual		70% reduction per unit consumption, 1962-82	
TISCO, India	Proposed		20% reduction in demand	
Istanbul	Projected	6% additional supply by reducing UFW 10%	17% reduction in industrial demand by reuse of wastewater	
Mexico City	Projected	10% reduction if water-saving flush systems used	14% reduction in demand by reuse of wastewater	

Managing Household Demand

In a number of developed countries--Israel, Canada, the United States, Australia and Great Britain–researchers have found that household water demand drops by 3-7 percent when prices rise 10 percent. In developing countries, there is a myth that prices do not play a significant role because the water bill is a small part of total household expenditure. However, there are no studies of household water demand in developing countries that support this belief. Since water tariffs have been traditionally low, the incentives for efficient use in households have been weak. It is difficult to estimate elasticity of demand where there is no metering of consumption and price changes have not been significant. However, where sharp increases in prices were made and consumers had to pay higher prices for additional quantities (increasing block rates) consumers did respond by reducing consumption (as in Bogor, discussed later).

To the extent that tariffs have been low and people have not been conscious of conserving water, the potential for savings is considerable if appropriate tariff policies are adopted. If water for domestic uses were priced at the marginal cost of providing it (including the opportunity cost of water), consumers would reduce some uses and eliminate others.[39] As long as there is a downward-sloping demand curve, prices will reduce demand.

In addition to prices, other methods have been used to reduce water demand in the household sector. Some of these cases have been described below:

☞ The case of the East Bay Municipal Utility District (EBMUD), California, illustrates the role of a comprehensive water conservation program for improving efficiency of municipal water use and reducing water demand during drought years of 1988 and 1989. A program of mandatory conservation goals for customer groups (single-family residential, multifamily residential, industrial, commercial, and irrigation), strict ordinances against water waste, an increasing block rate structure, and an extensive public relations program produced large reductions in water use. The overall conservation target was 25 percent for the summer of 1988 over 1986, but the actual reduction level was 30 percent. Similarly, during 1989 the actual reduction was 27 percent against the target of 15 percent.[40]

☞ As a result of the June 1988 tariff increase of 200-300 percent in different consumer groups, a household with monthly consumption of more than 30 m^3 had to pay \$0.42 for the last cubic meter of water consumed instead of \$0.15. This produced significant reductions--around 30 percent--in water use for domestic and commercial connections (Box 6).

BOX 6: Impact of price increase and water conservation campaign, Bogor

Bogor, Indonesia's water supply enterprise, PDAM, faced rising investment costs. The average incremental costs of the "next scheme" was double its "current scheme," and a decision was made to combine the augmentation of water supplies with nonstructural measures to reduce average water consumption to a maximum of 30 m^3 per month, and the surplus was to be used to supply water to those waiting for a connection. To ration water and balance demand with supply, the water utility introduced both price and nonprice policy instruments.

☞ **The Tariff Increase of June 1988:** A tariff increase of 200-300 percent decreased water use in Bogor significantly, especially for domestic users (household and yard connections). Between June 1988 and April 1989, average monthly consumption decreased from 39 m^3 to about 28 m^3 for users of household connections and from 37 m^3 to 26 m^3 for users of yard connections. These represent 28 percent and 30 percent reductions, respectively, in water use. Commercial users responded to the price increase by decreasing consumption by an average of about 29 percent. In April 1988 the average water use was around 59 m^3, and a year later that consumption had decreased to about 42 m^3. Features of the new water rate structure were (a) increase of water rates, (b) increased progressivity of the rate structure, and (c) higher fixed service charges.

☞ **Consumption Level Evaluation Program:** In spite of the favorable impact of the new tariff on water consumption, not all customers achieved the desired consumption target of 30 m^3 per month. About 33 percent of household connections were using more than that. In March 1989, PDAM initiated a campaign to reduce water use intended specially for customers using more than 100 m^3 per month. The campaign had three objectives: (a) to make customers aware of water use habits, (b) to provide advice on making changes in those habits, and (c) to provide the necessary tools to reduce consumption. PDAM employees visited customers' homes to look for leaks inside the house, and when leaks were found, they provided an estimate of repair costs and total savings. After three months,average water use decreased 29 percent, from 159 m^3 per month in February 1989 to 113 m^3 per month in May 1989.

Sources: IWACO-WASECO, "The Impact of the Price Increase of June 1988 on the Water Demand in Bogor (Special Report 17) and Consumption Level Evaluation Programmer (Special Report 19)," 1989.

Managing Industrial Water Demand

In industrialized countries, demand for water does not increase with industrial output due to changes in processes, technology, mix of industrial output, and increased recycling of effluent. In some OECD countries, industrial water use in

2000 may be 50 percent less than 25 years earlier.[41] However, in developing countries, many industrial units and thermal power plants have enjoyed low water tariffs and easy availability, and they use "once-through" processes and cooling ponds (instead of cooling towers) that do not economize on water consumption. Further, since pollution control regulations are either nonexistent or impotent, there is no incentive to treat industrial effluent and sewage for recycling water in plants. To the small extent that they are required to meet effluent quality standards, some industrial units and thermal plants find it convenient and economic to dilute their pollutants rather than treat their effluent.

However, conservation is possible and achievable if the right policy environment is created. There is scattered but compelling evidence that regulatory measures and economic incentives (mainly water tariffs) have caused significant reductions in water demand by industrial units. There are examples where administrative and legislative measures such as licenses, quotas on water use and effluent discharge, and introduction of water-saving technologies have resulted in 40-70 percent savings in industrial water consumption. Economic incentives such as water tariffs, tax and subsidy policies for equipment purchases, interest rate subsidies and soft loans for water-saving and/or effluent-treatment equipment, and effluent charges can promote efficient use of water.

☞ In India, in Zuari Agro-Chemical Limited (ZACL) chemical fertilizer plant at Goa, over a six-year period (1982-88), water consumption was reduced by 50 percent from the plant's designed 22,000 m^3/day to 11,000 m^3/day in response to a price increase for raw water (about $0.10 per m^3).[42] Government pressure to reduce industrial effluent discharged to the sea brought about a reduction from 132,000 m^3 per day to nil. (Box 7).

☞ In Israel between 1962 and 1982, average water consumption steadily declined from 20 m^3/NIR 1,000 of production output at fixed prices to about 6 m^3/NIR 1,000 of output. An expansion of 300 percent in the output of the industrial product was achieved with only a 20 percent increase in water consumption.

BOX 7: Water prices and Pollution Control Reduce Consumption in a Fertilizer Plant in India

In India, in a fertilizer plant (Zuari Agro-Chemical Limited, ZACL) at Goa, over a six-year period (1982-88) water consumption was reduced by 50 percent, from the plant's designed 22,000 m^3/day to 11,000 m^3/day in response to high price of water and government pressure to reduce industrial effluent discharged in the sea. As a result of these measures, water consumption in ZACL in 1990 was 10.3 m^3/ton of nutrient. This unit consumption was only 40 percent of the water consumed in another fertilizer unit, Indian Explosives Limited (IEL) at Kanpur (24.35 m^3/ton of nutrient. The significantly lower consumption in ZACL is a response to (i) higher price of water ($0.12/$m^3$) charged by the PWD (Public Works Department) compared with the cost incurred ($0.01/$m^3$) by the IEL in self-provisioning.

The cost of water in the Kanpur unit is low because it pumps water from the lower Ganges Canal where the irrigation department charges a nominal fee of 0.2 cents per cubic meter. Further, in the case of Goa where effluent water is to be discharge into the sea, it is expected to affect fish, cattle, and plant life in the area adversely. In the early stages (1969) of setting up the plant, ZACL had to pay about $2,000 to 50 farmers as compensation. A wastewater treatment plant was then installed under the control of the Central Pollution Control Board. Subsequently, the management made investments in pollution control and reuse facilities that reduced liquid generation from 13,200 m^3/day to nil, implying 100 percent recycling of liquid effluent. In contrast to this, IEL, Kanpur discharges about 6,000 m^3/day.

Source: D. B. Gupta, M. N. Murty and R. Pandey, "Water Conservation and Pollution Abatement in Indian Industry," National Institute of Public Finance and Policy, New Delhi, April 1989.

☞ The increasing efficiency in industrial water use can be attributed to policies adopted by the Water Commission: (a) license of water supply (water is supplied to industrial firms under license, and the quantity allocated is calculated on a normative basis which depend on nature of the end product, production processes, existing equipment, and raw material, etc.; (b) introduction of water-saving technologies; and (c) subsidized financing for investment in water-saving processes and appliances.[43]

☞ In many Chinese cities, conservation and reuse of water have become increasingly important. By using propaganda, education, and various economic, administrative, and legislative measures, Tianjin has decreased industrial water use per Y 10,000 of gross production output from 360 m^3 in 1981 to 145 m^3 in 1988, a reduction of about 60 percent of the industrial water consumption per unit of industrial output. In Beijing between 1978 and 1984, the decrease was from 880 m^3 per Y 10,000 of production value to about 335 m^3. Annual water consumption was reduced an average of 17 percent over the six-year period.[44]

The measures applied include (a) a strict water quota and effluent quota per production unit, (b) a progressive water price system under which those consumers who exceed their allocation have to pay 10 and 50 times the normal charge, (c) a progressive fee for pollutant discharge exceeding the limits, and (d) regular water audits and flow surveys.[45]

The Effects of Pollution Control on Water Demand

☞ In Sao Paulo, Brazil, after effluent charges were levied three plants reduced their consumption between 42 percent and 62 percent in 1982 compared to 1980 (Box 8).

BOX 8: Effluent charges encourage reduction in effluent and water use in Sao Paulo

In Sao Paulo, Brazil, three industrial plants were asked to pay effluent charges to the central effluent treatment facility. The management of these firms decided to economize through changes in processes, substitution of inputs, use of more efficient equipment, and use of mechanical washing instead of manual washing. In the pharmaceutical industry, the volume of effluent (and of water consumption) per unit of output in 1982 was 49 percent less than in 1980. In the food processing industry, effluent and water consumption were lower by 42 percent per unit of output in 1982 compared with 1980. The steps taken to achieve these reductions were changes in washing processes and effluent recycling, and modifications in cleaning process. In the dairy industry, the unitary coefficients of volume of effluent and water use were lowered by 62 percent through improvements in washing process and expansion of the on-site treatment plant.

Source: Luis Caetano Miglino, "Industrial Wastewater Management in Metropolitan Sao Paulo," Harvard University, Massachusetts, 1984.

☞ In Jamshedpur, India, a number of industrial units currently discharge their mostly untreated industrial effluent to the Subernarekha River. Although a part of the municipal sewage is treated, it is not recycled for industrial use because fresh water is available at low cost. Since the Irrigation Department is constructing a reservoir on the river, the managers of industrial units fear that they will have to pay for water in the future, and there may also be shortage of water in the dry season. The management of the steel company, Tata Iron and Steel Company (TISCO, which accounts for 90 percent of the total industrial water use of 55 MCM), is preparing plans for water conservation and recycling of treated industrial effluent and sewage in their plant. If 50 percent of effluent water is treated and recycled, it will reduce intake (withdrawal) of fresh water by 13 MCM, or about 30 percent of the total intake of the factory. However, as shown in Box 9, the cost of treated water would be about 110 percent more than the industrial water tariff if the tariff were based on financial (marginal) costs of water supply. Even when the tariff is fixed on the basis of economic cost including the opportunity cost of water, the financial cost of recycling will be higher than the water tariff.

- Under this situation, there is no incentive to invest in treatment and recycling of water. In this classic case of externalities, the enterprise will continue to dump industrial waste in the river and will not invest in treating the sewage wastewater unless the regulatory authority (pollution control board) becomes effective in checking pollution and the entrepreneur has incentives to invest in treatment plants.

- If the damage caused by industrial pollution and wastewater discharge are considered serious enough, the society should either force the enterprise to comply with pollution control regulations or make it worthwhile for the entrepreneur to invest in treatment plants by using policy instruments such as soft loans and investment subsidies for individual or community effluent treatment plants.

- Given the administrative difficulties of enforcing pollution control regulations on rich and politically powerful industrialists by low-paid government officials, it is necessary to find ways to make it worthwhile for polluters to treat and recycle municipal and industrial waste. Among such incentives are providing soft loans at low interest rates and investment support. These would cost much less than the investment required to supply fresh water to the industries[46] (Box 9).

The examples above show that the appropriate policy instruments can bring the twin benefits of environmental improvement and cost reduction. The incentives may be a mix of regulation, effluent charges, water tariffs, and tax and subsidy policies including low-interest loans.

Conservation to Augment Capacity

☞ The Metropolitan Water District of Southern California expects to develop additional supplies by financing water conservation projects, especially improvements in irrigation efficiency, within the Imperial Irrigation District in exchange for rights to use conserved water. The cost of water obtained in this manner has been calculated to be, at the most, half that of water from the next available undeveloped source.[47]

Management of Resources

☞ Three sensible steps--requiring three utilities to cooperate, improving reservoir operating practices, and reducing the planned frequency of shortfalls from 1 in 100 years to 1 in 10 years--the Washington, DC metropolitan area was able to reduce the number of reservoirs required from 16 to 1, and the investment cost from $400 million to $31 million.[48]

☞ To control direct abstractions of water, France has imposed a comprehensive charging system differentiated by zone, water source, season, quantity abstracted, and quantity consumed. The imposition of charges by the Picardy Agence de Bassin in 1970 reduced industrial water consumption by 50 percent over ten years.[49]

BOX 9: Encouraging conservation, recycling, and reuse

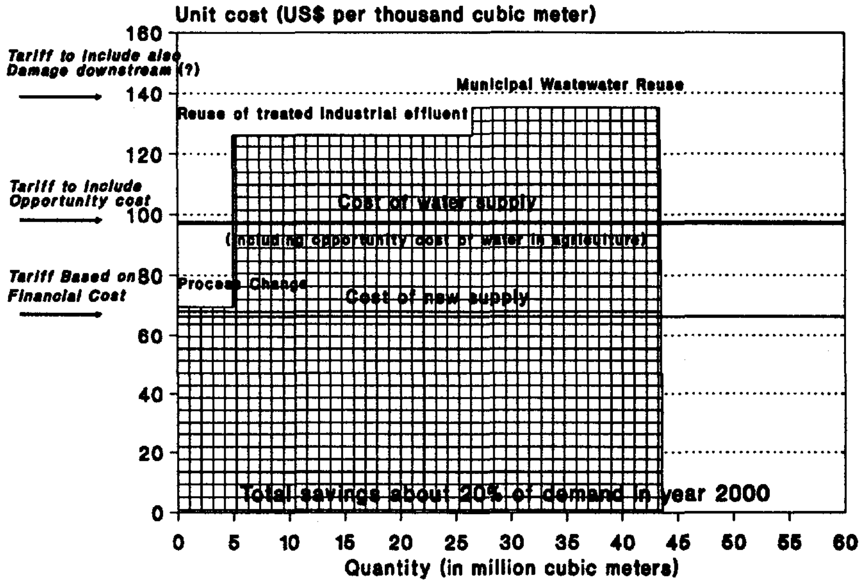
Preliminary results from the case study in Jamshedpur (India) show the significance of water pricing and tax/subsidy policies in encouraging water conservation, recycling, and reuse. About 5 million cubic meters (MCM) per year could be saved in an industrial unit (Tin Plate Co) at a unit cost of $65 per thousand cubic meter (TCM). If the average tariff for water supplied to this industrial unit is set to cover the financial cost of new supplies, the tariff will be less than the unit cost of water conservation, and from the viewpoint of the enterprise it will not be to its financial advantage to invest in process change technology to save water. However, if the tariff is fixed to reflect the economic cost, inclusive of the opportunity cost of water in alternative use (for example, agriculture), then it will be to the firm's financial advantage to invest in water-saving technology. Tariffs that reflect the true economic cost of water supply to an industry encourage investment in water-saving technologies.

However, even when the tariff incorporates the opportunity cost of water, it does not "internalize" another important externality, the cost of damage done by industries and households in contaminating water supplies. It is empirically difficult to estimate damage functions for deterioration of water quality since this requires quantifying the effects of various contaminants on a large number of downstream users. Nevertheless, it is important to recognize that water tariff should include an estimate of the likely adverse impact of lower water quality on the public. If the water tariff does not reflect this cost, there is no incentive for enterprises to treat water before discharging it into the river.

BOX 9 (continued)

Under these circumstances, it is necessary to induce industries to treat the effluent before discharge, particularly if the likely damages are high and the (marginal) economic value of water is higher than the cost of effluent treatment. In this case the cost of treatment of water for recycling were 30-35 percent higher than the economic cost of water (inclusive of opportunity cost). There will be no incentive for an enterprise to treat water for recycling even if tariffs are increased to reflect economic costs. If, for political reasons or because of a lack of information regarding real damage costs, the water tariff cannot be raised by 35 percent or more, an alternative solution will have to be found to prevent the discharge of polluted water into the river.

Cost of Conserved Water in Industry and Water Supply



This might be accomplished in two ways: first, by enforcing legislation regarding treatment of effluent water, and, second, by providing soft loans and/or subsidies or investment support toward meeting the initial cost of effluent or sewage treatment plants. In developing countries such as India, there is no experience implementing pollution control legislation, and it is difficult to visualize the extent to which such a regulatory measure could be enforced legally and administratively.

Given the administrative difficulties of enforcing pollution controls on powerful industries by low-paid government officials, it will be necessary to find economic incentives to make the industrial unit treat and recycle its effluent water for its own plant. Making the industry reuse its own treated water will provide the necessary incentive to treat its effluent.

One such incentive could be to provide loans at low interest, investment support, or a subsidy for investment costs. In Jamshedpur, the required subsidy would be of the order of 25-30 percent of the investment cost, or about $4.5 million. This level of subsidy is about one third the estimated investment cost of treatment and distribution of 40 MCM of water using conventional surface sources if recycled water is not available.

This approach would ensure that the industry will treat effluent for its own use and stop contaminating the river. In addition to ensuring that water quality does not deteriorate from industrial pollution, this will release fresh water that is not used because the unit is using its recycled effluent.

Source: Field Study, The World Bank, INUWS, 1991.

Trading Water Among Sectors

There are a number of institutional changes that can reallocate water supplies among users. Trading of water rights, water banks, and water auctions have successfully reallocated water from "low-value" uses to "high-value" uses.

☞ During the 1991 drought, California purchased approximately 920 million m^3 of water from farmers to meet critical urban and agricultural needs. This volume represents about 10 percent of municipal and industrial demand in normal conditions. The Department of Water Resources, through the newly formed Water Bank, acquired water at $0.10/$m^3$ and then sold it at an average price of $0.14/$m^3$ (Box 10).

BOX 10: Water reallocation through the California Water Bank

Water transfers and exchanges are important in the management of California's water resources. There are many forms of transfer incentives, and the government has focused on establishing the legal and institutional framework to allow for all kinds of transfers. To cope with the 1987-1991 drought, the Department of Water Resources established a water bank to facilitate water transfers. Through this mechanism water could be allocated for critical urban and agricultural use, and fish and wildlife, and could also be made available for carryover storage. Approximately 920 million m^3 (about 11 percent of statewide domestic and industrial consumption) were purchased from farmers on a voluntary basis. The price offered was sufficient to compensate rice, corn, and tomato farmers. For example, a rice grower was offered $925 for every hectare not planted, 25 percent above the farmer's probable profit. Since each hectare of rice uses about 9,100 m^3 of water per year, the farmer received $0.10 for a cubic meter of water. Water thus obtained was sold at an average price of $0.14.$m^3$. About 80 percent was used to satisfy critical urban needs and the remaining 20 percent went to critical agricultural needs.

Source: David N. Kennedy, "Allocating California's Water Supplies During the Current Drought," Presented at the World Bank International Workshop on Comprehensive Water Resources Management Polices, Washington, D.C., 1991.

PROVIDING SERVICE TO THE POOR

There is compelling evidence that conservation via judicious tariff policies and institutional changes can increase supplies 20-30 percent in the household sector. In the industrial sector, water-saving processes and technologies can reduce water withdrawals by 10-25 percent. Further, encouraging industries and power plants to treat their effluent and sewage water and recycle or reuse it in their own processes has the twin benefits of environmental protection and economic gain. It reduces withdrawals of water since a portion of industrial need is met from recycled water. This reduction of use provides a net economic benefit if water has a higher economic value than if it were used downstream or pumped from the ground.[50] It provides an environmental benefit by improving the quality of water in the river or pond where the effluent and sewage were previously discharged. The environmental objective of improving water quality in receiving bodies complements the economic efficiency of obtaining higher net benefit from water made available for other uses.

In view of the weak regulatory apparatus in developing countries, it will be necessary to use water tariff policies in conjunction with subsidies and soft loans for treatment plants so that entrepreneurs will find it worthwhile to treat industrial effluent and sewage for recycling in their own plants. The amount saved in each use and its implications for the urban poor will depend on the volume saved in households and/or industries and the number of persons who remain unserved in a particular setting. To illustrate these implications in quantitative terms, a few cases have been selected to indicate:

- The savings in the household sector;
- The savings in the industrial sector as a result of conservation achieved through a changeover to new processes and technologies;
- The reduction in withdrawals of water for industries through recycling and reuse of treated effluent and sewage;
- The number of persons who could be provided piped water supply as a result of these measures without substantial additional cost for storage, transportation, or treatment; and
- The savings required in the agriculture sector to release water to provide 100 percent coverage to the urban population.

The four illustration cases are Jamshedpur, a city of around one million in Eastern India; Istanbul, with a population of around 6.6 million; the Mexico City metropolitan area, with an estimated population of over 19 million; and Jakarta, with a population estimated at 8.5 million in 1988. Table 2 gives an overview of the additional water supplies made available by conservation and recycling in the four metropolitan areas. In Jamshedpur and Mexico City, additional supplies could provide 150 lcd of water to the entire unserved population (at present) without incurring additional costs. In the case of Istanbul, the additional water would supply about 80 percent of the unserved population, and in Jakarta it would provide water to a quarter of the unserved.

Jamshedpur

There is considerable scope for conservation and recycling (see Box 9), but industries will implement these plans only if (a) the water tariff reflects the economic cost, which includes the opportunity cost of water; and (b) if soft loans and/or investment subsidies make it worthwhile for industries to treat their effluent and sewage water and recycle it. Table 2 shows the volumes of water saved through these methods if two major consumers of water, TISCO and Tin Plate Co., invest in new technologies and process to save water. Together they could save as mush as 15 MCM, about 25 percent of total industrial consumption, without affecting output or employment. Further, if 50 percent of effluent water is treated and recycled, this would reduce withdrawals by about 20 MCM. The additional supplies would be sufficient for new industrial units and for domestic supplies (150 lcd) to the entire unserved population of Jamshedpur and neighboring areas. However, institutional changes will be required to make these additional supplies available to the poor.

Istanbul

Istanbul's population is approximately 6.6 million, about 80 percent of whom have access to piped water supply. A 5-percent reduction in the level of unaccounted-for water (UFW) (from 30 percent to 25 percent, assuming leakage of 10 percent) will save 17.5 MCM of water that could then be used to supply other areas. There are plans to build wastewater treatment facilities that will produce high-quality secondary effluent. If 30 percent of currently collected domestic wastewater is treated and reused in the industrial sector, industrial water withdrawals can be reduced by 36 MCM. Thus, the additional volume of water released could reach 54 MCM, enough to provide 150 lcd to 1.0 million persons (Table 2).

Table 2: Additional Water Supplies Available As a Result of Conservation and Recycling in Four Metropolitan Areas (millions of cubic meters per year)

	Jamshedpur	Istanbul	Mexico City	Jakarta[a]
Total household demand	65	276	1,160	210
Total industrial demand	60	213	390	56
Savings in household sector	N.A.	18	110	45
Savings from conservation by industries	15	N.A.	N.A.	N.A.
Savings from recycling & reuse by industries	20	36	165	N.A.
Total estimated savings	**35**	**54**	**165**	**45**
Number of persons who could be provided additional supplies (millions)[b]	0.5	1	3	0.8
Total population (millions)	1	6.6	19	5.1
Population without piped supply	0.5	1.3	2.8	3.6

Notes:
N.A. not available
a Only the service area of PDAM.
b Assuming an average consumption of 150 lcd (liters per capita per day)

Sources: For Jamshedpur: Field Study. For Istanbul: "Istanbul Water Supply and Sewerage Project," SAR 6985-TU, 1987. For Mexico City: "Mexico City Metropolitan Area Water Supply and Sewerage Sector Overview" (Draft), Report 8150-ME, 1989. For Jakarta: "Jakarta Water Supply PDAM Jaya System Improvement Project," Safege, Beture, Satame & Sooreah, 1988-89; and "Second Jabotabek Urban Development Project (JUDP II), Report #8339-IND, 1990.

Mexico City

The population of the Mexico City metropolitan area in 1986 was estimated at around 18.7 million, of which about 85 percent have access to piped water supply and about 71 percent have access to sanitation services. Average gross domestic per capita consumption is about 200 lcd (15 percent of the population consume on average 350 lcd, 25 percent about 250 lcd and the rest 140 lcd). If traditional water closets (flush systems) that use 16 liters per flush are replaced by more efficient ones that use only 7 liters, domestic and commercial demands would be reduced by 10 percent. This will result in a total saving of about 110 MCM. If just 20 percent of currently collected domestic wastewater is treated and reused in the industrial sector, industrial water requirement will be reduced by 55 MCM. As a result of the above conservation measures, about 3 million inhabitants could be served at a gross rate of about 150 lcd (Table 2). Thus, 100 percent of the currently unserved would be served without incurring huge investments to develop new supplies.

Jakarta

In 1988, only 28.4 percent of households in the service area of PDAM, or 1.45 million persons, received water through direct connection to the municipal system (house connections, 21 percent, and public standpipes, 7.4 percent). The rest of the population either relied on private wells or bought water from vendors. Per capita consumption for piped water ranges from 250 liters per capita per day (lcd) in high-income group to 150 lcd among the middle-income group. Consumption from standpipes is estimated as 30 lcd, but accurate data on the volume of water extracted from groundwater sources do not exist. For the industrial sector, it has been estimated that only one eighth of its water demand is met from public piped water, and the rest comes from private groundwater abstraction. In the domestic sector it has been assumed that the unserved population has to rely on this source, and their consumption is about 120 lcd. If UFW is reduced by 20 percent, from its current level of 51 percent, the urban water supply authority could save about 45 MCM. This volume could provide additional water to about 0.8 million persons (at 150 lcd).

These savings are important in providing immediate relief to those without water supply must be considered short-term solutions. There is a need for change from the present subsectoral, piecemeal approach to a framework of analysis that incorporates the economic and environmental linkages among user sectors. Since this is crucial for policy analysis, it is dealt with in detail in the following section.

IMPERATIVES FOR A NEW APPROACH

Some of the water resources sector's malfunctions (discussed in part III) arise because water-related decisions are made without recognizing the fact that water is a unitary resource.[51] Rainwater, surface water in rivers and lakes, groundwater, and polluted water are all parts of the same resource base. They are all the same resource, but they occur in different parts of the hydrologic cycle. Actions in one part of the system often have significant impacts on other parts of the system (externalities). Hence, the connections must be taken into account to assess accurately the costs and benefits of specific actions.

The externalities of both water quantity and water quality are visible in the relationship between upstream and downstream users, and in a temporal senses between different seasonal releases of stored water, common pool effects on groundwater, and the export of pollution. These externalities can be broadly classified as economic and environmental in order to assess the effects of various policy instruments.

Economic Externalities

Because it is a unitary resource, water in the basin can be used for different purposes and in sequential uses. Each use implies withdrawal of a given volume of water of a certain specified quality (drinking water standards differ from those applied to water used in industrial cooling). When a certain volume is withdrawn for one particular use, that quantity is not available at the same time and location for irrigation or drinking. The water has an opportunity cost since the continued abstraction by one user reduces the amount available to another, and there is a loss of the opportunity to use the water.[52]

This lost opportunity costs the affected user the amount he values the units of water. At this point the "value" of the water should reflect the willingness to pay of the user who is losing water. If total water is in short supply and is allocated to an industrial unit, the relevant opportunity cost would be the farmer's willingness to pay for irrigation water. If there are well-established markets for water, then the market price itself reflects the opportunity cost.

Since such markets do not exist in most countries, it is necessary to estimate the opportunity cost of water in indirect ways. Estimates used in an industrial plant require an appraisal of the benefits foregone in an alternative use, often agriculture. This can be estimated by calculating the economic value of water in irrigating a crop.

Estimates of opportunity cost are useful in setting water prices or tariffs in different sectors. For example, in Jamshedpur (Box 9) the inclusion of the opportunity cost of water may result in a 25 percent increase in the water tariff charged industrial users. This has implications for the financial viability of investments in water-saving processes and technologies, also detailed in Box 9. If the tariff is fixed to cover only the financial costs of new water supply, there is no incentive for the entrepreneur to invest in water-saving process. However, if the tariff reflects the economic cost inclusive of the opportunity cost of water, then it will be financially worthwhile to conserve water.

Extended Environmental Analysis

A new awareness of upstream-downstream connections in the river basin is required on the part of the scientific community, decision makers, and policy analysts. This requires the general development problem to be defined in the larger environmental perspective of the whole river-basin population. The basin's population depends, on the one hand, on rainfall over the basin to support the water-consuming biomass production in agriculture and forestry, and, on the other hand, depends on the remaining water surplus that does not return to the atmosphere but goes to recharge aquifers and watercourses and is accessible for various water-dependent uses.

As vegetation management will influence the return flow to the atmosphere, and, therefore, the amount that remains to recharge aquifers and rivers, land use and water have to be integrated. This level of analysis considers multiple uses of water simultaneously, and it goes a step further by integrating all water-consuming activities in the basin including vegetation (biomass production, both natural and anthropogenic) for meeting basic needs and market requirements.

Such an extended environmental analysis should encourage planning so that upstream and intracity-generated threats to urban water supply can be taken into account and downstream impacts from urban activities can be minimized. These would include:

- Threats from upstream activities to the sustainability of the city system: (a) from land use (agriculture, forestry) and diversions that influence long-term availability of water in the city surroundings, and from upstream land management that influences the silt transport and therefore the sustainability of city reservoirs; and (b) from upstream cities and industries influencing the quality of the surface water in the downstream city's area;

- Threats induced by city activities to other city activities, particularly those related to groundwater level and quality;

☞ Threats induced by the city's system to downstream activities: to downstream surface water and therefore to usefulness for irrigation, edibility of fish, and impacts on human health from contact with water polluted by urban wastewater; and

☞ The potential for sequential reuse along the river if wastewater is treated.

Table 3 shows the relationships among various threats and risks to be assessed in a long-term environmental study of the urban water supply system its regional context. Such a study should include ways to:

☞ Avoid pollution of periurban aquifers by assuring acceptable waste handling by the city and the industries;

☞ Avoid pollution of surface water by assuring acceptable wastewater treatment; and

☞ Plan for changes in upstream conditions that will influence the reliability of the water supply system: changes in the quantity of water from reforestation or irrigated agriculture; and in the quality of the water caused by upstream industrial pollution and urban wastewater.

At the project level, the following environmental impacts of water development projects must be considered: water pollution caused by water used in agriculture, industry, and households; social and environmental impacts of large reservoirs in terms of loss of forests and wildlife and welfare losses of resettlement of displaced populations; and waterlogging, salinity, and diseases caused by irrigation of land.

Integrated Water Resource Planning and Management

Integrated water resources planning (IWRP) can take into account the geophysical relationships in the hydrological cycle, the value of water to different users, and national policy objectives. This approach can provide links between economic and environmental considerations in the use of water resources. It considers the water in the basin as an economic good and assesses the economically optimal use of this resource and the economically optimal instruments to achieve

Table 3: Relationship Between Threats and Risks to be Included in Analysis						
	----- City -----		------------ Downstream ------------			
Risks to: / Threats from:	Water availability	Water quality & health	Irrigated agriculture supply and land fertility	City water supply	Industrial water supply	Fishery
Upstream						
Reforestation	*					
Irrigation	*	*				
City pollution		*	*	*	*	*
Industrial pollution		*	*	*	*	*
Diversion out	*		*	*	*	
City						
Municipal waste	-	*	*	*	*	*
Industrial waste	-	*	*	*	*	*

this. Using an optimization framework, near-optimal solutions can be evaluated under a variety of demand and price options.

The systems analysis approach, IWRP, may be extended so that the integration would go further and include the water-consuming biomass production in the basin. There is a very good reason for doing so in poor, semiarid countries where water and land availability are serious constraints to income generation. Such an approach would include both water-balance based planning of land and water use with due attention to quantity and quality links between upstream, city, and downstream land and water uses; and also a broad-based cost awareness that includes the benefits foregone (opportunity costs) of a given water use, including biomass production. In areas where afforestation is taking place or being planned, future water supplies may be threatened by the increased water requirements of the additional biomass. In areas where only a limited amount of rainwater goes to recharge aquifers and rivers, and most rainwater returns to the atmosphere from high evaporation losses, this limited return flow may produce significant runoff changes.

CONCLUSIONS

In summary, this paper concludes that:

- ☞ The present subsectoral policies in water resource management (subsidized tariffs that ignore the opportunity cost of water, lack of pollution taxes) cause excessive quantities of water to be used and excess pollution to be produced; and the urban poor bear the brunt of shortages by paying high prices and/or suffering adverse health effects.

- ☞ There is compelling evidence that, at a minimum, 20-30 percent of water currently used in developing countries by households and industries could be saved by adopting appropriate regulatory and policy instruments such as tariffs, quotas, and groundwater extraction charges. Similar savings are also possible in irrigated agriculture by investments in canal lining, encouraging less-water-intensive crops (through relative output prices), and raising irrigation rates.

- ☞ Twin benefits of clean water and reduced demand (up to 20 percent) can be obtained if industrial recycling and reuse of water are encouraged through pollution control measures and economic incentives (water tariffs based on economic costs, effluent charges. and low-interest loans for effluent and sewage treatment plants).

- ☞ These conservation and recycling efforts would release enough water to supply adequate amounts of clean water to a significant portion of the now-unserved urban poor without incurring additional costs for distribution and water treatment.

- ☞ However, these measures require institutional changes, both organizational restructuring and incentive systems, to motivate users so that the regulatory mechanisms and economic incentives will achieve the desired objectives.

- ☞ There is a need to change the approach for analyzing water resource issues in developing countries. Analysis of environmental links requires an awareness of the upstream-downstream links in a river basin. The approach suggested here is to integrate all water-consuming activities in the basin and include all forms of vegetation. Such an analysis should encourage planning in such a way that upstream and intracity-generated threats to urban water supplies will be taken into account and downstream impact of urban activities can be minimized.

Annex A: Discussion Points for the Working Group

In view of massive urban population growth, rapidly increasing costs of new supplies, and excessive pollution (both "old" microbiological and "new" organic-chemical and heavy-metal pollutants), the number of urban poor bearing the brunt of shortages and quality deterioration is expected to increase in the next three decades and beyond. To mitigate the health problems arising from inadequate and contaminated water supplies, and to avoid productivity and welfare losses associated with unreliable water supply (to manufacturing units as well as households) will require new thinking and new approaches as well as concerted efforts at the national and international levels. The delegates to the Dublin Conference may, therefore, discuss actions needed on the following key points:

☞ Efforts needed for accelerating rural development, better income distribution in the countryside, and child-spacing in urban areas with a view to **slowing urban population growth.**

☞ The **role of the international community** (governments, multilateral and scientific organizations, NGOs) in developing new thinking regarding spatial patterns of urban growth (more medium-size cities); in supporting national efforts through human resource development (training networks), R & D in technology and new approaches in pollution-avoidance (waste treatment and water reuse); water conservation and integrated plans for upstream-downstream land and water use.

☞ Defining the situations under which **international funding** can stimulate local efforts (including private sector and community actions) in providing water supply to target populations.

☞ At the national level, this requires **comprehensive integrated land- and water-use plans** using the systems analysis approach for river basins containing urban areas. Such plans should explicitly consider all sources of water supply and pollution (from agriculture, industries, and cities) and suggest methods for improving and protecting water quality.

☞ The role of key policy instruments in encouraging efficient, equitable, and sustainable use of water resources in developing countries. These policy instruments may be grouped under (a) **institutional changes and regulatory measures** such as water quality standards, groundwater regulation, pollution control, water rights, water markets, private-sector participation, etc.; and (b) **economic incentives** such as tariffs, tax and subsidy policies, interest rate policies (soft loans), groundwater extraction charges, effluent charges, etc.

Annex B: Main Messages

☞ There is compelling evidence in both developed and developing countries that a mix of regulatory and economic incentives (tariffs, fiscal incentives) have produced 20-30 percent (and higher) reductions in water use by industries, thermal power plants, and households. Hence, demand management should be a major component of investment and pricing policies for the water subsectors.

☞ Encouraging the treatment of industrial effluent and sewage for recycling within the industrial units reduces the demand for raw water and makes it available for other uses without incurring investment costs in new projects. This complementarity of the environmental and economic objectives can be obtained by a judicious mix of water tariffs, pollution taxes, and fiscal incentives (tax concessions, soft loans, subsidies).

☞ There is a need for a new approach that takes into account the economic links among various users of the unitary resource, incorporates environmental links among upstream and downstream users, and includes interactions between land use and water resources supply and demand.

Notes

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2 Although the quantity of water that seeps to become available via groundwater is not "waste" from the system perspective, this does result in additional costs of pumping water from the ground. Further, the quantity that comes back as "return flow" would be less than what seeped in because of losses in groundwater use.

3 Unaccounted-for-water includes both physical losses of water and loss of revenues by the utility. This section will only make reference to reduction of the former because of the clear welfare implications.

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for farm products are kept lower than the import prices as a matter of government policy; and (f) similar subsidies are available to farmers in the United States and other developed countries. See Small et al, op.cit.

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