Water Crisis in Developing World: Misconceptions about Solutions

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Abstract: The United Nations forecasts a world population growth of 1 billion in the next decade and 2 billion in the next two decades—growth that will place immense demands on the developing nations' water resources. The extent of these demands when placed against the constraints of time, water, and funds, and the lack of plans to manage droughts confirm that the world faces a serious water crisis. Yet, most actions proposed in today's debate offer questionable solutions, many built on faulty assumptions. Water markets and increases in irrigation efficiency will do little to meet the needs of these countries. Reallocations will have far-reaching social repercussions. The time constraints dictate that the situation be addressed with a greater sense of urgency and that proven measures, even if controversial, should be promptly implemented, while studies should concentrate on approaches that can realistically offer significant help in the following decades. An example of the consequences of the international community's confined if not distorted perspectives is offered by a case study of India's Sardar Sarovar Project.

THE SITUATION

Even with today's population, the demand for water is exceeding supply in several regions of the world. Some of these regions are experiencing droughts that cost thousands of lives and inflict severe economic and social damage. In late 1994 the United Nations announced its projections on population growth: 94,000,000 people per year—a total of 1 billion over the next 10 years and 2 billion over the next two decades (World 1994) (Fig. 1). Little else needs to be said to describe the magnitude of the world's water crisis and the need to act. Little else should need to be said about the urgency of applying proven solutions if priority problems are to be dealt with in time to make a difference.

Many governments worldwide are already unacceptably deficient in providing urban and rural domestic water supply, stemming pollution, and tackling environmental degradation, and soon may be unable to meet food demands (Frederiksen et al. 1993). The most serious conditions are found in developing countries where most of the population increases will occur. Even if population control, which seems ultimately the only effective way to deal with the water situation, is effected under the most optimistic schedule, the world population growth will not stabilize for decades.

Yet, the selection of means to deal with the many critical situations is often inhibited, if not misguided. There is a growing reluctance even to consider measures that may be contentious. And there is no effort to look carefully at the social, economic, and environmental consequences of further procrastination or of doing nothing. Those actions that are put forth as relatively simple and environmentally appealing dominate attention, but unfortunately will do little, particularly in the coming decades. The most serious aspect of the water crisis is the misconceptions about solutions now proposed. Emotion dominates debate and decisions instead of sound data and rational analysis of facts, while the world's water crisis worsens. Solutions that satisfy needs and meet environmental objectives in a balanced manner must be found.

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BASIC ISSUES

There are four important constraints that are inadequately considered in today's debate on dealing with the water crisis: (1) Scarce time to act if we are to meet the pending needs; (2) the limited measures available for securing essential water supplies; (3) the competing demands for funds to provide the means; and (4) minimal ability to manage droughts when they strike unannounced.

Critically Short Time to Act

Perhaps the most important constraint on solving the water-resources crisis is time. There is very little time to do all that needs to be done to accommodate the 1 billion new people to be born in the next 10 years. Very few actions of the magnitude needed can be completed in this period. Indeed, the world already has most of the developed water supplies that will have to be spread among the additional people. And during this period, the world must also act on a broader front to complete the still larger actions to cope with the following years.

The world does not have the luxury of placing our resources under endless studies, conferences, and workshops about new concepts, followed by pilot projects to experiment still further. Study should be confined to new approaches that may truly help in 20 years, while feasible measures are applied in the meantime—and much more extensively in the future than many recognize. What has worked to solve these problems in the past should be assessed, and those that have proven appropriate to the developing countries should be applied. The

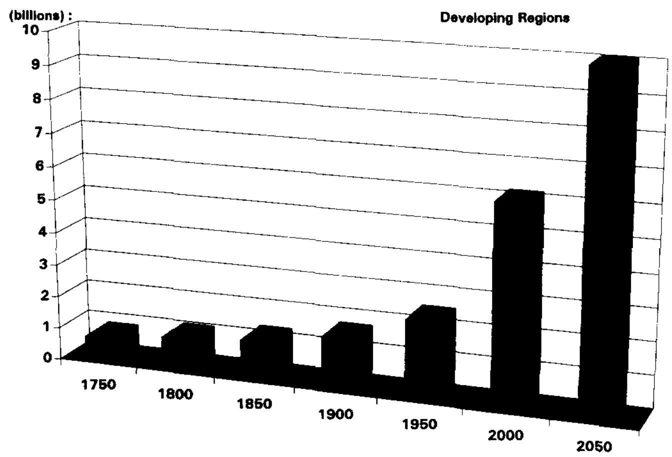

FIG. 1. Trends and Projections in World Population Growth, 1750–2050

gestation period for legislation, program formulation, institutional strengthening, and financing and implementation of the type of measures demanded by the situation is 15–30 years.

And if the international community is too fainthearted to support unavoidable, though controversial measures, it should step aside and let the countries who literally have to survive or fall with the situation continue with their actions.

Few Measures Can Produce the Needed Water

The constraints on water availability are obvious. Many of the world's strategic rivers are already overcommitted. Many aquifers are in overdraft. Pollution is rising to such an extent that it is reducing the amount of usable water. And this is occurring during a period of relatively normal precipitation, yet at a time when population growth continues in these basins.

So what is the international community doing about even this most basic question? Much of it has ducked the extremely difficult real-world options by conducting analyses of politically correct theory that even the developed countries have not adopted. Many solutions to the water supply situation being promoted contain fundamental flaws—few will contribute in a substantial way.

Bear in mind what countries with successful economies, concerned societies, mature institutions, and sophisticated active populations are doing to manage their water today. Examine what is actually happening in these countries and in the emerging nations—not what is under consideration or recently initiated, which will require many years to prove. Mistaken beliefs on the nature of and solutions to the water constraint seriously and adversely affect all other actions in the sector. Some common beliefs underlying these proposals and their realistic potential for meeting the water demands of the world's population and economic growth are summarized in the following discussion.

Features common to most misconceptions in water-resources management are the use of general and inconsistently defined terms and a lack of rigorous analysis of specific situations. Annual quantities are used when it is seasonal quantities that count, averages are used when it is the extremes that count; and major quantities are ignored while concentrating on minor amounts. And too often there is no comprehensive accounting of all quantities involved in a given situation—only of those judged pertinent from the perspective of the particular person or group.

Complicating the situation are the many presentations on the subject in the popular press, for this, correctly so in our society, has great influence on public policy. It is for those working in the water-resources field to help provide facts and assure balances in their material.

Solution 1: A majority of a nation's total runoff, usually expressed as a per capita value, is utilizable, and most of that is committed to agricultural uses.

This is one of the more frequently heard assumptions with misleading implications. In part, this is because official data is lacking and little analysis has been conducted using data that is available. Let's take an example with accurately measured quantities and in a location that relies on irrigation in the dry season—California. Most people, by reading the press and books, believe that California has substantial quantities of water of which 80% or more is set aside for irrigation uses (''Water'' 1993; ''California'' 1991). In large part this value depends on the definition of ''uses.'' The basic fact is that any water that is set aside to the exclusion of other uses is also ''used'' and should be treated accordingly in analysis and public discussion. Recent state water-planning documents present the data.

In normal years California receives 193,000,000 acre-ft

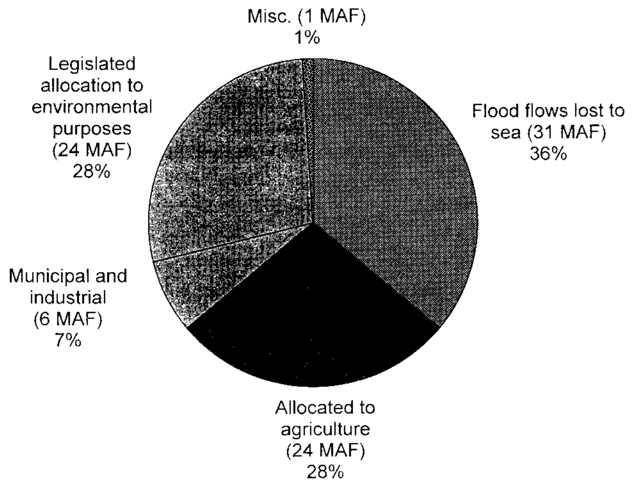

FIG. 2. Disposition of California's Annual Precipitation of 193 MAF

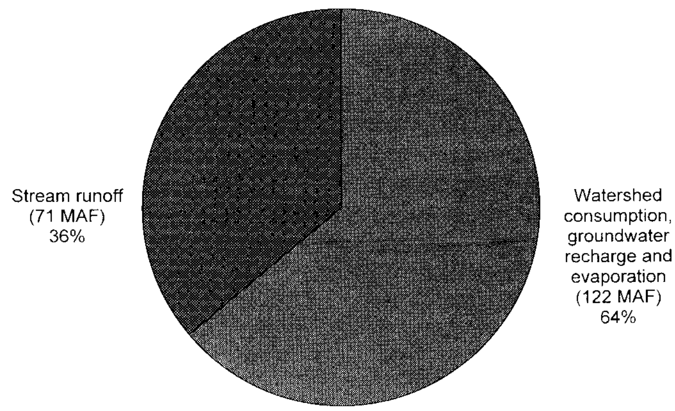

FIG. 3. Disposition of Total Quantity of Water Available to the State—85 MAF

(MAF) of precipitation (*California* 1994). (One acre-ft of water is the quantity required to cover one acre of land to a depth of 1 ft or 325,850 gal.). After uptake by watershed vegetation, direct evaporation and ground-water recharge, only 71 MAF of precipitation appear as stream runoff; this is augmented by 6 MAF of inflow from outside—the Colorado and the Klamath rivers—to make a total of 77 MAF of stream runoff. At 1990 rates of use, an additional 8 MAF net is extracted from ground water (Fig. 2).

Of California's 85 MAF natural runoff plus surface water imports and ground water used, 36% is lost to the sea; 28% is allocated by legislation to environmental purposes; an equal amount, 28%, is allocated to agriculture; 7% is allocated to urban and industrial uses; and 1% is used for miscellaneous purposes (Fig. 3). In fact, irrigation uses less than 28% of the average runoff within California.

California has about 850 MAF of ground water, one-half of which is of suitable quality for general use (*California* 1994). Although, at the 1990 rate of use, industry and agriculture extract 14 MAF and consumptively use 8 MAF each year, the ground-water recharge from precipitation, irrigation, and other means leaves an average annual overdraft of only 1 MAF. During recent droughts net use of ground water rose from the average 1990 rate of 8 MAF to 13 MAF, a portion of which was sold to the state's drought ''water bank.'' Contrary to common belief, large quantities of ground water (and uncommitted reservoir water) entered the drought water bank, not just surface waters being transferred by market forces. The reallocation of additional surface flows to environmental purposes enacted by law in 1994 will cause farmers and rural cities to increase pumping, further aggravating the ground-water overdraft aspect of the environment.

Increasing nonenvironmental demands will cause an annual shortfall of 2.2–4.2 MAF by 2020, which can be satisfied by constructing additional storage and conveyance facilities, increasing overdraft, limiting transfers among the existing uses, and curtailing some uses. Complicating the situation, California's annual runoff varies greatly from as little as 15 MAF in 1976–77 to 135 MAF in 1982–83. The importance of its carryover storage is obvious.

These figures illustrate the difference between runoff, water available for designated uses and the quantity used. The only quantity of water that can meet a country's economic and social needs and a portion of the environmental is the utilizable quantity, not total precipitation or total stream runoff. This quantity varies annually and by season and can be altered by constructing storage—reservoirs or dedicated ground-water recharge. It is the utilizable quantity that should be determined and used in discussions, recognizing that substantial portions of even that may not be available to support human activities. And this fact is largely not understood. Actually, the proportion of utilizable runoff is high in California because of the large amount occurring as summer snowmelt, effectively a storage for summer use, and the large number of reservoirs. (Reservoir capacity on state streams is 60% of average annual runoff, while on the Colorado River, California's other source, storage is more than 400%). By comparison, it has been estimated that only about 36 percent of India's runoff would be utilizable even with construction of a substantial number of additional reservoirs.

The second fact illustrated by the foregoing figures, from the standpoint of allocating water, is that water set aside and unavailable for other purposes is "used" just as surely as irrigation and urban uses. At issue is not just whether a particular use is consumptive or not. All consumptive plus all water made unavailable for other purposes, whether to grow crops or dedicated to flow to the sea or otherwise irretrievably lost to the hydrologic system, should be accounted for in public discussion.

Solution 2: All water used by agriculture can be made available for reallocation to other purposes.

Agricultural crops do use large amounts of water, but that does not always equate to availability for other uses. Farmers in many developing countries raise more than one crop a year and the largest cropped area in the topical zones, such as the south Asian countries, is during the high-runoff period. (Since Asia will have by far the largest population growth, its situation is of particular concern.) However, the other water users have a surplus at that time; indeed, they may be under water. So in a normal year in countries that have a monsoon season, most of that season's quantity of water used by agriculture must be removed from the "available water for reallocation" list. Obviously, the quantities vary widely among countries.

This leaves the portion of annual irrigation water used by agriculture in the dry season. This varies even more as it depends on the area's precipitation pattern, the dry season's natural stream flow derived from the ground water feeding the rivers, snow pack, and reservoirs behind dams. (Due to the seasonal temperature differences and hence limitations on when crops can be raised, California's dry season diversions account for a major portion of total flows, quite different from that of many developing countries in the tropical zones.) In a monsoon region maybe only 30% of agriculture's total annual usage could be diverted to the needs of other users. However, if irrigation, whether of one or two crops, occurs predominantly during the normal low-flow season, agriculture may divert 90% of its annual usage during this period. In general, it is the agricultural uses during the low-flow season that count, not agriculture's annual usage.

Solution 3: Minor reductions in countrywide irrigation allocations would minimally disturb farmers, yet would meet urban needs.

Irrigation may divert a large percentage of the usable water. The implied concept is that diverting a little from the entire irrigation sector should be easy, inexpensive, and painless. However, urban centers will try to take all their incremental needs from the immediately adjacent irrigated areas for physical and economic reasons. And if they do so, they will have substantial impact on the production of the affected farmers and the economy of the villages, creating serious social and economic consequences.

Nevertheless, this may become the primary way for water to be reallocated to urban areas. However, the impact of localized water acquisition will call into play the same reimbursement and resettlement policies (with like unit costs) as those adopted under land acquisition for reservoirs and canals, except many more people will be affected by the reallocations. (The magnitude is illustrated in a later section.)

Solution 4: Improved agricultural efficiency will yield substantial quantities of new water.

This is perhaps the most common misconception concerning the potential sources to meet future water demands ["The First" (1992), and a 1994 United Nations-Food and Agricultural Organization (UN-FAO) news release]. Individual irrigation projects may have an efficiency of only 40%. However, most projects pass the other 50–60% of project "losses" on to irrigation and urban users downstream, or to underlying aquifers, for subsequent use. This results in a very high efficiency (87% in the United States) (America's 1981) for the irrigation sector. It is even higher in most key basins of the world where one project's losses and return flows is the next project's source. Many basins such as the Ganges (supporting a current population of 400,000,000), Chao Phraya (supporting Bangkok and the heartland of Thailand), and the Yellow (supporting several hundred million people in central China) are already at 100% efficiency during much of the year.

Urban uses are far less efficient than irrigation, except where per capita deliveries are exceedingly low. The efficiency may approach 15–25% in developed countries and, with system losses, maybe 20–50% in developing countries where per capita use is low but system leakage is higher. The coastal urban centers discharge their return flows into the sea with the same results as where irrigation returns discharge into saline sinks—all is lost. Only in these situations is there a potential water savings through improving project efficiency. And it is under these conditions that water-saving plumbing appliances are effective in reducing basin water demand.

The fundamental fact to remember is that it is basin efficiency that counts, not project efficiency, except where return flows discharge into the sea or saline sinks. What percentage of the usable water in a basin during low flow is consumed and what percentage is wasted to the sea or is irretrievably lost to the system? In most situations (not all) there is no significant quantity of water that can be obtained by improving irrigation efficiency. (The potential gain by changing crops is discussed in a later section.) Ironically, by improving project efficiencies and providing the water "saved" to areas within a project that are not currently served will reduce supply to existing downstream users, thereby exchanging current production for new production, at a cost but without net gain.

Solution 5: Demand management will free substantial quantities in the urban and agricultural sectors of developing countries.

Farmers in many water-constrained regions, particularly in major regions of South Asia and China where basin efficiencies are high, already have inadequate water supplies to irrigate their entire farm. This is inevitably the situation during the low-flow season, the very time when all users are seeking additional supplies.

These farmers already practice demand management to maximize the farm return on their water, for water is their limiting input. Increased charges for water will only reduce net incomes until they reach the level where farmers abandon agriculture altogether.

Demand management is effective in the urban centers in the developed countries where per capita use is 200–600 L per day. However, there is no opportunity where the uses in poor urban areas may be only 10–15 L per day, and where the goal is to reach 40–100 L per day. And even where there is opportunity, the resulting quantities will only be marginal.

Solution 6: The reuse of wastewater has the potential for greatly augmenting water supplies.

Indirectly, wastewater reuse is a major source of supply in many areas. It is already fully applied to the interior of basins as shown in the earlier discussion on basin efficiency. The only situations where reuse will yield further gains is in coastal settings. Costly provisions can produce results in urban centers and by quite reasonable measures in irrigation projects if no subsequent users are already using the return flow.

But additional wastewater reuse will be of consequence only in limited local situations in the developing countries. Because of the inevitable recycling already found within basins, it will have little impact on a nation's overall shortages.

Solution 7: Improved management and operations of river basin facilities will offer significant gains in available water supply.

Opportunities do lie in improving conjunctive management of surface and ground water. It could expand yields in those aquifers that have an annual surplus. Perhaps it would allow the use of a portion of ground-water storage for long-term carryover to serve priority needs during droughts. But it will take years to introduce a water rights system and the necessary government regulatory capacity that is essential to effective conjunctive management. Fortunately, many developing countries are enacting the required comprehensive ground-water legislation much faster than the developed countries.

The amount of new water supply from better ground-water management will be marginal over the near term. Improved management will be more of a factor in halting the current overexploitation and loss of capacity that is almost universal in urban centers.

Most stream flow is efficiently managed using the available structures today as demonstrated by the negligible discharge into the sea during the dry season. Better monitoring and control capability would allow some users to be more effective, but little of their diversions would be freed up for other purposes. However, substantial improvements in managing the surface runoff in many basins can be realized by increasing storage. This, now controversial option, has potential and is discussed further in later sections.

Solution 8: Water markets and trading will free up most needed water while meeting the only legitimate measure of water allocation—economic efficiency.

Free markets for the sale of water rights and the trading of water are being promoted as means of increasing economic efficiency in the use of water in conformance with the mantra of free enterprise. And, more importantly, the mechanisms are promoted as freeing up water for the highest economic purposes, negating the need to develop new water sources. Somehow, lower economic purposes, whatever they may be, can be deleted from the list without concern.

There are examples of water markets and trading in North America, and other attempts are under way in South America and Africa. In the United States, however, the only significant rights market is in one area of Colorado where the rights to water imported from outside the basin remain with the importer, essentially precluding third-party acquisition of rights to the return flows. Thus, the legal constraints to trading, and theoretically the absence of third-party effects that otherwise would preclude a free market condition, do not arise in this case. Though few legal constraints actually exist in many states of the United States, only minimal sales have occurred, because the identification of third parties and determination of the level of compensation due for any direct or indirect losses have proven to be overwhelmingly difficult.

Water trading with and without "water banking" has been practiced in several areas. The California Drought Water Bank operated by the State Department of Water Resources in 1991–92 is often cited. However, the actual operation was different from that commonly reported. Another reason to examine the California experience with banking is that it is one of the few applications where complete data are available.

As stated earlier, the annual volume of surface water normally used by agricultural, urban, and industrial users in California is 30 MAF, while banked quantities were very small. Of the 0.82 MAF purchased for the bank in 1991, about 68% was surface water—75% of that freed by land set-aside programs (*California* 1994). The remaining 32% was from overdraft of ground water. Only 0.39 MAF of the state's purchase (slightly more than 1% of the annual quantity of water normally used in the state), priced at $175 per acre-ft, was sold, and a substantial amount of that purchased by the bank was used to prevent saltwater intrusion during transfers across the Sacramento Delta. In 1992, 80% of the 0.19 MAF banked was secured by overdraft, with the remaining obtained from reservoir storage of uncommitted water; 0.13 MAF were sold.

Thus, even in a country with sophisticated rights and legal institutions, full public awareness, a high value for urban and industrial water, and the plumbing to physically move water throughout the state, banking has proved to be of limited value except in periods of severe drought. No banking has been carried out in California under normal hydrological conditions as the many negative impacts, particularly the third-party impacts on the rural communities and regional economy, remain inadequately defined and the means of compensation uncertain. The outcome of future studies and approaches is unknown, but state officials assume that these issues cannot be resolved in time for water banking to meet any normal needs prior to 2020 (*California* 1994).

An overriding obstacle to implementing these concepts in developing countries, even in times of severe drought, is the absence of the required institutional and physical infrastructure. The financial transactions and physical movement of water require government intervention to provide indisputable means to measure the water, convey the water, and monitor its movement. There must be an honest broker to hold the money and take control of the water and an enforcement agency to record and oversee these movements. And before that there must be a clear and firmly enforced water-rights system fully in place, establishing both individual and project rights. No developing country has all of these components, and only a few have even some of them.

Further, water-rights markets and transfers do not produce any additional water for a country: they only reallocate water already applied productively. These means would be largely counterproductive where poverty alleviation is a primary objective. Awarding water to the highest bidder would not help, and probably would undermine a country's primary social, regional development, security, and environmental goals.

Simple water trading is common among local users for enhancing operational flexibility. Emergency application of water transfers may ensure a supply of water to urban areas at times of limited shortage with compensation. But trading will not meet a significant portion of the growing, normal demands of developing countries. By virtue of water's characteristics, transfers will almost always cause serious third-party impacts. To overcome even primary impacts, high-priority users would have to pay water prices equal to the net income that the water-rights holder would have realized by using the water, plus compensation to all third parties and mitigating measures for any environmental impacts.

None of the previously described ways of producing waters can free up significant quantities of water in the next two decades, and after that the potential remains a question. The following measures, solutions nine–13, do, however, afford the means to providing additional water for selected uses. The potential magnitude and impacts differ. Some produce additional water for the nation while others transfer water from existing productive or environmental uses to other uses without a gain in the total resource. The potential costs and benefits of such a transfer depends on the social, economic, and environmental impacts specific to the transfer.

Solution 9: Water can be reallocated from other present uses to meet urban uses.

Reallocating water from lower-priority uses to urban and industrial uses is a physically feasible way of meeting the high-priority demands. The users losing water would be agriculture or the environment, each incurring different impacts. There may be fewer problems where the water to be reallocated is used on agricultural land that is being converted directly to urban land. However, this depends on the population that subsequently occupies the converted land.

It is a different matter where water is reallocated from irrigated land that otherwise remains in agriculture. The social and economic losses to farmers in these situations are identical in nature, but may be of greater magnitude, as those in the development of reservoirs. Compensation and resettlement costs and all that goes with such actions are involved.

However, there is one important difference between these two choices—developing urban supplies by relocating farmers from irrigated lands or relocating inhabitants from reservoir sites. That is the scale of the impact. Assume that a farm family of six tills 1 ha of land, common in many irrigated regions in developing countries, from which 6,000 m^3 (consumptive use of one rice crop and a generous annual consumptive-use allocation for most irrigated farms) are to be taken. Then 1,000,000 people would have to give up a full crop to free up the water provided by one reservoir yielding 1 billion m^3. Where they fully rely on irrigation, 5,800,000 people would have to be relocated from farms and an additional 4,000,000–5,000,000 from the villages and cities supporting the farm activities and processing the products to equal the yield of the Sardar Sarovar Reservoir in India (described later in this case study). But securing that yield from the Sardar Sarovar Reservoir displaces only 100,000, or 1% as many! Even if rainfall can produce some crop (of much less value) after the irrigation supply is cut off, several million would still have to move. And where farms are smaller than 1 ha, many more people will be affected. (Obviously, the numbers will depend on the situation.)

In addition, the nation permanently loses the production, and hence food and annual economic contribution, which is vastly greater from the irrigated area than from the land lost to the reservoir. Taking water from agriculture increases rather than alleviates poverty. Reservoirs produce new water, and associated economic production, for the nation and invariably offer the additional benefits of flood protection and clean energy generation.

To be able to evaluate reallocation choices and calculate the potential costs and benefits, the public should be fully informed of the true social, economic, and environmental ramifications and costs of the reallocation options versus other sources. And right now they are completely unaware.

Solution 10: Increased pollution control will increase useable water supply.

Pollution control offers opportunities to increase water supplies, particularly where streams and lakes have been rendered unusable. A reduced pollution load multiplies usable water during times of shortage because, otherwise, the pollutants overwhelm the reduced dilution flows, rendering the water worthless. This positive impact of pollution control is amplified precisely during the periods of greatest need, and investments yield both economic and environmental benefits. The old concept that "dilution is a solution to pollution" is wrong under these conditions.

The quantity of the freed water, however, is limited and location-specific. And even in developed countries, it has taken decades to devise the most effective program, pass legislation, secure financing, and design and build facilities. It will not be a rapid or inexpensive fix in the developing countries, but pollution control in its own right should have high priority.

Solution 11: There are still substantial water resources that can be developed by most countries.

The nature and extent of resources that can be developed varies among the countries. Ground water, surface runoff, saline-water conversion, and more exotic sources such as transport from high-runoff regions are the usual candidates cited. The latter two are included only to provide a complete list, not as countrywide solutions of any consequence in the usual situation.

Ground Water

Ground waters are nearing their exploitable limits in many countries, with overdrafts in almost all important urban centers and many rural areas. There is little water left to exploit. Artificial recharge of surplus flows offers limited opportunities and is costly and location-specific. By far the greatest amount of artificial recharge is now by irrigation. Ironically, the future reduction in irrigation will cause a net reduction in the artificial recharge of ground water in the very countries where the greatest need for long-term carryover and annual regulation of storage exists.

Natural Surface-Water Flows

There is little uncommitted water remaining to be diverted directly from unregulated rivers. Direct diversions encounter their most severe limits almost everywhere during periods of minimum natural stream discharge. And increased pollution control to match the increasing watershed population will be required just to retain the present quantities of usable flow. This offers little opportunity for satisfying future demands.

Surface-Water Storage

The primary remaining means of providing new water is to construct reservoirs, onstream or offstream. Although opposed by many, the construction of reservoirs may nevertheless be the only physically feasible means that will help a nation reduce poverty, improve its economy, and avoid drought disasters. It can increase the utilizable quantities of water available to the nation while providing other essential benefits of clean energy and flood protection. Perhaps of greatest importance, it provides carryover storage, now so critically short, for use in times of severe drought.

A factual understanding of the positive and negative impacts of reservoirs by the public and the national leaders will allow more rational decisions regarding this source. The performance of the Aswan Reservoir during the recent extended drought silenced criticism of that structure as many could finally visualize the catastrophe had it not been there. The public should be informed about all the benefits and disadvantages of specific reservoir proposals and what can be done to maintain a healthy environment, and not just shown only those "facts" that support one or the other group's views.

Desalination

The desalination of brackish and sea water has been researched and applied to a limited extent throughout the world. Though actively pursued for more than five decades, it remains a costly source. The physical problems of conveyance and disposal of wastewater limits its application. It will not be feasible for agricultural use in the foreseeable future. However, it does hold potential for meeting the needs of some cities located near an ocean. This holds true where users can afford the high costs and, perhaps more common, where separate sources of supply are needed to meet emergency—not routine—shortages. It does not offer a solution to the major needs of developing countries in the near future.

Water Import from Distant Regions

Substantial water surpluses exist in the extreme northern and southern latitudes. Indeed, Alaska has passed legislation to allow the export of water. Conveyance by tanker, barge fleets, and underocean pipelines have been priced by the state. Ocean transport appears to be economically competitive with desalting in southern California. However, water import of this type in developing countries could be applied only in extremely limited conditions where catastrophic emergencies arise, and then only in limited locations of high populations.

Solution 12: Increased recycling of process water in industry can reduce both consumptive and nonconsumptive use of water.

Considerable progress has been made in reducing the use of process water in the mining and industrial sectors. This has freed up significant amounts of water in specific locations within developed countries. Further, it has typically reduced pollution loads on downstream receiving waters. Significant improvements in recycling are also being made in developing countries. However, the impacts are location-specific and usually not of major consequence within the context of a nation's total needs.

Solution 13: Opportunity exists for improving the effectiveness of water used consumptively in the production and processing of crops.

The discussion on the effectiveness of irrigation completes the primary list of proposals to ease the water situation and has been separated, here, from irrigation efficiency in order to emphasize their differences. Regarding water usage, the effectiveness of crop production and the associated processing may be defined as the quantity of water consumptively used to produce 1 kg of usable product. The amount may vary significantly depending on the crop and variety selected, cultural practices, and the type of processing involved to make the product usable (Kreith 1991).

For example, sugar beets are more effective in producing sugar per unit of water than cane. Maize is very effective in producing sweeteners, and is a more effective grain than oats, barley, and wheat. In some areas, both brown and white rice are more effective than soy beans.

A parallel characteristic of crops that may bear on a nation's usable water supplies, which should be reflected in water management, is in using water of marginal quality, particularly saline water. Certain cereals are relatively tolerant. Another characteristic is drought resistance, particularly under rainfed conditions. Higher-tolerance crops can survive under large variations in water supply under rainfed or irrigated cultivation where less-tolerant crops fail under small water deficiencies. Charging the full rate for water will provide incentives to conserve, but a more effective application of water entails much more sophisticated crop husbandry, irrigation methods, equipment, and delivery.

However, there are several limitations to realizing any significant impacts worldwide that would free substantial quantities of water, since further improvements in the basic crops, by far the dominant water users, will be slow. The water use of many crops, such as rice, is already far more effective than assumed by the public. And the cultural practices for improved yields of high-value crops have long received attention.

So which measures have the potential to significantly contribute to the water crisis of the immediate decades? Of the 13 discussed here, only three—reallocation, increased pollution control, and development of new sources—can provide substantial quantities of water to priority users. And only two of the 13—pollution control and reservoirs—increase the water available to the country, and pollution control will be of consequence only in limited areas.

LIMITED FUNDING FOR WATER PROGRAMS

The developing countries did not close the shortfall in urban and rural water supply during the past "water decade," as designated by the United Nations, even with a smaller population during the period and a focused program in every country and every bilateral and international lending agency. Lack of funds was the primary constraint.

Henceforth, funding will be far more difficult to secure as countries try to satisfy other urgent demands from every public sector. In spite of this, the major funding constraint for the water-resources sector is not one of the priorities in the international debate, although some recent publications have discussed the subject (Serageldin 1994). Indeed, neither the sector's financial needs in most countries nor their priorities are known to any degree of accuracy, and sources have not been identified for the next two decades.

Three policies in the water sector are being promoted to, among other purposes, ease the money crunch: (1) Increased privatization; (2) Increased service fees and transfer of government responsibilities to the beneficiaries; and (3) Removal of subsidies from all water-related services.

Increased Privatization (by Investor-Owned Entities) Should Ease Demands on Government Funds

The functions most amenable to private-sector management are urban supply and waste management. However, contracting out the system management and maintenance functions will not change the source (the government or customers) of funds, although it is hoped the amount required will be reduced. Some assume that funding construction and operation and maintenance needs can be met by private firms. But to what extent is this feasible in developing countries? Limited build, own, operate, and transfer (BOOT) undertakings for water and sewerage treatment are moving forward. But the number of privatization ventures that will bring outside financing is uncertain. And continued use of government bonds and guarantees for these arrangements also has an impact on the government's total financing capacity.

Private investor-owned development of irrigation was tried in the 1800s and universally failed under prolonged droughts and the marginal payment capacity of farmers during recessions. Thus, privatization by investor-owned entities will not reduce government investment in irrigation, or in agricultural drainage, flood control, and storm drainage.

Other factors reinforce the doubt that, for many years to come, widespread privatization of services in the water-resources sector could greatly reduce government funding. An overriding constraint is the lack of mature institutions with adequate budgets in essential areas, particularly the regulatory agencies. In these cases, financial impropriety may become a problem, and it is difficult to forecast when the necessary institutional features can be in place in developing countries. The difficulties with the recent reorganizations in the water sector in the United Kingdom, and the improper political influences of the private investor-owned water enterprises in France (Fitchett 1994; "Will" 1995) have occurred under long-established mature institutions and a well-informed, influential population. These programs have been under way for several decades, they are not just commencing as would be the case in most developing countries.

And finally, the generally poor physical conditions of the urban centers in developing countries make it almost impossible to estimate the level of investment needed by a private investor to rehabilitate and expand them. The financial, physical, and political risks are excessive in these situations.

With all these factors taken together, privatization in the next two decades is not likely to greatly ease the demand on government treasuries.

Increased Water-Service Fees and Transfer of Service Responsibilities to Customers/Beneficiaries

Where possible, this will replace government funds for operation and maintenance (O&M). The recovery of the O&M costs for all services—supply, sewerage, irrigation, drainage, and flood control—should be pursued and could make a major contribution to easing the financial pressures on governments. (It would also help focus attention on building only economically and financially viable projects.) The full recovery of O&M costs for all these services has proven acceptable in most countries whether they are provided directly or indirectly through local government or by beneficiary-owned entities. The introduction of O&M cost recovery may progress much more rapidly than most other means to relieve the funding constraint. The recovery of investment costs will prove to be more difficult, but beneficiaries should pay an ever-increasing portion of these costs.

For major works and complex systems, independent subunits of government agencies, formed as financially self-sufficient "utilities," can assume responsibility for the agency's O&M function. These will provide the conditions of operational transparency and financial accountability necessary for beneficiaries to trust that the service charges fairly represent the cost of services received.

Indeed, government charges for full costs are an essential incentive for customers to take on the additional O&M responsibilities that come with the transfer of facilities from government to customer entities. Customer and user organizations can and should assume O&M responsibility for the lower portions of the irrigation systems. Every country has systems that are fully owned and maintained by users, which are proven models tailored to the individual country.

In the much longer term, a major shift in financing will be possible as beneficiary-owned entities assume greater responsibilities for services. Once these entities mature and demonstrate financial responsibility and own the facilities, they will be able to go, independent of government, to financial markets to finance system rehabilitation and expansion.

Instituting the full recovery of all costs of all water services and the transfer of O&M responsibilities are the most promising means of helping alleviate the shortfall in government funding constraints. But again, governments must create the necessary regulatory capacity, establish policies on financing and ownership of facilities, and alter conditions that now favor the agencies retaining these responsibilities.

International agencies fully recognize the need for cost recovery, but focus primarily on urban services and irrigation. The other areas of service—agricultural drainage, storm drainage, and flood control—warrant equal effort.

Removal of Urban and Irrigation Subsidies Will Greatly Decrease Demands on Government Budgets

Essentially all subsidies for O&M in the water-resources sector should be removed as rapidly as possible. (The internal rate structure may have to be formulated to subsidize the poorer urban customers.) The transfer of service responsibility to customers and users, discussed earlier, will likely provide the best vehicle. There are to varying degrees some subsidies, however, for most services in the water sector, particularly on investments. And opponents to their removal point out that subsidies are also common in the developed countries.

Worldwide, the general public is usually not informed of all these subsidy policies and programs in the water sector. For example, while the subsidies on U.S. federal irrigation projects are frequently cited ("California Harvest" 1991; "California's Drought" 1991; "The First" 1992), the fact that the metropolitan region of southern California pays only $0.25/acre-ft and Las Vegas pays only $0.50/acre-ft for bulk water from the U.S. Bureau of Reclamation reservoirs goes unreported (according to the 1942 Boulder Canyon Project Act). The urban and industrial subsidies under the Clean Water and Toxic Waste Clean-Up Acts exceed subsidies in the rural water sector, including the irrigation component. Urban, industrial, and rural areas benefit from extensive flood control and navigation projects. And of course, the heavily subsidized urban transport in our wealthiest cities opens the debate even further. The foregoing conditions in the United States are cited because they indicate most clearly the subsidy problem throughout the world.

Overcoming all subsidies in the developed as well as the developing world will be a slow process, if even possible (or appropriate), lasting well beyond the next two decades. But identifying all subsidies and opening the debate on equitable policies and measures removing inappropriate ones is an urgently needed first step if changes are to be accepted.

After considering all approaches, allocating adequate funds for meeting minimum investment needs in the next decade will be an immense strain on country budgets, and those measures judged feasible in the near term should be pursued aggressively. Yet, it does not appear that the near-term funding issue has been elevated to a level that matches the situation. Few countries or agencies have determined the total financial needs of their water sector over the next decades and, through rigorous analysis, prioritized the projects within their overall available funds and total demands.

Inadequate Preparation for Droughts

The preceding discussion assumed conditions of "normal" precipitation, defined as average runoff. Unfortunately, normal conditions include droughts of various duration and severity. The most severe manifestations of the world's water-resources crisis will be in droughts. With the normal runoff of rivers fully committed and ground water in overdraft, there is no cushion at all today. And what will be the situation in 10 or 30 years?

Even brief dry spells are reported daily in the press serving affected localities. This reflects the direct and immediate economic, social, and environmental impacts of water shortages. Severe droughts of two to five years are relatively common. The countrywide impacts of these are serious and remain so for years: e.g., the 80% runoff reduction in California in 1976–77 where only the large volume of long-term carryover storage, including huge ground-water reservoirs, and the drought's short duration prevented calamity.

Many developed countries have formulated detailed drought-management plans that are updated at regular intervals. These inform the public of what conditions constitute a pending drought, the actions that will be taken, and the penalties for violations. The plans include temporary regional shifts of supply from lower-priority uses to high-priority uses, and reflect the public hearings and special legislation required to effect the measures in a timely and efficient manner ("The National" 1991; Kappus et al. 1989; Mach 1989). Some have included construction of desalters for the sole purpose of drought supply.

Now, in the developing countries, there is less opportunity to retain the low-priority uses, so the water is available to serve priority needs in times of shortage. Many urban centers now rely on only one hydrologic source without backup. There is no low-priority water to reallocate during emergencies. When the next drought strikes, there will be massive economic and social disruptions and, if it is extreme, relocations. Yet, few if any drought-management plans are found in developing countries.

The urgency for countries to draw up national and local drought plans cannot be overemphasized, because their components must be incorporated into both the real-time and long-term management plans of governments and the private sector. Cities and industries, the high-priority users, must know what to anticipate as severe shortages will affect their fundamental operating plans. Drawing up emergency plans must be moved to the very top of the list of purposes for every basin and metropolitan water plan and program.

CASE STUDY: NARMADA BASIN DEVELOPMENT IN INDIA

Several examples could be cited that display the distortions in the current water debate and their consequences for developing countries. But to avoid superficial treatment within the limits of this paper, only one is offered—a project that is still held up by some people in international organizations, government agencies, and publicly sponsored groups as an unquestionable mistake.

The Narmada Basin Development has been the subject of intense exchanges in the media [e.g., in the 1995 Canadian Broadcasting Corporation (CBC) documentary, "The Dammed"], displaying many of the misconceptions discussed here. The Sardar Sarovar Project (SSP), in the state of Gujarat, is one of several interdependent features of a four-state scheme to harness the Narmada River for the betterment of the region's millions who live in poverty. The reasoning that has led to unrelenting opposition to the project, by the developed countries and nongovernmental organizations (NGOs), demonstrates better than any other example the widespread lack of facts about the water crisis, the attitude of many leaders in the international community, and the poorly informed public.

A truly remarkable undertaking, the Sardar Sarovar facility will underpin the future of Gujarat. It will provide the primary incremental domestic supply of water to 65% of the state's population. It will provide food and employment by irrigating 1,800,000 ha, half the irrigated area of California, with similar growing conditions. Gujarat's share of the hydropower—1,450 MW generated by the SSP and 1,900 MW generated by the Narmada Sagar Complex (NSC) located upstream in the state of Madhya Pradesh—will produce large amounts of environmentally clean energy for the rural and urban regions of the state. This water and power will be the foundation for rural development and employment that will stem the current "distressed migration" in the state. Similar benefits will accrue to the other basin states.

The World Bank and several bilateral agencies supported the SSP facilities for the first phase of the multipurpose Sardar Sarovar reservoir and the extensive water-distribution system it serves. But an evaluation of the first phase of the SSP project and the appropriateness of this support requires an understanding of the larger interstate basin program and the linkage of Sardar Sarovar with the other basin features provided under that program.

The Narmada River, the fifth largest in India, flows for 1,300 km through one of the poorest regions of India. Extreme poverty and poor health are endemic. The rapidly expanding population, common to India's poor regions, has already outstripped the available land and water resources. The watersheds have been deforested for fuel and subsistence farming. The large portion of Madhya Pradesh and all of Gujarat that will be served by the Narmada development—40,000,000 people today and many more millions by 2010—is without adequate water or electrical supply, and conditions worsen. Most of the inhabitants depend on rainfed agriculture in a zone vulnerable to frequent and severe droughts and famine.

Against these appalling circumstances, the three primary basin states and Rajasthan spent several decades examining alternative schemes for the comprehensive development and management of this resource to best meet their social, economic, and environmental objectives. Most urgent was the need to supply clean domestic water to cities and villages, irrigation water to farming communities, and electrical energy to prevent the relocation to overcrowded urban centers of tens of millions of rural people living in abject poverty. As India's National Commission on Urbanization report of August 1988 stated: "Since the recommended policy is to reduce the flow of migrants to the bigger cities, viable strategies must be conceptualized for these rural districts to develop."

The widening distress from inadequate water for drinking and washing was reflected in thousands of deaths annually, accelerating the migration of people to the cities. (During the 1980s, Gujarat spent almost US$1 billion to bring water to the rural areas during droughts. Nevertheless, thousands lost their lives and tens of thousands migrated to adjacent states seeking food and water for their livestock, losing their property and personal belongings in the process. Such migrations occurred not once, but repeatedly, from the periodic droughts and famine.) At the same time, India's agricultural production was leveling off, making it even more difficult to find food and fiber by viable, sustainable means. Given the present and future conditions, it was unconscionable for these states and India to tolerate the human and social costs of delaying the productive use of the Narmada resources.

Under an interstate treaty, the basin states plus Rajasthan agreed on: (1) How the basins' water would be allocated; (2) the detailed configuration of a multipurpose development plan to harness the resources efficiently; (3) interlinked ownership and financing of the key basin features costing billions of U.S. dollars; (4) real-time water-operations criteria; and (5) interstate and intrastate institutional arrangements for overseeing and coordinating the development and management of these resources. The basin development and management scheme represents all the features of wise management of water resources that are sought today: a comprehensive basin development and management plan, a binding interstate agreement for execution, institutional and financial arrangements for sustainability, and unquestioned local ownership of the undertaking. The Narmada Basin Development plan, certainly the most well-conceived and the largest in India, should serve as an example, like the renowned Tennessee Valley Authority development, of an ambitious, but efficient way to uplift a large poverty-stricken region.

On finalization of the basin agreement, the states sought international participation in the basin development. Concurrent work on the SSP and the upstream NSC was launched to bring the basin program forward in a manner consistent with the interstate agreement and its goals. In addition to technical assistance, Madhya Pradesh obtained advice on creating the Narmada Valley Development Authority (NVDA) to manage its portion of the basin. The proposed construction staging of the NSC would make the NVDA and its development program essentially self-financing. Indeed, the NVDA adopted the policy that a percentage of the revenues from the basin's hydropower would be dedicated to funding reforestation and improvement of the watershed.

There has been mixed success in implementing the early stages of the SSP. The new technology in design, construction, and operation, and the organizational adjustments introduced on the project will yield valuable and widespread benefits in service and sustainability. Construction progress has been satisfactory, particularly when compared to results on smaller, simpler undertakings. Stable and effective institutions have been created that will complete and manage the development. The state has sold bonds on the market to help financing. But, unfortunately, interruptions in international funding have delayed completion and the realization of benefits, prolonging the terrible suffering of the region's poor.

Delays in relocating people displaced by the reservoir and incomplete description of environmental concerns in project documents pertaining to the SSP brought severe pressure on the states. In part these problems evolved from the lack of formal procedures in the early 1980s when the project was prepared, a situation aggravated further by initial problems with instituting new untested policies and approaches, called for by the lenders, statewide in each of the affected states. Eventually, these problems and the international condemnation of the SSP caused the severance of international assistance for the entire basin development program.

The negative issues in relocating 100,000 inhabitants from the reservoir area completely overrode consideration of the positive benefits the basin development would mean to 40,000,000 people. Of all the benefits, perhaps the most ironic is that the project was expected to bring a halt to the massive, desperate migrations to the cities. Though the country will now complete the development without outside participation, the delays will cause untold misery and loss of life within the states, forego the early benefits of clean power, and exacerbate the degenerating environments in cities and marginal rural lands. It is truly sad that the states and outside assistance agencies could not work out the remaining differences in a timely manner to avoid the resulting disruptions in completing the program.

Indeed, by extremely distorted reports that are repeated without being questioned, opponents have gained the power to attack all projects in developing countries (Zagorin 1994). The water crisis will not be solved nor will the environment in these countries be protected by this approach.

CONCLUSIONS

The most fundamental changes in what are considered normal conditions for the world's water resources will occur in the next decade and thereafter. The world's environment, not just its waters, will be impacted in dramatic ways. The economics and social conditions of many developing countries, and even the stability in some, will be altered permanently.

The world can no longer afford divisive unproductive debate concerning these matters. The developing countries and their people need and must be given steady constructive help by the international community. Reports promoting concepts inappropriate to conditions in the specific country, shallow reviews of its current programs, or arrogant directives only interrupt a country's efforts to deal with its pressing problems. Most countries will welcome help, but only if it is practical and based on comprehensive analysis of all information, including an in-depth understanding of their specific situation. After all they have to live with their decisions!

Accordingly, the thrust of the international community's efforts should be adjusted. It is urgent that all professionals working in the water-resources field and all responsible political leaders and respected figures in the world community clearly and aggressively articulate the situation and realistic solutions—in terms everyone can understand. Rational analysis, knowledgeable debate, and sound counsel on immediate actions are imperative; however, any proposed solution to be useful must address all four interdependent constraints—time, water, funding, and drought-management options. And whatever actions are proposed must meet the near-term crisis and equally well ensure the most sustainable positive conditions over the long term.

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