Water-Related Limitations to Local Development

Round Table Discussion

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Seven international water experts were asked to discuss certain fundamental water-management problems. It was agreed that water shortage is a medium-term constraint requiring attention when deciding on policies for economic development within the resource base. Wise policies include best use of local rain, a top level national water authority, and transport of food rather than water. Point disposal of toxic wastes should be considered a deliberate illegal act. Since treatment technology is generally available, the main problem is unwillingness to bear the cost. Water pollution originating from land use is best met by merging land-use and water-management policies. The present tendency to meet growing domestic or international water disputes is by negotiation rather than by confrontation. Critical to the problems discussed is to ensure that decision makers and the general public have an adequate understanding of mankind's long-term dependence on life-supporting systems, and of the fundamental role of the water cycle in these systems.

POINTS DISCUSSED

INTRODUCTION

The tenth anniversary of the UN Water Conference provides an excellent opportunity to address some of the main water-related problems that have presented themselves during the past decade. Indeed, as some problems have been solved, other more serious problems have developed, mainly due to both over- and underexploitation of the limited supplies available to human activities, to the mobility of water, and to population increases, which increase the stress on the hydrologically limited water availability (Figure 1).

Ten years after the special AMBIO water issue, which appeared in 1977, Professor Malin Falkenmark, Rapporteur General of the Mar del Plata Conference and scientific editor for AMBIO's water issue was requested by AMBIO to address—together with a group of invited experts—a few selected issues. The issues to be discussed were seen as particularly crucial in a medium-term perspective of about 20 years. Special attention was given to the main lessons of the past and to the most realistic ways to proceed in the near future.

THE WATER BARRIER FOR SEMIARID DEVELOPMENT—A REAL OR INVENTED PROBLEM?

Falkenmark: The number of individuals that society can successfully support on each flow unit of water depends on many factors among which are climate, patterns of water use, technology used and water management capability (institutional and administrative) (Figures 2 and 3). Some scholars claim that population growth drives countries with low per capita water availability towards a water barrier, which will make it increasingly difficult to satisfy further water demands, but others disagree with this concept. Israel may be close to this barrier already —by means of advanced water management 2000 individuals are supported on each flow unit of one million cubic meters per year. Population growth, together with water-consuming agricultural development, appears to be pushing Poland towards the same barrier.

Other scholars claim that there is no definable barrier for water scarcity, provided management practices adequately reflect the situation. Water needs will then automatically be matched with water availability.

A dry river bed in Botswana that remains a source of groundwater. Photo: U. Simonsson/Tiofoto.

For the semiarid developing countries, where populations are expected to double within the next few decades, the general goal of self-sufficiency in food production may be inconsistent with the dependence of semiarid agricultural techniques on irrigation.

How serious is this problem in the African countries facing rapid population growth? Will water management practices be helpful in attaining self-sufficiency in rainfed agricultural production? What will be the consequences of intensified rainfed agriculture for the water supply?

Water Availability A Medium-Term Barrier for Local Development

Rogers: If an arid country decides that it has to produce its own food, then it will immediately come into conflict with a shortage of water available for irrigation. In the past humankind has always lived within the limits of locally available resources. If a population grew to such an extent that it began to overstress the resource base, part of the population migrated or was forced out to areas where there were adequate resources.

It is only since the last century, with the rise of nation states in many parts of the world, that this is no longer easily possible. The only realistic alternative now appears to be development *in situ*. However, the population carrying-capacity of a desert is very low, unless one is able to bring in resources such as water from the outside. Man has been very creative in engineering such solutions as evidenced by cities such as Los Angeles, California, and Phoenix, Arizona.

Biswas: The concept of "water barrier" is as invalid today as the thesis "limits to growth" was invalid in 1972. While there may be a theoretical barrier at any one specific time in any specific region, this barrier is a function of many variables, among which are technology, institutions, level of education and training, economic factors, social and psychological norms, standard of living, elasticity of demand, and a variety of other factors. As is the case for any resource whose usage depends on a multitude of interconnected factors, which change with time, the concept of any "limit" or "barrier" is purely hypothetical and static. In terms of management and efficient water use many alternatives are always available, some of which may be more palatable and less complex than others.

The statement that Israel or Poland or any other country are near a "barrier" to development due to water scarcity is difficult to accept. In both countries, water management practices can be made significantly more efficient than they are at present, and one can certainly question the presently "sacrosanct" use patterns. *Politically it may be a difficult process, and it may create short-term perturbations, but for the long term, there are solutions.*

Self-sufficiency in Agricultural Production is Not Always Feasible

Biswas: The concept of self-sufficiency in agricultural production in developing countries, or elsewhere for that matter, is neither a feasible nor economic solution. I do not know of a single country that is fully self-sufficient in agricultural production, that does not import any agricultural product whatsoever. Countries always trade with each other, not only in terms of agricultural products, but also with other products as well. I do not expect to see a time when all countries will be self-sufficient in agricultural production so that agricultural trade will disappear. What we can say is that countries should try to be as self-sufficient in agricultural production as warranted by social, economic, political and technical considerations. We cannot go any further than that.

Rogers: The conflict between population growth and available water is felt most keenly in many African countries. Telling people that "mother nature knows best," and that they should live in such arid regions without massive economic resources to sustain them, is of little help to the populations of these countries. It seems to me that in such settings encouraging farmers to get involved in widespread irrigation on the basis of the Asian model is not helpful either.

Real help would focus on devising ways in which the countries' growing populations could participate in some form of economic development that would stay well within their water resource base. Such a proposal immediately raises the question of food policy, since the irrigation of food grains will

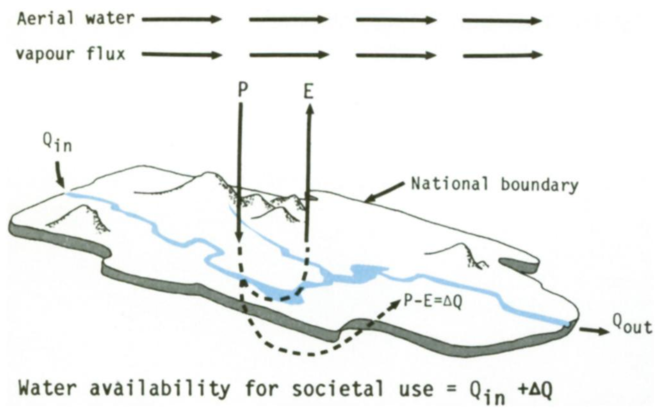


Figure 1. Endogenous water (△ Q) is generated in the country itself through precipitation (P), which in part returns to the atmosphere by evaporation and evapotranspiration (E) and in part feeds local aquifers and rivers which constitute the water available for societal use (P – E = △ Q). Exogenous flow (Q_{in}) is the water entering from upstream countries in deep aquifers and rivers.

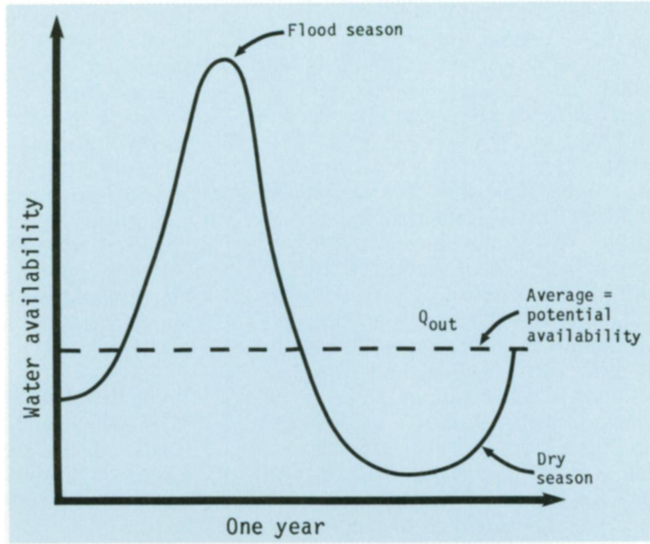


Figure 2. Water availability can fluctuate seasonally between one or several flood and dry periods. Figure 1 represents only part of the year-round water availability. In order to increase dry-season availability, surplus water from the flood season must be stored in surface or sub-surface reservoirs.

always remain a wasteful and nonoptimal use of water. Should a country put itself into the position of relying on imports from abroad for the bulk of its food supply?

Given the wild price fluctuations in the world grain trade over the past 15 years, many a prudent statesman would conclude that such a strategy is too risky. Looking back to only the last five or six years of the international grain trade, on the other hand, one could arrive at the opposite conclusion. From these same observations one could also conclude that *the best thing that the world at large could do for our brothers and sisters in arid countries would be to ensure a stable international grain trade.*

Internationally controlled foodgrain stockpiles were proposed by a number of people and institutions shortly after the UN's 1974 World Food Conference. The general consensus that emerged in the early 1980s was that the grain market left to itself could take care of the problem—which it indeed did fairly well. I believe that the future outlook is even better. The grain trade now has more suppliers than previously, with countries like China and India starting to market small quantities of grain. With more geographically dispersed traders the risk of a major shortfall is reduced.

What is now needed is to introduce some form of market stability for both suppliers and purchasers. The obvious and the cheapest way to achieve this is by strengthening the current market mechanisms. If for instance long-term future contracts were available, then, for a small premium, food-grain importing countries would be able to look to stable food prices for several years in the future. Not only would the consuming countries benefit from such a system, but the food producers would also greatly benefit from long-term stable prices.

Long-term futures for food grains (or "long-term contracts," if "futures" look too much like a gambling casino) may seem to be an odd way to "solve" the water problem, but I do not see any other economic means of locating or importing the large quantities of water

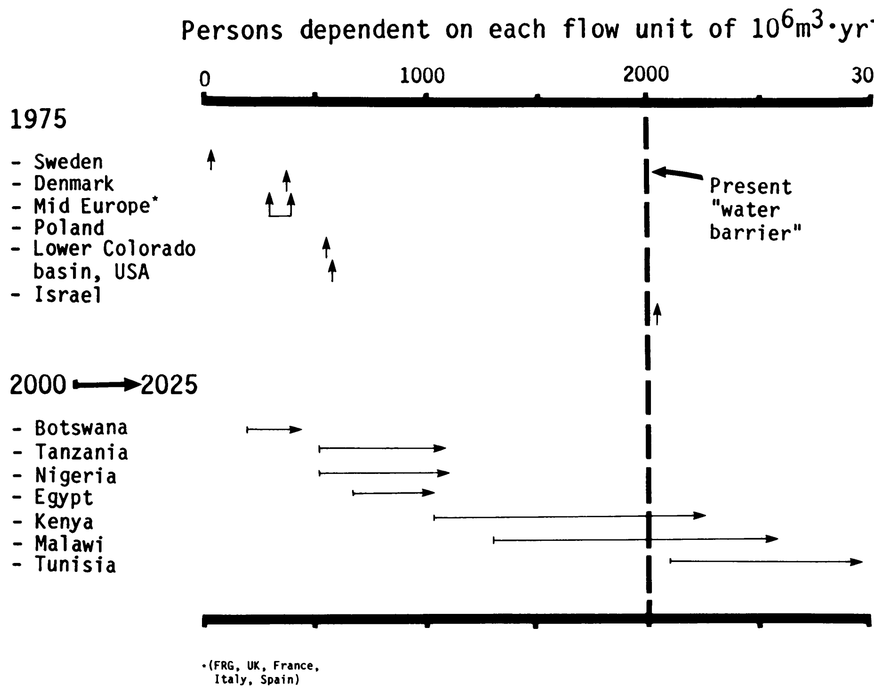


Figure 3. Levels of water consumption in selected countries in 1975 and forecast for the years 2000 and 2025. Water consumption level is the potential water availability (Q_{out} in Figure 1), divided by the population, i.e. the number of individuals jointly depending on each flow unit (10^6 $m^3 \cdot yr^{-1}$) available from the water cycle. The "water barrier" represents the maximum consumption level under conditions of advanced technology and administrative capability (2000 persons/flow unit). In poorer countries the water barrier may be much lower (10–20%) especially if seasonality (Figure 2) plays a major role.

(as much as 3000 tons of water per ton of grain) needed to produce food grains in many arid countries.

Removing the need for such large quantities of water removes the "water barrier" in all countries. The above proposal does not imply that the countries should give up all agriculture, but rather that they *should concentrate on highly valued and low water-using crops for both domestic use and export.* Remember that in agricultural countries agriculture is often the only significant source for generating the economic surplus necessary for development.

Problem of Reversing an Existing Policy

Rogers: Water use in all societies is inextricably embedded in the origins and development of the local culture. Since water is a "fugitive resource," how it has traditionally been appropriated or alienated by different social groups determines, to a large extent, the patterns of current access to water in the society.

For example, in the western states of the US the first major users of water were miners who needed large quantities of water, at a distance from the rivers, for hydraulic mining. These miners lived under the anarchic system of the "wild west" and were largely left to their own devices with respect to legal codes. In this almost Hobbesian world he who got to the water first could claim the right to it—provided of course that he had the force to exercise his claim. This practice has led to the doctrine of "prior appropriation" of water rights in all of the states west of the 100th meridian. The subsequent gradual encroachment by federal and state authority on these rights has resulted in a complex system of water laws that makes "rational" economic models difficult to apply. In most governments around the world politicians show great reluctance to tamper with the common view of water being a gift from God that ought to be supplied to all users at the lowest possible cost. In the isolated cases in which serious attempts were made to raise the cost of supply closer to its economic value, the politicians who initiated the change did not survive for very long. For example, a recent study in the United States documents the *rapid recall of the entire city council of Tuscon, Arizona, by an enraged electorate after the council had had the temerity to raise the costs of the municipal water supply in that desert city to the level of water charges in Boston* (a notoriously damp city).

Another example can be cited from Beijing, China, which is governed under a quite different political system. There we see the politicians unwilling to recommend the reallocation of water away from agriculture, including wasteful wet-paddy rice cultivation, which consumes more than 80 percent of the metropolitan area's water that could be put to much higher-valued industrial and domestic uses. They are willing to make, and apparently able to survive, substantial raises in the cost of the relatively small amount of water that is available to industry and to domestic users. But, they are not willing to do the same with respect to agricultural users who use the greatest quantity of water and pay the least. In this case they are captives to one of the very powerful symbols and myths from China's recent past—the ever present specter of famine.

In addition to legal contexts, which vary from society to society and—as the US demonstrates—sometimes from one part of a country to another, there is an almost universal feeling that water is somehow "different" from other resources. The "water-is-different" syndrome has deep and murky roots in all cultures and religions. Water is essential for life—but so is food, and heat for those who choose to live in cold climates such as Sweden or parts of North America. The idea in most cultures is of water as a "gift from God," and as such it is considered immoral to exclude anyone from using it. It is strange that in many cultures this "gift from God" argument does not apply to land—perhaps because land is not fugitive! Other necessities such as food and heat are items that man himself must work to produce.

Biswas: As to the second aspect of the issue, pricing, this is not a simple problem either. As a result of social, economic, institutional and political reasons, pricing has not played a significant role in developing countries. Cost recovery from water projects in developing countries has not worked thus far, but then large farmers in California do not pay the full cost of water they use either.

Water Shortage May Be Limiting Also in Large Cities

Kovacs: There are two cases where water shortage may indeed be a limiting factor for future economic development:

- Large cities and industrial centers in arid regions having very limited endogenous resources and without exogenous water, where development has been forced by the presence of other natural resources regardless of the availability of water (e.g. oil development in the Gulf countries).
- Arid regions where the food supply of the increasing population can be ensured only by large irrigation schemes (e.g. the Sahel zone).

In these cases pricing policy is only one possible tool, but sustainable water management requires application of the complete arsenal of water resources control (e.g. desalinization of seawater as a form of quantitative control, and the reuse of wastewater for irrigation being a part of quality control).

In the second case even such complete control cannot provide an economic solution, because irrigation requires large amounts of water and its availability can be ensured only by large investments. The price of food produced in such systems exceeds several times the reasonable prices of the world market. It is necessary, therefore, *to investigate whether the efforts to achieve self-sufficiency in food supply in such regions is reasonable, by comparing the relative cost of food transport with that of water.*

OPTIONS FOR MEDIUM-TERM SOLUTIONS TO CHRONIC WATER SHORTAGE

Falkenmark: Large areas with chronic water shortage have semiarid climates, the year alternating between a rainy season and a dry season (Figure 2). A key measure in water resources development is therefore water storage, whereby the wet season surplus can be stored and used during the following dry season. The storage options vary with the locality, smaller schemes being adequate higher up in the river basin, whereas larger projects are called for in downstream parts of the river. The size of the reservoir will be defined by the size of the flow, together with its annual and interannual fluctuations. The fact that surface water reservoirs imply

large water losses to the atmosphere has directed increasing interest towards subsurface water storage.

Especially interesting in the medium-term perspective, where no extravagant macro-projects are available in the most drought-prone poverty-stricken rural areas is the potential for water conservation projects. This is a traditional method in some areas, involving the collection of rainwater from a certain area conveying it to a percolation pond where it may infiltrate. The water is stored as groundwater and made available through wells. Especially successful seem to be projects—like the Naigaon project in Maharashtra state in India—where the water allocated to the users is based on the size of the

Indian field irrigation. Photo: T. Arvidson/Tiofoto.

family, not the size of landownership. A maximum limit per family might even add a component of family-control incentives.

What are the prospects of these and similar solutions in different parts of the semiarid and arid zone? What are the main problems involved and how can they be solved?

Conservation of Irrigation Water

Biswas: The issue of water conservation is very narrowly defined here, and is basically limited to rainwater harvesting. Surely the most important task in water management facing developing countries at present is how to use irrigation water more efficiently since more than half extracted at present is now being "lost." In many cases, only about 30 percent of water extracted reaches the agricultural fields. Since irrigation uses some 80 percent of all water used in the world, the total quantity of water that could be made available for further use by more efficient irrigation management is tremendous. Yet enough attention is not being paid to make irrigation management practices more efficient. The scope for water conservation in this field is tremendous.

Rogers: As I outlined under the first question above, the major response of the water system will depend on the policies implemented with respect to irrigated agriculture. Small percentage changes in irrigation-water use will lead to very large increases in the total water available for other uses. Countries already engaged in irrigated agriculture can almost certainly and relatively easily improve the efficiencies of their water use by 20 to 30 percent.

In countries without substantial amounts of irrigated agricultural land, the best strategy will be to *encourage farmers to develop only those techniques that conserve water*. A large international effort to encourage this sort of behavior by governments as well as farmers is currently being spearheaded by the International Irrigation Management Institute (IIMI) in Kandy, Sri Lanka. The relative importance of management versus technology in achieving high levels of water conservation is being stressed in IIMI's work.

Wastewater Reuse Possible

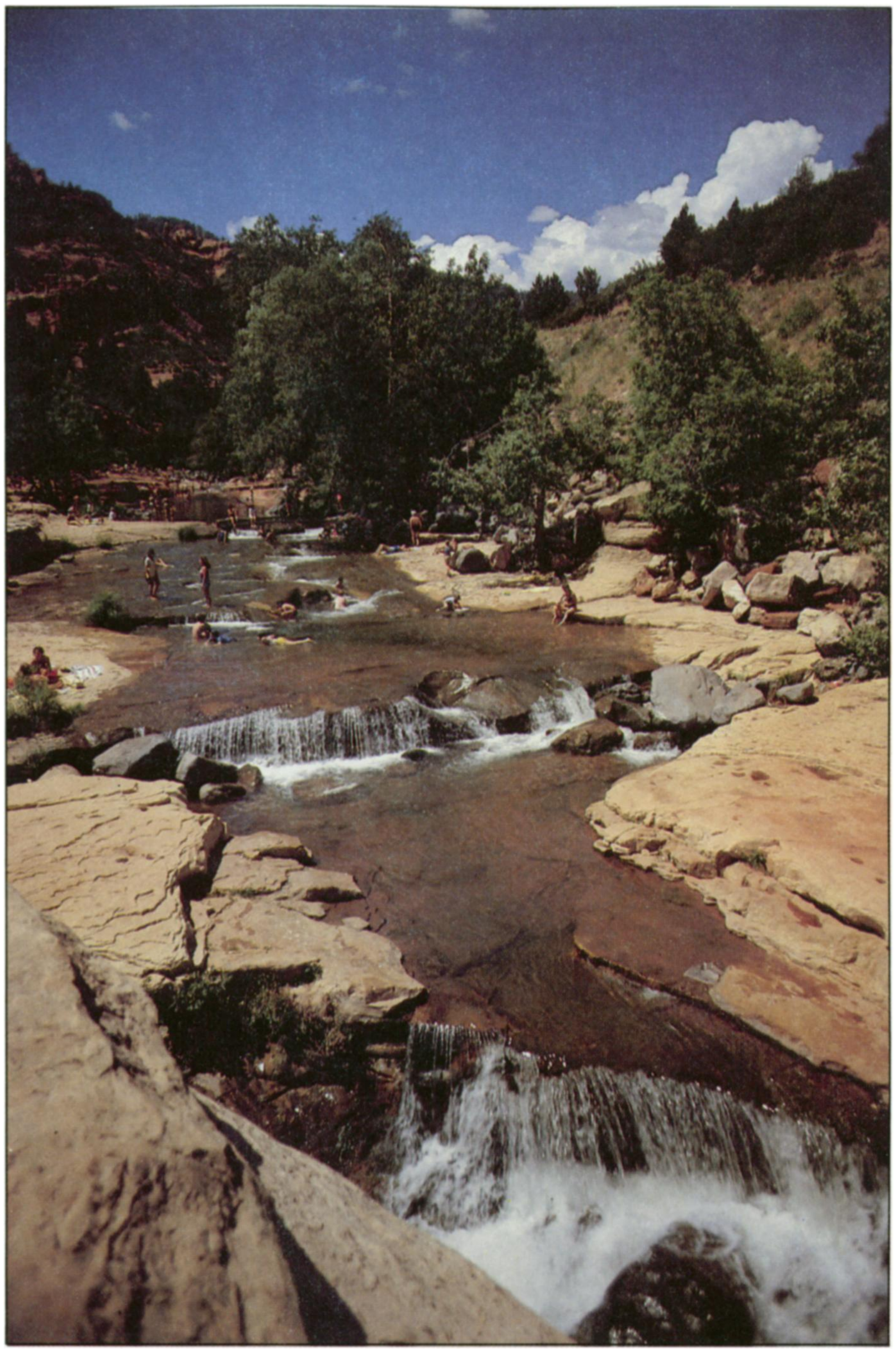
Shuval: The reuse of wastewater from major urban centers for agricultural irrigation, greenbelts, or industrial use can prove to be a highly effective strategy for increasing the water resource potential while reducing environmental pollution.

In Israel, total wastewater reuse is now the declared national water policy. Some 30 percent of all urban wastewater is currently being utilized mainly in agricultural irrigation. This has resulted in an increase in available water resources and has reduced pollution of streams and coastal recreational areas. Irrigation with wastewater has the additional benefit of supplying all of the nitrogen, and most of the other nutrients normally required by agricultural crops.

In countries such as Israel with a long dry summer season, large interseasonal wastewater reservoirs have proved to be effective in increasing the amount of water available during the irrigation season.

Recent studies by the World Bank (1) have provided a sound basis for wastewater irrigation practice while effectively controlling health risks. In general the report has shown that many current health regulations concerning wastewater irrigation are overly strict. The study has resulted in the development of more liberal irrigation standards which should provide a rational basis for simple, practical wastewater reuse in developing countries (2).

The World Bank study points out that the conventional wastewater-treatment technology mainly used in the developed countries is expensive to construct and operate, and less effective in pathogen removal than are simple, robust oxidation pond systems, which are particularly suited to developing countries. This is a good example of simple, low cost technology which is actually more appropriate and suitable than so-called conventional equipment, energy intensive technology.



A high desert resort at Oak Creek Canyon, Sedona, Arizona.
Photo: C. Ehlers/Tiofoto.

Developing New Water Resources

Rogers: Even though it is almost always cheaper to conserve water than to provide new sources of water, it may not be possible to find enough water by conservation alone. Under these circumstances new sources of ground or surface water must be developed. In many places developing groundwater storage may be more than one-third less expensive than developing surface-water impoundments.

In addition, good surface-water storage sites are becoming harder and harder to find as the best sites are rapidly being developed. Also, all surface impoundments in the tropics cause very severe impacts upon the local and regional environments. *The environmentalists are mobilizing on a global scale to stop many proposed large dam projects.* One does not even have to argue the merits of specific cases anymore; it is simply becoming increasingly difficult to obtain international funding for large dam projects anywhere in the world, regardless of particular countries' political and economic systems.

Underground storage is cheaper, much more environmentally benign and—more to the point—is in many cases the only significant storage potential that has not yet been exploited. Some recent work indicates that there *may also be significant storage potential in deep fractured rock.* If this turns out to be the case then many arid countries will have the potential to create substantial water supplies for nonirrigation purposes.

Kovacs: The comparison of the impacts of small and large reservoirs stating that, "small is beautiful" is a misleading concept. The utilization of large exogenous water resources requires the construction of large reservoirs, while the small reservoirs serve the quantitative control of local endogenous resources. The combination of surface and groundwater reservoirs (the conjunctive use) depends also on local conditions. The final purpose of water-management policy is always the determination of the optimum combination of the various controls depending on the local conditions of the region.

Some Suggestions Based on Japanese Experience

Ishibashi/Hori: Taking into account the apparent differences in the natural and socioeconomic conditions that exist between semiarid areas and Japan, there seems to be little for us to suggest in response to the given series of questions.

The following points could, however, be useful for people living in semiarid areas. These have been chosen on the basis of lessons from past and present Japanese experience.

a) For Farming Areas (Paddy Fields)

- Integrate water intakes for irrigation and shift the location of such integrated intake further upstream.
- Replace sandy paddy soil by more clayey soils.
- Supply irrigation water only intermittently.
- Pump underground in areas remote from rivers.

b) For Towns and Cities

- Improve water-supply pipes to decrease water leakage.
- Pump underground water for both domestic and industrial use, taking into account eventual ground degradation.
- Promote recycling of water in factories.
- Promote installation of facilities to utilize rainwater as much as possible by improving roof and school playgrounds, which provide broad recipient areas for water storage.
- Separate or shift water-consuming industries from populous cities and towns.
- Try to inspire and maintain a water-saving spirit among citizens, parallel to efforts to establish administrative means for the adoption of a progressive water rate.

WHAT ARE REALISTIC WAYS TO PREVENT GLOBAL SPREAD OF LARGE-SCALE WATER POLLUTION?

Falkenmark: Some of the large surprises of today originate from the mobility and chemical activity of water in the atmosphere and in terrestrial branches of the water cycle. As a consequence, human activities in one locality are transformed into water quality responses and higher-order effects elsewhere.

The poor general understanding of this dimension of water-related issues has made it possible for decision makers to neglect future negative feedback on the natural environment, although the principal outcome of slowly operating hydrobiogeochemical systems has generally been foreseeable. Still, today there appears to be an impasse in regard to the more general pollution-reducing measures—except in the case of a few substances which have already been proven to produce damage. Pollution problems still tend to be taken seriously only in retrospect. When the general public becomes concerned enough over widespread and alarming effects, the available "solutions" that remain might simply be the creation of high-level committees. The problem facing these committees is the difficulty in finding countermeasures for pollution generated decades ago and already mobile in soil layers, subsurface aquifers and slow-reacting ecosystems.

The general tools needed to predict the water-related or water-propagated responses from a certain land-based activity have not emerged from the environmental research of past decades, as this research has been effect-oriented rather than mechanism-oriented. We are not yet prepared to define, at an acceptable level of precision, the time delays involved in such slow systems, or the expected response delays to the source-reduction measures proposed.

What are the real problems behind the impasse? What is the time scale involved in today's decisions on polluting activities? Is there a way to pay more adequate attention—from the perspective of the next generation—to permanent damage to water resources, resulting from the present decision-making trade-off between long-term costs and short-term benefits in terms of economy, employment, etc?

The Most Serious Problem is Hazardous Waste

Biswas: Only a negative stance is taken here. Lake Erie and the River Thames, both of which were pronounced to be "dead" in the late sixties, are now "alive" again. India now has a major program for cleaning up the River Ganges. We are winning some battles but losing others. A real problem facing us at present is the environmentally-safe disposal of hazardous wastes and to ensure such wastes do not contaminate various sources of water. This is an important problem in many developing countries, but so far not enough attention has been paid to it.

Kovacs: In many regions the most serious problem hindering the utilization of water resources is the deterioration of water caused by pollution. From the point of view of the qualitative control of water resources three different types of pollution should be distinguished:

- *Point-source pollution*, the elimination of which requires the development of efficient technologies of sewage treatment. In many cases —especially when the purpose is not only the maintenance of the self-purification ability of the recipient, but also the protection of water bodies against eutrophication—even the application of tertiary treatment is needed. In general, the necessary technologies are known, only the high costs of treatment cause problems.
- The protection of water against *non-point-source pollution* is a more difficult task, because of the disperse character. The development of environmentally sound agricultural and forestry management and the pollution control of urbanized areas provide the most reasonable tools to protect the water against disperse pollutions. Land-use and water-management policies are, therefore, interrelated and inseparable actions.
- *Accidental pollution* has recently caused very serious damage. Because of the random character of this type of pollution elimination of the impact cannot be planned in advance. Considering, however, that in large river basins, located in industrialized regions, the number of such incidences may be as high as several hundreds, it is reasonable to organize specialized teams to locate accidental pollution and to minimize undesirable impact. The preparation of strategies for such protective teams can be facilitated by simulation, using models of various kinds of pollution accidents. This can be carried out along different stretches of the river systems to study the propagation, dispersion and chemical reaction of the pollutants.

Pollution a Deliberate Crime Rather than a Surprise

Rogers: I maintain that there are very few surprises in what has happened with regard to the widespread pollution of our water resources. If one reads carefully the literature of the 1950s and the 1960s one finds warnings about what was going on. More to the point, however, *one simply cannot believe that trained chemists and biologists could promiscuously dispose of known toxic materials directly into the environment and claim that they did not expect any damaging effects*.

The chemical companies knew exactly what they were doing in Love Canal. See how carefully they made sure that the property was transferred to the local townships at bargain prices, and with instructions as to what they could and could not do on these lands. These instructions were readily ignored by the laymen politicians—but even they should not have been surprised by what happened, given the warnings provided to them by the chemical companies.

Orphaned landfills, midnight dumping, and unauthorized discharges from industry and municipalities leaching into ground and surface waters are not surprises, they are deliberate crimes committed against the population at large. In no way should the environmental movement provide excuses for the people who have committed these crimes by calling them "surprises."

Of course, vindictive pursuit of the criminals should not become the sole focus of the government agencies dealing with environmental protection. These agencies should devote most of their attention to making sure such environmental abuses do not occur in the future. The goal should be to internalize the external damage caused by a

Potable water in mountain streams characteristic of northern Sweden.
Photo: R. Andersson/Tiofoto.

polluter. Simply saying that "the polluter pays" is not the only way to deal with this problem. There are a number of creative ways of allowing polluters to trade effluents in such a way that the overall impact of waste diposal is less, at lower economic costs.

Crucial Policy Tools to Stop Pollution

Rogers: The best way to stop the pollution of the aquatic ecosystem which is becoming widespread over the globe is to stop it! Many of the persistent contaminants that end up in the ground or surface waters should never have been disposed of directly into the environment in the first place. We know that it is much easier and cheaper to deal with waste products in a concentrated form, i.e. before they are diluted in the water environment. Therefore, we need to use all possible means to avoid contaminating the aquatic systems in the first place. Bill Martin of Arizona State University suggests the *three Ps, Preachments, Politics, and Prices as the policy tools to control water use*. Preachments appeal to people's better nature, politics ensure that the tradeoffs between groups are reasonable and set out the legal frameworks for enforcing water quality, and pricing ensures that the most efficient incentives are used to send the message. Pollution can be effectively controlled only if all three of these policy tools are used.

WATER AS A CONFLICT-CREATING ISSUE

Falkenmark: Pollution generated in upstream countries may involve severe degradation of the water resources of downstream countries. Europe provides numerous examples of polluted international rivers. In The Netherlands a private water tribunal has been established, using public exposure via mass media as a powerful disincentive for cynical polluters.

International conflicts are inherent even in cases where upstream states, in water-short regions, plan or execute water withdrawals from the river, causing problems for downstream states. The UN International Law Commission is extremely slow and inefficient in developing the code of conduct for shared water resources so eagerly called for by the 1977 Water Conference in Mar del Plata.

There are also other kinds of water-related conflicts of a regional character, one instance being when water-short states claim the right to demand water to be transferred from better endowed states. Even if continental-scale water transfers, eagerly discussed as feasible solutions during the 60s and 70s, seem to have vanished from the present agenda, medium-scale water transfers seem to have retained their relevance.

Disputes are going on, or are latent, in many regions between surplus and deficit states and between polluting and polluted states. What are the present prospects and problems of the water transfer technique as such? What set of really powerful incentives/disincentives will provide constructive solutions in a 20-year perspective of international water conflicts?

Water Scarcity may Generate Both Intranational and International Disputes

Biswas: It is true that globally there are 214 international river and lake basins which are shared by two or more countries, and water quality and quantity management in these systems has always been a difficult process. As the demands for water increase, there are likely to be more conflicts in the future.

While it is not possible to forecast the future accurately, it is unlikely that serious conflicts between countries will develop on a large scale because of water scarcity only. On the basis of my own analyses, what may happen is that if the existing relationship between countries sharing the same water system is poor, potential conflicts over water may further aggravate the situation. As far as water transfer from deficit to abundant regions is concerned, the potential of intracountry transfer is much higher than intercountry. Even for intercountry transfer countries like Canada or India where provinces have the main juridisdiction over water, resolution of conflicts over water-sharing and pollution prevention is not an easy task.

Rogers: Water diverted from aquifers or streams for consumption or other uses, or polluted water returned to a stream or an aquifer, will almost always cause some conflict between users or potential users of the resource. These conflicts do not necessarily have to be international conflicts. Many of the most vicious water conflicts have arisen within national boundaries between different regions or groups. The nature of water as a fugitive resource, and the nature of the current technologies for water supply, water use, and wastewater treatment cause these conflicts.

Domestically, government policies toward resource use and environmental protection are meant to ameliorate these conflicts. Depending upon the country and the particular circumstances, such policies have been more or less effective in achieving conflict resolution. However, it is in the international setting that there appears to exist little effective international law and few regulatory institutions. Hence, much of the discussion of conflicts focuses on these international cases.

Negotiation Rather Than Confrontation

Rogers: If one examines what has recently been happening in Europe and North America in domestic settings, one can be more optimistic about the future of the international issues. In the US we have recently seen a movement away from confrontation (which had usually occurred in the courts) to negotiation and arbitration on many environmental and resource issues. This change stems from a gradual realization that under the confrontational mode of operating nobody wins, except perhaps the lawyers.

Now it is common for all parties to an environmental dispute to work together to keep the issues from degenerating into unreconcilable differences. *Most law schools and planning departments at US universities now offer courses in environmental negotiation.* The attempt is to get only the afflicted parties together, rather than using the usual regulatory approach of considering all in the polity as being interested in all issues.

In the international setting this concept has major implications for the modalities for resolving conflicts over water-resource use. First and foremost, it stresses bilateralism or restricted multilateralism: get only the most directly impacted nations involved in the negotiations. Second, it calls for skilled negotiators from third countries or international institutions. Finally, it requires that the countries involved come to understand that it is possible to arrive at negotiated solutions under which all parties are better off.

I am fairly optimistic that many of the water conflicts we see today between nations can be resolved using the new approaches.

Disputes Over Dam Constructions

Hori: International rivers can be classified into three categories, i.e., the penetration type, the country-boundary type and the complexed type. Meanwhile, the purpose of dam construction is to utilize water for the consumptive use, the non-consumptive use and the complexed use. The above elements would affect both the natural and social environmental problems as well as the economic and political advantages and disadvantages of each riparian country when a dam is constructed somewhere in the river basin. Therefore, the difficulty in reaching agreements for dam construction arises because of differences of standpoint of the governments of the countries concerned. When the construction of a dam is programmed in an international river basin, each riparian government should try to identify its standing on these elements and then make efforts to predict probable environmental effects. It will be needless to mention that other aspects such as the study of benefits and costs should also be investigated, while trying to command an overview of the entire river basin project.

After examining predicted environmental effects, in addition to other general studies, the government can identify whether the project is acceptable as it is or whether it requires modifications.

Any development plan acceptable to one riparian country is not necessarily welcomed by others. It is, therefore, necessary to deal with the matter through negotiations between the countries involved and to determine an acceptable solution for each country. The success of such negotiations may only be achieved by mutual concession among the related governments. The best way to reach (an) acceptable solution(s) would be to organize an international committee, in which the issues relating to the environment should be given top priority.

Role of United Nations

Kovacs: The application of any form of water resources control—and especially the demand control—may create serious conflicts. Management of such conflicts is a difficult task even within a given country, and the difficulties are even greater in international basins. It seems necessary indeed to accelerate the development of a code of conduct for shared water resources as was urged at the UN Water Conference in 1977 at Mar del Plata. Any effort aiming at either the technical or the legal development of managing systems in large international river basins should be supported.

Biswas: The United Nations has played an important role in water management in developing countries, certainly much more than they are often given credit for. This in a sense is not surprising since there are many UN agencies working in developing countries. Very few individuals or organizations have a clear view of what UN agencies are doing as a whole in developing countries.

In this connection, it is worth mentioning the role played by the United Nations Environment Programme (UNEP) on the management of shared natural resources, especially water. With the assistance of governmental experts, UNEP has managed to draft a code of conduct for countries sharing natural resources like water. Through the personal initiative of the Executive Director of UNEP, Dr Mostafa Kamal Tolba, all the co-basin countries of the Zambezi Basin have got together in an effort to decide how best to develop the river for the optimal benefit of the countries concerned. The countries involved have now approved a common Zambezi Action Plan. Through this UNEP initiative, not only the countries sharing the Zambezi River are working towards a common goal but also bilateral and multilateral donors have been brought together to make that goal a reality by providing financial and technical assistance. Similarly the Indus River Treaty between India and Pakistan was signed mainly because the initiative and leadership of the then President of the World Bank. These two events clearly indicate that given the courage and proper leadership UN agencies can play an important role in the development and management of international water bodies.

Rogers: It would be extremely naive to imagine that either the UN system or the World Court will be able to resolve the water conflicts involving apparent national sovereignty any better than they have been able to resolve many other and much more pressing issues.

CONCLUSIONS

Water Shortages May Be a Temporarily Limiting Factor

There are five sets of conclusions. The first is related to water shortage as a constraint for development. The discussion on water-related limitations to semiarid development concluded that the water-barrier concept is basically theoretical and unnecessarily drastic. Even if water shortage is indeed a medium-term barrier to local development--especially in developing countries—there are numerous solutions for the long term.

Generally, water management practices can be made more effective, water losses can be reduced, and water-use patterns can be altered. The need for large quantities of water to support self-sufficiency in food production may be avoided once a stable international grain trade has been established. The present "water-is-different" attitude may be altered by stimulating people to take a more realistic approach to paying the real cost of society making water accessible for use. It is often easier to transport food than to transport water!

New Distinctions in Water Resources Assessment

The second set of conclusions is related to the planning needed to formulate efficient policies in order to address the problems under discussion. As pointed out by Kovacs, the two most important aspects to be considered are

- To make a distinction between local (endogenous) and transported (exogenous) water resources.
- To divide the users into two groups: the first where consumptive use is a high percentage of the total water demand (irrigation) and the second where this ratio is almost negligible (practically all other water users).

It is obvious that in an upstream subcatchment of a basin only water resources of local origin are available (surface runoff originating from and groundwater recharged by local precipitation). This endogenous resource, available with a given probability, provides the upper limit of freshwater demand that can be met within the region. With efficient quality control (the treatment of effluents) this amount would be made available several times in a consecutive series, although none of the users can receive a higher supply than the limit. Any demand exceeding the limiting amount can be covered only by applying quantitative control (storage or water transfer).

Along the lower stretches of a river collecting water from a large basin, the transported water arriving from the upper catchment—even the minimum of these exogenous water resources expected with a given probability—is usually several times higher than the freshwater demand of the users located in the region. Here only inadequate quality control, hindering the reuse of the discharge at a lower section of the river, or a large water intake not compensated for by a proportional release of effluents (e.g. due to transport to other basins or users with high consumptive use) may endanger the undisturbed supply of the users.

With these distinctions new principles in water resources assessment have to be *developed*. These new principles should separate the role of local and transported resources from the new form of water balance, and compare consumptive use to available water instead of total freshwater demand.

A clear definition of endogenous and exogenous resources is the first requirement. The next step is the separate statistical analysis of the availability of water for the two groups. In the case of local surface water resources, the determination of storage vs. yield relationship provides the planners with the most decisive information. To characterize transported surface-water availability, the probability distribution for low water discharges and the determination of the seasonal base-flow fluctuation are required. Base-flow calculation indicates the need to investigate the interactions between surface and groundwater resources. Such an analysis is indispensable, even in the case of regions that have only endogenous resources, to determine the optimum ratio of the conjunctive use of the two different resources.

National Water Authority

The third set of conclusions is related to the administration needed to realize an efficient policy. As pointed out by Shuval, a prerequisite for rational water planning and management, particularly in countries facing serious water shortages, is the establishment of a top level national water authority. This authority should be empowered to:

1. Carry out inventories of available water resources and monitor their use and quality.
2. Draft a long-term national water plan as well as short-term plans.
3. Direct budget allocations for the development of water resources.
4. Establish water policy including limitations on utilization of various ground and surface water resources; water prices, allocations for agricultural, urban and industrial development as well as recreational use.

It is important that this authority be independent of the economic interests of the various water consumers such as agriculture, and have as its long-term goal the development and conservation of limited water resources for the benefit of all sectors of the economy.

Water Conservation Potential

The fourth set of conclusions refers to various water conservation measures. These measures tend to be different under upstream as opposed to downstream conditions.

In *upstream* locations the only source of water is local rain, i.e. endogenous water. The wisest strategy would be to stimulate the best use of local rain in crop production and forestry, and for various water-dependent activities. Tactics include careful crop selection and maximum societal adaptation to the natural moisturize pattern of the local landscape. Soil conservation has to be integrated with water conservation in order to maximize rainwater infiltration, increase groundwater recharge, and reduce surface flow that causes erosion and rapid disappearance of flood flow. In other words to stimulate underground storage of any water surplus as much as possible by environmental management.

In *downstream* localities, also supplied by exogenous water from passing rivers, additional measures would add to water conservation. In irrigated areas with low water-use efficiency, much water could be saved for alternative uses simply by reducing unnecessary losses. Tactics include canal lining, altered methods for water distribution and application, measures to reduce seepage of excess water, etc. The traditional method used to stop seasonal excess water from leaving an area is water storage. The technique selected depends on the size of the flood flow. Even in downstream areas maximum use should be made of possibilities to store water underground. The technical options partly depend on the size of the flow to be stored. Soil conservation should secure maximum storage of endogenous flow. Exogenous flow could also be stored underground by allowing flood flow to inundate large areas and percolate to the groundwater aquifer.

Large flows have to be stored in river reservoirs behind large dams. Some major problems could be minimized or even avoided simply by better planning. For example, schistosomiasis is one consequence of poor sanitation, allowing disease vectors to reach a water body where they may be transmitted to individuals visiting that water area. Social problems involved in moving local populations from the area to be inundated by the reservoir are on the other hand unavoidable, but can be minimized by careful planning. It may indeed be seen as the price to be paid for increasing water availability during dry seasons and years. Problems affecting populations in neighboring countries have to be met by negotiations and mutual concessions.

In view of the importance of water conservation measures in water-short regions the present opposition from environmental groups against reservoirs is somewhat antiproductive. In highly water-stressed regions, there is no alternative way of increasing dry season availability of water than by storing wet season surplus.

Understanding Necessary for Awareness

The final set of conclusions refers to the falseness of the general hypothesis of safe waste disposal on lands and in waters. That this basic hypothesis of environmental planners in the past is entirely false has been amply proven during recent decades. The conclusion is that the time now has come to reverse this hypothesis. In other words no chemical substances should be allowed to transfer to the natural environment, unless it can be proven that they will safely decompose into natural components such as carbon dioxide, minerals and water. In such cases, society should be prepared to accept the ecological consequences of increases in these compounds.

There is also a massive need for broad education on the functioning of the biosphere and its main subsystems: the physical spheres (atmosphere, lithosphere, world oceans), the water circulation between and within these spheres (hydrological cycle), the chemical cycles, and the biological systems developing under different physicochemical conditions. The general public has the right to information on the way mankind depends, for sustainable existence, on a long-term balance in the life-supporting systems. This knowledge will force us to accept crucial constraints on our activities in order to secure the possibility of handing over well-functioning life-supportive systems to our children and grandchildren.

References and Notes

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