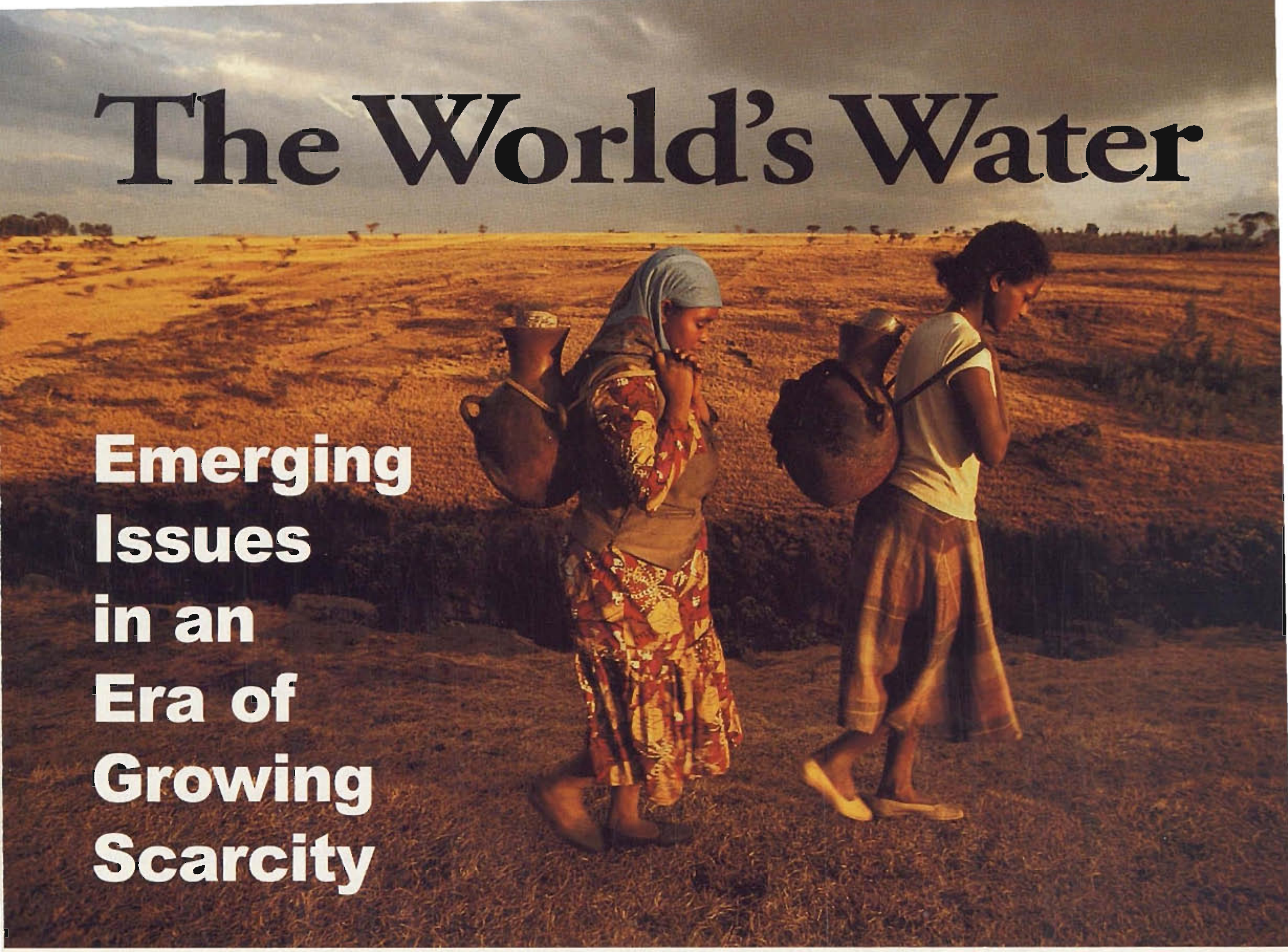
The World's Water

Emerging Issues in an Era of Growing Scarcity



by Randolph Barker, David Seckler, and Upali Amarasinghe

Until recently most people believed that we would always have enough water to grow food, to drink, and to support industry. At the turn of the century, however, many countries are entering an era of severe water shortage. Water scarcity will have a profound impact on the world's poorest people and could lead to global conflicts.

The International Water Management Institute (IWMI) has launched a long-term program to improve our understanding of water problems and to help guide irrigation development and related food security efforts as we move into the next century.

The nature and extent of water scarcity

In 1990 irrigation consumed or depleted over 70 percent of the total developed water supplies of the world. Many people believe that existing irrigation systems are so inefficient that most—if, indeed, not all—of the water needs of all sectors could be met by increasing the efficiency of irrigation and transferring the water saved to the domestic, industrial, and environmental sectors. Our analysis questions this assumption.

The IWMI study estimated irrigation efficiency (defined as the water required by the plant divided by the water withdrawn from a given source and delivered to the field) for each country in 1990 and projected high but not unreasonable levels for 2025. For the world as a whole, we assumed that the average efficiency increases from 47 percent in 1990 to 70 percent in 2025. Individual country estimates of irrigation efficiency provided the basis for two scenarios of water supply and demand in 2025. In the first "business as usual" scenario (S1 in table 1), we assume that the 1990 level of irrigation efficiency remains constant through 2025. In the second scenario (S2) we assume higher efficiencies. Even at this higher efficiency, more storage dams and reservoirs would be needed to achieve the projected 13 percent increase in withdrawals (water withdrawn to meet plant needs and cover conveyance, deep percolation, and other losses).

Assuming current irrigation technology in 2025, we project that total water withdrawals worldwide will increase by 56 percent over 1990 levels. If irrigation efficiency improved to our S2 level, water withdrawals for all purposes would increase by a much lower 23 percent.

We assume that annual water resources (AWR) from rainfall and rivers remain constant between 1990 and 2025. Floods to the seas, lack of storage, the need for discharges of water into coastal areas, and the like all reduce availability. Based on our experience, when total withdrawals exceed 50 percent of AWR, the cost of further development becomes prohibitively high. Countries with percentage withdrawals greater than 50 percent face an absolute water scarcity (last column of the table).

The country groups

Countries (except India and China) were divided into two groups according to the nature and degree of their projected water scarcity in 2025. In group I countries, total withdrawals are projected to exceed 50 percent of AWR. We say these countries face *absolute water scarcity.* In addition, we estimate that approximately one-third of the populations of India and China live in regions projected to have absolute water scarcity. We project that 1.8 billion people (living in the area shown in red in figure 1) will face absolute water scarcity by 2025!

By 2025, group II countries will face varying degrees of what we define as *economic water scarcity.* These countries have sufficient potential water resources to meet projected 2025 requirements. But many will need to embark on massive water development and management programs to augment and enhance available supplies.

We divided group II countries into three subgroups based on projected increases in irrigation withdrawals between 1990 and 2025 and assuming the high S2 irrigation efficiencies. For subgroup 1 (in yellow on the map), we projected withdrawals to increase by over 100 percent between 1990 and 2025. For subgroup 2 (green), projected withdrawal increases from 25 to 100 percent. For subgroup 3 (blue), projected withdrawal increases by less than 25 percent.

Subgroup 1 countries are mainly in sub-Saharan Africa. Countries in this region, comprising a population of approximately 350 million, will face the high cost of mobilizing annual water resources for both agricultural and nonagricultural uses. The countries in the other two subgroups will experience relatively less pressure on supplies, although competition for water will result in shortages and rising prices, particularly around urban centers where the demand is rising sharply.

In summary, we estimate that 2.7 billion people, one-third of the world's population, will live in regions that will face severe water scarcity (absolute water scarcity plus economic water scarcity) within the first quarter of the next century. However, the shortage of water will be pervasive, extending well beyond the semi-arid regions depicted in red and affecting even populations in well-watered areas. Expanding demand for water will drain some of the world's major rivers, leaving them dry throughout most of the year, including, we project, the Yellow River in China, the Cauvery and Ponnaiar rivers in South India, and the Rio Grande on the U.S.-Mexican border. Urban centers will experience periodic shortages similar to those experienced for energy. But the rural poor will suffer the most serious consequences. Many will lack access to potable water and to the quantity and quality of water needed for agricultural production.

Emerging issues

The growing scarcity and competition for water will dramatically change the way we value and utilize wa-

Table 1. Water supply and demand—1990 estimates with projections to 2025

Country	No. in Group	Population: 1990 (UN Medium) (Millions)	Population: 2025—% Increase from 1990 (%)	Domestic & Industrial Use: 2025 Total—% Increase from 1990 (%)	Irrigation Withdrawals 2025 Total—% Increase from 1990: (S1) (%)	Irrigation Withdrawals 2025 Total—% Increase from 1990: (S2) (%)	Indicators, 2025 Total Withdrawals: (S1) % Change from 1990 (%)	Indicators, 2025 Total Withdrawals: (S2) % Change from 1990 (%)	Indicators, 2025 Total Withdrawals: (S2) % of AWR (%)
		1	2	3	4	5	6	7	8
All countries	118	4,892	60	47	60	13	56	23	9
Group I	17	377	122	126	122	88	122	91	91
Group II									
Subgroup 1	24	348	157	350	157	105	191	148	2
Subgroup 2	35	777	76	107	76	20	86	48	2
Subgroup 3	40	1,385	30	25	30	−14	27	5	9
China	1	1,155	32	84	32	−14	39	−1	19
India	1	851	64	100	64	8	66	15	29

Source: Adapted from Seckler et al. 1998, Appendix B, Table 1.
Notes: Group definitions are as follows: Group I. Absolute water scarcity—projected withdrawals exceed 50 percent of annual water resources (AWR). Group II. Economic water scarcity: Subgroup 1—projected water withdrawals increase over 100 percent; Subgroup 2—projeted water withdrawals increase by 25 to 100 percent; Subgroup 3—projected withdrawals increase by less than 25 percent. The same groupings are used in the text and map. S1 (scenario 1)—no improvement in average water efficiency; S2 (scenario 2)—average water efficiency improves from 47 to70 percent; AWR—annual water resources from rainfall and rivers.

ter and the way we mobilize and manage water resources. Here we identify some of the most critical issues and assess the implications for food security and the poor.

The real life of water scarcity

Behind these rather tedious figures and groupings lie dramatic tragedies of water scarcity exemplified by women who must carry heavy pots of water several kilometers every day to meet household needs; farmers who lose their lands because they lack irrigation water or because the soil has become too saline to cultivate; the loss of wetlands and estuaries because the water no longer flows to these downstream needs; and a rise in incidents of water-borne diseases.

Water scarcity leads to declining water quality and pollution, which have an especially adverse impact on the poor. Many, probably most, of the poorest people in the developing countries are forced to drink water that is unfit for human consumption. They suffer from a range of skin and internal diseases and health problems.

Water resource development has helped to alleviate poverty both by adding to food supplies for the poor and by providing employment. People below the poverty line in Asia spend approximately 60 percent of their total income on cereals. Over two-thirds of the total increase in cereal production in Asia since the 1960s has been from irrigated land. Largely as a result of the spread of the high-yielding fertilizer-responsive varieties on an expanding irrigated area, real cereal prices have fallen to less than half of their previous levels.

Irrigation means more work more days of the year. Landless workers from rain-fed villages sometimes migrate long distances to take advantage of employment opportunities in irrigated areas. Higher incomes in agriculture also create employment opportunities off the farm.

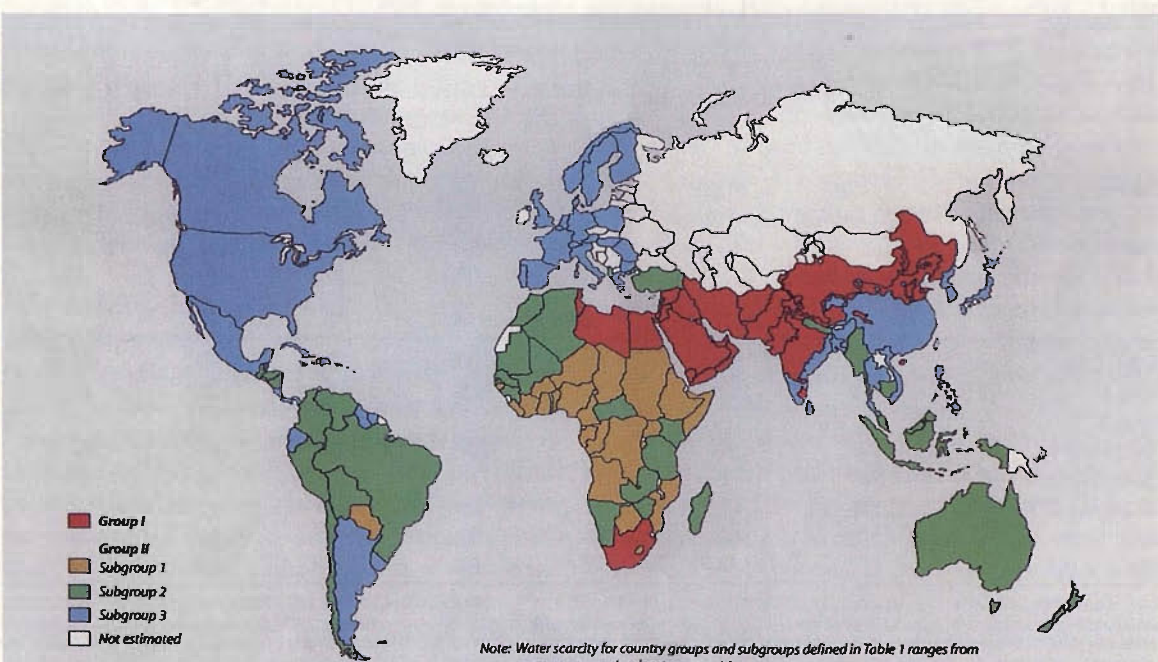
The direct and indirect effects of the green revolution on irrigated land have been by far the greatest way out of poverty in Asia. Between the mid 1970s and the early 1990s, the rural population below the poverty line in India fell from over 50 percent to approximately 35 percent (Datt) and fell by a similar amount in Bangladesh as well (Palmer-Jones). Advances in tubewell technologies have paved the way for higher crop yields and farm incomes in two of Asia's poorest regions, Eastern India and Bangladesh (Barker and van Koppen).

The groundwater problem

There is a tendency to associate irrigated agriculture in the developing world with canals, dams, and tanks or reservoirs. Most recently the world's attention focused on the problems associated with the construction of large dams, such as environmental degradation and the dislocation of people. By contrast, hidden from view and attention, a worldwide explosion in the use of wells and pumps for irrigation, domestic, and industrial uses has degraded groundwater resources in many areas.

In India and China (which account for 40 percent of the world's irrigated area) the area irrigated by groundwater has grown from less than 30 percent in the early 1960s to well over 50 percent, exceeding the area irrigated by canals and tanks combined. Pump irrigation has supplemented canal irrigation, facilitating the multiple cropping of irrigated areas. The reliability of water deliveries served by tube wells permits the growth of high valued crops with returns often

Figure 1. Projected water scarcity for country groups in 2025



two to three times greater than those obtained in areas irrigated only by canal (Dhawan).

The point has now been reached in some areas, however, where the overexploitation of groundwater poses a major threat to environment, health, and food security. The problems are most severe in the arid and semi-arid regions of China, India, Pakistan, the Middle East, and North Africa, the areas in red on the map projected to have *absolute water scarcity.* Two of Asia's major breadbaskets, the Indian Punjab and the North China Plain, are experiencing a decline in groundwater tables and a reduction in groundwater supplies (Chand, Brown and Halweil). Rising groundwater tables in Pakistan, and the accompanying problems of salinity and waterlogging, have led to lower yields and a reduction in land area suitable for cropping (Kijne et al.). And in many places, elements such as nitrates from high applications of chemical fertilizers have polluted groundwater aquifers.

While the problems of groundwater are clear, the solutions are not. Political forces often prevent pricing and regulation of pumping. Both uncertain technology and high cost make aquifer recharge problematic. Although there are technical solutions for reducing salinity, the financial costs of various options and the appropriate management strategies at farm and system levels are not well understood. In sum, given the truly alarming threat of groundwater depletion in the world, it is astonishing how little attention, whether in research or action, is given to it.

Marginal areas

As noted above, advances in production in the irrigated areas have helped provide global food security and have reduced poverty. This fact notwithstanding, much poverty still exists in vast marginal areas of rain-fed agriculture, including much of sub-Saharan Africa. An array of water harvesting and supplemental irrigation technologies has shown great promise, when tested by agricultural scientists, for increasing crop yields (Oweis et al.). Many scientists believe that the rain-fed areas offer the greatest immediate potential for production gains in the immediate future. But farmers have been extremely reluctant to adopt these technologies, apparently because the risk and costs seem to outweigh the benefits. Finding techniques to increase the productivity of rainwater with low cost and modest management requirements continues to be the major constraint to the realization of this potential.

Implications for food security and human welfare

Growing more food with less water is the challenge we face. To meet this challenge institutions and policies must change. The continuing neglect of the emerging groundwater problem poses the greatest threat to both food security and human welfare. Improvements in canal irrigation and groundwater management for crop production must go hand in hand. Also, solutions must be found to groundwater and surface water pollution, a serious threat to human and animal health. National and international development agencies pay too little attention to the growing water scarcity and its implications for food security and for the welfare of the poor. C

For more information

Barker, R., and B. van Koppen. *Water Scarcity and Poverty.* IWMI Water Brief 3. Colombo, Sri Lanka: International Water Management Institute, 1999.

Brown, L.R. and B. Halweil. "China's Water Shortage Could Shake World Food Security." *World Watch,* July/August 1998.

Chand, R. "Emerging Crisis in Punjab Agriculture: Severity and Options for Future." *Economic and Political Weekly,* 27 March 1999.

Datt, G., and M. Ravallion. "Why Have Some Indian States Done Better Than Others At Reducing Rural Poverty?" *Economica* 64(1998):17–38.

Dhawan, B.D. "Output Impact According to Main Irrigation Sources: Empirical Evidence from Four Selected States." Paper given at seminar on water management, The Key to Development Agriculture, Indian National Science Academy, New Delhi, 28–30 April 1986.

Kijne, J.W., S.A. Prathapar, M.C.S. Wopereis, and K.L. Sahrawat. *How to Manage Salinity in Irrigated Lands: A Selective Review with Particular Reference to Irrigation in Developing Countries.* SWIM Paper 2. Colombo, Sri Lanka: International Irrigation Management Institute, 1998.

Oweis, T., A. Hachum, and J. Kijne. *Water Harvesting and Supplemental Irrigation for Improved Water Use Efficiency in Dry Areas.* SWIM Paper 7. Colombo, Sri Lanka: International Water Management Institute, 1999.

Palmer-Jones, R.W. "Sustaining Serendipity? Groundwater Irrigation, Growth of Agricultural Production, and Poverty in Bangladesh." *Economic and Political Weekly,* 26 September 1992.

Postel, S.L. "Water for Food Production: Will There Be Enough in 2025?" *BioScience* 48, no. 8(1998):629–37.

Seckler, D., U. Amarasinghe, D. Molden, R. de Silva, and R. Barker. *World Water Demand and Supply, 1990 to 2025: Scenarios and Issues.* Research Report 19. Colombo, Sri Lanka: International Water Management Institute, 1998.

The authors are with the International Water Management Institute in Colombo, Sri Lanka.