SPECIAL FEATURE

Principles of Water Management for People and the Environment

At the IUCN World Conservation Congress in Montreal in October 1996, a workshop was held on Water and Population Dynamics. This was a collaborative venture between IUCN and the Population Reference Bureau and was funded by the US Agency for International Development. In preparation for the workshop, IUCN assisted in the creation of nine country teams, each composed of one water and one population expert, that researched case studies focusing on the interplay between population variables and water. As a member of the expert panel for the workshop, I formulated some ideas to stimulate discussion and to provide a framework for the case studies.

Water, the environment and population

Water is the lifeblood of our planet. It is fundamental to the biochemistry of all living organisms. The planet's ecosystems are linked and maintained by water, it drives plant growth and provides a habitat for many species, such as 8,500 species of fish and most of the world's 4,200 species of amphibians and reptiles described so far. Water is also a universal solvent and provides the major pathway for the flow of sediment, nutrients and pollutants. Through erosion, transportation and deposition by rivers, glaciers and ice sheets, water shapes the landscape, and through evaporation it drives the energy exchange between land and the atmosphere, thus controlling the Earth's climate.

The total amount of water on earth is fairly fixed at around 1.4 billion km^3, but only around $41{,}000km^3$ circulates through the hydrological cycle, the remainder being stored for long periods in the oceans, ice caps and aquifers. In contrast, the renewal rate provided by rainfall varies around the world, from practically zero in the Atacama Desert in southern Peru, to 6,000mm per year in parts of New Zealand. In any one place rainfall also varies from year to year. In the early 1980s drought and starvation hit the Sahel, but by August 1988 floods had ravaged the same region. Water availability also varies over a longer time scale. Some 10,000–20,000 years ago, during glacial phases in high latitudes, rainfall over the current Sahara Desert and the Middle East was much higher than today and percolation of water to underlying rocks led to the build-up of substantial groundwater resources. However, the recent drier climate in these regions means that recharge is greatly reduced and groundwater exploited is not being replaced at the same rate. Superimposed upon natural climate cycles are man-induced global changes. The consensus is that during the next century global temperatures will rise by about 0.2°C per decade. However, it is uncertain how this will affect water resources. Evaporation is likely to rise, but changes in rainfall patterns are less easy to predict. It is feared that many areas will become drier and floods and droughts will become more frequent and extreme.

The unprecedented rise in human populations, from 2.8 billion in 1955 to 5.3 billion in 1990 (with 8–9 billion anticipated by 2025), has increased demands for water. The amount of water that people use varies, but tends to rise with living standards. In the USA, each individual typically uses 700 litres per day for domestic tasks (drinking, cooking and washing), whilst in Senegal, the average use is 29 litres per day. Because of the spatial mismatch between water resources and people, it is predicted that by 2000, 12 African countries with a total population of approximately 250 million will suffer severe water stress. A further 10 countries containing some 1,100 million people, or two-thirds of Africa's population, will be similarly stressed by the year 2025, while 4 (Kenya, Rwanda, Burundi and Malawi) will be facing an extreme water crisis.

Water for people or the environment?

With such a water crisis facing many countries, it seems an immense task just to manage water so that there is enough for people to drink, let alone for agricultural and industrial uses. Thus, providing water for "the environment" must surely be given a low priority? Indeed, the situation is often presented as a conflict of competing demand, as though it was a matter of choice between water for people and water for wildlife. The Bruntland Report, *Our Common Future*, and the UNCED Conference in Rio in 1992 seemed to mark a turning point in modern thinking. A central principle of Agenda 21 and of *Caring for the Earth* (IUCN/UNEP/WWF, 1991) is that the lives of people and the environment are profoundly inter-linked. Ecological processes keep the planet fit for life, providing our food, air to breathe, medicines and much of what we call "quality of life". The immense biological, chemical and physical diversity of the Earth forms the essential building blocks of the ecosystem. Thus whilst people need access to water directly to drink, providing water to the environment means water indirectly for people.

This concept is so basic that it has permeated all aspects of water resource management, such as the new water law of South Africa, whose principle 9 states that: "the quantity, quality and reliability of water required to maintain the ecological functions on which humans depend shall be reserved so that the human use of water does not individually or cumulatively compromise the long-term sustainability of aquatic and associated ecosystems".

More attention needs to be given to the role of natural ecosystems in managing the hydrological cycle and their potential as alternatives to major engineering works. Conserving wetlands in particular, by ensuring that they have adequate supplies of water to maintain their functioning, can be a positive benefit to man. Many wetlands provide important fisheries, arable and pasture land, fuelwood and medicines as well as habitats for wildlife. Some wetlands also perform many important natural hydrological functions, including flooding reduction, water quality improvement (by removing pollutants) and groundwater recharge. Thus for the millions of people worldwide who depend directly on wetland resources or benefit from wetland functions, providing water for the environment and for people are one and the same.

Principles for water management for people and the environment

Box 1 lists 10 principles of water management which form a framework for examples of water and population dynamics from around the world. These are explained more fully below. It is not presupposed that this is a definitive list, but it nevertheless captures many issues that must be addressed if water is to be managed sustainably for people and the environment.

1. Value water

To decide on the best use of water, an independent measure of benefits of various alternative options is required. Monetary value is frequently employed, as this is how most goods and services are exchanged in everyday life. In northern Nigeria, large dams were constructed on the Hadejia River to feed intensive irrigation, which led to a reduction in the Hadejia-Nguru wetlands downstream. It was demonstrated that the economic value of water when used for intensive irrigation was many times less than its value for supporting fisheries, agriculture and fuelwood in the wetlands downstream. (See Newsletter 14, pp. 10–12). Consequently, the

Box 1. Ten Principles of water management for people and the environment

1. Value water
2. Use water sustainably
3. Develop suitable institutions to manage water
4. Collect and disseminate information
5. Maintain a social and cultural perspective
6. Ensure equitable access to water
7. Use appropriate technology
8. Try to solve causes not symptoms (but accept practical solutions)
9. Take an ecosystem approach
10. Work as multidisciplinary teams

Nigerian government is now exploring the potential for releasing water from the dams to restore the wetlands. Economic valuation thus provided a sound basis for water management decision-making. It is, nevertheless, not a panacea. Frequently, there is a lack of information on the value of ecological and hydrological processes, such as the nutrient recycling or groundwater recharge function of wetlands. Furthermore, some members of society may argue that certain environmental systems, such as a tropical rainforest, may have additional 'pre-eminent' values in themselves beyond what they can provide in terms of satisfying human preferences. Thus, economic values represent just one input into water management decision-making, alongside other important considerations.

2. Use water sustainably

When water resources are used at a rate greater than they are being replenished, the resources will decline and the usage becomes unsustainable. In many areas of the world, for example, groundwater is being extracted from the underlying aquifer more rapidly than it is being replenished. Around Quetta in Pakistan, where the abstraction rate is 2.5 m^3/sec, whilst the recharge rate is 2.0 m^3/sec, the groundwater level is falling at around 1m per year. Furthermore, the problem is likely to worsen as the population is growing at 7% per year (i.e. a doubling in 10–11 years). Even where groundwater abstraction might be reduced to equal the recharge, the groundwater levels have often been lowered to a point where key ecosystems have been destroyed. For example, intensive use for irrigated agriculture of the water from aquifers underlying the upper Guadiana river basin in central Spain has resulted in the almost complete and irreversible destruction of the Tablas de Daimiel wetlands. There are many ways in which water can be used more sustainably, such as drip irrigation, which delivers water to plant roots via a pipe with small holes; reusing waste water; charging for water.

3. Develop suitable institutions to manage water

Institutions at various levels are essential for the equitable allocation of water. At the global level two initiatives are currently underway: the World Water Council, which aims to assess global water resources and policy issues: and the Global Water Partnership, which has proposed co-ordination of large-scale programmes on water and sanitation, agriculture and irrigation.

For some international river basins, a special management authority has been established. OMVS (Organisation pour la mise en valeur du fleuve Sénégal) has defined a water-sharing agreement for the Senegal River between Mali, Mauritania and Senegal. Effective institutions are also required at national, provincial and local level, to ensure that all stakeholders can contribute to the decision-making process. A good example is provided by the Pongolo River in north-east South Africa, near its borders with Swaziland and Mozambique, where water committees were established representing the user community (e.g. fishermen, livestock keepers) and were given the mandate to decide when floodwaters should be released from a reservoir. Whatever the level, institutions need well-informed members who have an appreciation of the wide range of issues facing water resource allocation. Training is an essential element, but training needs vary with the type of institution.

4. Collect and disseminate information

Effective management of resources can only be achieved if decisions are based on sound information. In many countries not even main rivers are monitored effectively, which means that the true water resource is largely unknown and hydrological measurements on slow-flowing or static water bodies, such as fens and marshes, are very rare. Likewise, levels of water use, such as for irrigation, are not known precisely. Thus, in few countries is it possible to base demand management strategies on accurate data. In times of economic difficulty, data collection and research are often the first activities to be cut. In contrast, hydrological data collection needs to be expanded to cover more rivers, wetlands and aquifers, in terms of both water quantity and quality. Communication and dissemination of information are also vital. Whilst a raw data file on diskette may be appropriate for transferring information to a university researcher, local communities need to receive their information through easily understandable brochures, newspaper articles, radio broadcasts and public meetings.

5. Maintain a social and cultural perspective

Water is a fundamental part of life and is interwoven into the fabric of our societies. For example, many Hindus believe the River Ganges is sacred: a dip in it will purify the soul and scattering the ashes of a cremated body on the water will aid rebirth in a higher existence. Management and allocation of water are thus particularly sensitive issues. Unlike other resources, such as coal or timber, ownership is not accepted in the same way, partly because water is dynamic, flowing through the environment and perceived as God-given. Proposals to charge money for water supply are often met with hostile reactions, even though it can be argued that the costs are related to the infrastructure and its maintenance rather than the water itself. Thus, although water pricing may be theoretically a sound demand management strategy, its implementation is frequently not acceptable. Whilst a scientific approach to water management has many advantages, decision-making needs to take into account ethical, aesthetic and religious values.

6. Ensure equitable access to water

Water resource statistics are often provided on a per capita basis. This represents an average across the entire population, giving the impression of equality in the availability of the resource, i.e. equal access and equal ability to pay (if charged for). The contrast in access is strikingly evident in many developing countries. Several studies have shown that the urban poor pay higher prices and spend proportionally more of their income on water. In Jakarta, Indonesia, 32% of the population buy water from street vendors at US$1.5–US$5.2 per m^3, some 25 to 50 times more than the 14% of households who receive water from the municipal system. In addition, the burden of insufficient water quantity or quality for domestic use is likely to be borne disproportionately by women and children. Being the primary water collectors, longer collection times mean that women have less time for agricultural production and child care.

7. Use appropriate technology

Many water resource schemes in developing countries were conceived, designed and implemented from a developed country viewpoint. Until the 1970s, one of the main underlying philosophies was the need to control nature. Technology was seen as the means to bring order to the vagaries of the world's climate. For example, dams are used to store water during rainy periods and release it when needed during the dry season for industry, agriculture or power generation. Climate extremes, such as floods, were seen as wholly negative, and there was little appreciation that the inundation of floodplains provides a breeding ground for large numbers of fish, and brings essential moisture and nutrients to the soil, supporting, for example, gallery forests and essential dry-season grazing for migrant herds. As an alternative to large river engineering schemes, the Hadejia-Nguru Wetlands Conservation Project in Nigeria, for example, has promoted improved local water management within the wetlands, with the construction of small embankments and simple wooden sluice gates. The wooden gate can be replaced by wire-mesh screens to allow water into fields whilst keeping out fish, which eat the young rice shoots, until the plants have become established. Whilst technology has clearly brought benefits to many people, to be sustainable it must be appropriate in terms of the ability of local people to maintain the system, as well as for the environment.

8. Try to solve causes not symptoms

With many environmental, social, health or economic problems, it is easier to locate and treat the symptoms rather than the cause. As part of the development of the Senegal River basin the Diama barrage was built across the river mouth. This allowed its use for irrigation, since periods of saline water intrusion into the river, which used to occur during the dry season, were replaced by a regime of continuous freshwater. This also led to increased survival of snails and mosquitoes, which carry diseases. Before 1987 rift valley fever (a mosquito-borne viral disease) had never been recorded in West Africa and human intestinal schistosomiasis (an aquatic snail-borne worm parasite disease) was little recorded. Following construction of the Diama dam 200 human deaths from rift valley fever were recorded, along with an 80% abortion rate among sheep and goats. In 1988, there was a 2% prevalence rate of schistosomiasis; by 1989 this had risen to 72%. The traditional approach to disease control has been to spray chemicals to control the mosquitoes, and to inoculate local people. This clearly treats the symptom rather than the cause. However, the World Health Organisation's Panel of Experts on Environmental Management (PEEM) is now promoting environmental management as a health control measure which treats the cause.

9. Take an ecosystem approach

The statement from the Dublin Conference, which preceded the UNCED Conference in Rio, states that "since water sustains all life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems". There is a need to develop a broad-based approach to water management, with greater emphasis on integrated regional planning, normally at the river basin scale, and conservation of critical habitats. The ecosystem management approach aims to integrate all the important physical, chemical and biological components and processes which interact with social, economic and institutional factors. This requires integrated management of mountains, drylands, forests, agriculture, housing, industry, transport, waste disposal, aquifers, rivers, lakes, wetlands and anything which has an effect on the environment. Once the scientific basis for management options has been defined by professional staff, the participation of local communities, farmers, industry and conservation organisations is needed to satisfy the needs of different interest groups.

10. Work as multidisciplinary teams

Most river basins contain a variety of landscapes, land uses, habitats, industry, communities, laws and traditions. Thus, implementation of a truly integrated ecosystem approach as proposed above requires the establishment of interdisciplinary teams including hydrologists, water engineers, biologists, physicists, soil scientists, planners, human and animal health experts, ecologists, sociologists, demographers, legal experts and agro-foresters. These teams need to address a wide range of sectoral topics including population dynamics, water quality modelling, irrigation, health problems, water weeds, fish, herding, legislation, training, and participatory rural appraisal. Conventionally, different disciplines tend to specialise in separate sectors: for example, hydrologists and fisheries experts often belong to different ministries between which there is little formal contact. Each sector often has its own agencies and authorities responsible for development, many of which relate to water issues. Given the interconnection of the ecosystem, it is critical that inter-sector, interagency collaboration is established to develop the multidisciplinary team. Indeed, ecosystem management accepts that no individual or agency can cover all the different aspects involved. The various agencies should collaborate on all aspects of planning and implementation of projects, including problem analysis, project design, data collection, analysis and modelling, policy development, management and enforcement, monitoring and evaluation.

Conclusions

The Earth is shared by people and a range of plants and animals which is so wide that not all species have been, or ever will be, identified, or their functions understood. Despite the lack of detailed knowledge, it is clear that each of the physical, biological and chemical components of the Earth plays an important role in its structure and function. Furthermore, water is essential to people, plants and animals alike. Water management has traditionally been focused on providing enough for people to drink, grow their food and support their industries. Providing water to the "environment" is often viewed as a luxury which only rich countries can afford. As the world's population rises, there will be increasing demand to ensure that the direct supply of water to the human race is given top priority. However, people cannot live by water alone and require the services of the environment's life support system, which itself needs water to function. Sound water management should, therefore, focus on the global ecosystem and not as a conflict against nature to supply water for people. Mutual survival of people and the environment means that the ten principles of water management must be followed. Water must be valued, used sustainably, administered by suitable institutions, viewed through a social and cultural perspective; equally accessible to all, developed through the appropriate technology, cared for by treating the causes of problems and not just their symptoms, and managed through an ecosystem approach, employing multidisciplinary teams which collect and disseminate a wide range of information to produce sound decision-making.

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