

THE ETHICS OF FRESHWATER USE : A SURVEY

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FOREWORD

One can first of all simply wonder at the fact that it is only recently that humanity has begun to ponder the evolution and fate of water in the world when the very survival of our species depends upon it. How can one explain that it has been taken for granted for so long, at least by the major decision-makers, while one and a half billion people still do not have access to drinking water?

'Water, water, every where,
And all the boards did shrink;
Water, water, every where,
Nor any drop to drink.'

In his 'Rime of the Ancient Mariner', Coleridge beautifully sums up the vital nature of fresh water by expressing forcefully the agony of thirst on the becalmed ship, made ironically even more unbearable by the abundance of sea water.

This need, coupled with the uneven distribution of water resources on the globe's surface, explains the battles, sometimes even the bloodbaths, that man has waged since time immemorial to gain access to water. A scholarly observer of the Bible showed that its description of the various conflicts in the region at that time precisely dovetail with what we know about the geography of water in the Middle East today.

Will water be the stake of the wars of the 21st century? Many contemporary Cassandras put forth reasons for the inevitable conflict predicted. Is there no way to avoid it? And why could we not try to make this 'water of contention' the driving power to create a co-operative thrust, to pool humanity's innovative resources and goodwill?

Our memory of water may be boundless; not so our supply. Indispensable is not imperishable. And if, as Claudel said, water is our '*appareil à regarder le temps*', modern times inflict harsh punishment upon it (over-use, pollution etc...)

Against the growing scarcity and vulnerability of water, it is more than urgent to devise a common ethos, the touchstone of humanity's ability to place above the egoism of the privileged the intergenerational conscience of collective responsibility, which must heed the call of the young participants at the Second World Water Forum: 'We are idealistic, and this idealism inspires our vision. A vision of a better tomorrow, where clean water is available to everyone. Aid us in making this a reality (...).'

May we be infused with just a little wisdom in our quest for common ethical principles in this area. By Lao-tzu for example:

'Water may act without the fish.
But the fish cannot act without the water'
(Tao-te Ching, XXXIV)

Vigdís Finnbogadóttir

Reykjavik, 25 October 2000

INTRODUCTION

*'The Earth is one but the world is not. We all depend on one biosphere for sustaining our lives. Yet each community, each country, strives for survival and prosperity with little regard for its impact on others.'*¹

These words, taken from the groundbreaking Brundtland report, are as true today as they were thirteen years ago. Their context was the concept of sustainable development, a radical departure from previous notions and one which, in the words of Ms Gro Harlem Brundtland, chairman of the World Commission on Environment and Development, brought to the forefront the idea of 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' Thus, the traditional economic, material and technological parameters of development now had to be seen in a new light -- one of sharing, caring, saving and conserving -- in other words, in an ethical framework without which all efforts would be piecemeal, fragmented and ephemeral.

Like all movements that have marked their epoch, that of 'sustainable development' began with ideas about what relations between people have been, are and should be. Such ideas are no less than the very substance of ethics, the moral principles embodying the conceptions, interests and ideals from which human behaviour springs and the value systems on which they are based. The recognition that no sector of society is 'value free' and immune to ethical consideration has become the bedrock of all critical examination of how we live today.

1. *Our Common Future*, Report of the World Commission on Environment and Development, Oxford University Press, 1987, p.27.

Nowhere is this more evident than in the prodigious advancement of science and technology, certainly one of the most important factors shaping human history in our time. For the world we know is a direct result of these advances and their impact on all aspects of our existence -- economic, social and spiritual -- is profound and irreversible. Moreover, their complexity increasingly places vital social choices in the hands of a technologically-enlightened few, challenging hard-won principles of public debate and participation. Understanding the implications of this phenomenon and learning to treat social and practical decisions not as purely technical matters best left to the experts but as part and parcel of a whole range of human preoccupations are vital if we are to continue pursuing the goal of sustainable -- and equitable -- development.

This realization was at the heart of the initiative taken by UNESCO in 1997 'to promote ethical, multidisciplinary and multicultural reflection on a number of situations that might become a risk to society as a result of advances in science and technology, by setting up the World Commission on the Ethics of Scientific Knowledge and Technology.'² The Commission, known as COMEST, was to serve as a forum of reflection and was mandated to formulate principles that could provide decision-makers in sensitive areas with criteria that went beyond the purely economic or scientific. It would play a role in offering guidelines and moral leadership, contributing to the work of scientists charged with defining the issues for UNESCO and discussing their findings so as to suggest a prognosis for the global community to act on. Most importantly, COMEST would seek to motivate scientists by adding an ethical dimension to their intellectual freedom.

In January 1998, the Director-General of UNESCO named H.E. Mrs Vigdís Finnbogadóttir, President of the Republic of Iceland (1980-1996), as Chairperson of COMEST. To further its goals, the Commission set up three Working Groups, one of which was to examine the ethical questions concerning the use of freshwater resources. Mr Ramon Llamas, Professor in the Department of Geodynamics at the University Complutense in Madrid, was designated Co-ordinator of the Group.

During the first session of COMEST (Oslo, Norway, April 1999), several important issues were broached. In the field of freshwater resources, COMEST was to set out a number of ethical principles and guidelines based on solid scientific information and taking into account conflicts of interest which may exist. Age-old knowledge of water

2. Resolution 29C/13.2 of the 29th session of the General Conference of UNESCO, October-November 1997.

conservation and management within the ecosystem, occasionally confronted with technological choices -- often at a high cost --, drawn from principles of precaution, responsibility and transparency, should be at the forefront.

The Working Group on the Ethics of the Uses of Freshwater Resources was an intercultural and interdisciplinary team. During its four meetings (Paris, 28 October 1998; Paris, 10 January 1999; Oslo, 26 April, 1999; and Almeria (Spain), 31 July and 1 August, 1999) it looked at the ethics of: managing various water uses; water and food security; water and health and sanitation; water and natural disasters; decision making and water management; water and ecology; the special role of women in water; water history and broader social ethics; challenges of technology and standards of professionalism; special issues related to the recent intense use of groundwater in arid countries; water and conflict, and elements of a new ethic of water. An Executive Summary was produced reflecting its work.

A COMEST sub-commission on the Ethics of Fresh Water, composed of members of COMEST and chaired by the Earl of Selborne (UK), was established and met for the first time in Aswan, Egypt in October 1999. Presided by Ms Suzanne Mubarak, Vice-President of COMEST, the meeting was also attended by a number of experts and senior representatives from the industrial sector concerned with the distribution and use of freshwater resources. The debate centred on a number of fundamental ethical questions and explored various avenues for broadening international co-operation in the field of water research and data collection.

The present survey thus draws on a rich and varied body of discussion and documentation³ to provide an overview of the practical areas of concern so as to move to relevant ethical stances. The aim is to help lay a foundation of trust, justice and equity in the availability of and access to freshwater resources for the entire community of nations. For, as the Director-General of UNESCO, Mr Koïchiro Matsuura, pointed out in his Message on the occasion of World Water Day 2000, 'The challenge we face ... is to set in motion a dynamic that will make this the century of world water security. Water has long been too low on the public policy

3. Proceedings of the First Session of COMEST (Oslo, April 1999), four meetings of the Working Group (WG), eleven presentations provided by WG members and invited experts, the WG Executive Summary, the meeting of the Sub-Commission of the COMEST on the Ethics of Fresh Water (Aswan, November 1999), 9 presentations prepared by participants in the Aswan meeting.

agenda or presented only in terms of disasters, scarcity, pollution or as a potential source of conflict. We need to take a constructive approach to water: it is an essential, shared resource; it should be treated as a foremost priority in every community from the local to the global. There is a fundamental truth which I would like to emphasize ...the water supply does not run dry when it is drawn from the well of human wisdom.'

WATER AS AN ETHICAL ISSUE

*'The art and practice of equitable distribution of and access to fresh water for all people in the 21st century, as a fundamental human right and international obligation, is the mother of all ethical questions of all transboundary natural resources of a finite nature.'*⁴

Water, the common symbol for humanity, valued and respected in all religions and cultures, has also become a symbol for social equity. For the water crisis is mainly one of distribution of water, knowledge and resources and not one of absolute scarcity. As such, questions of access and deprivation underlie most water decisions. We need therefore to understand what common ethical principles can be accepted as applicable in all geographies, in all stages of economic development and for all time. We also need to recognise that in implementing these ethical principles there can and will be different strategies and methods which will be appropriate for different situations. However, the ethical principles which inform such policies will be consistent throughout the world.

While we all have a need for water, this does not give us the right to have access to as much water as we choose. Society must first ensure that appropriate prioritization of water access is put in place which allows humanity's essential needs to be met as well as those of our eco-systems. Thereafter, it is entirely appropriate that water should be allocated, if available, for our use, but there is no reason why the full costs imposed on society should not be reimbursed. Agricultural irrigation systems are the largest users of water and should require full economic recovery, even if agricultural subsidies represent an element of this payment.

4. Mr Thomas R. Odhiambo, Past President, The African Academy of Sciences, and Vice-chairperson of the COMEST in his closing address to the First Session of the COMEST, Oslo, April 1999.

Ethical principles require therefore appropriate pricing, as well as clarity and accountability to the wider community, the stakeholders. The regulatory framework must reflect the interests of these stakeholders, which might be identified as a local, regional, national or international grouping. There are clearly problems if the regulatory framework is developed along administrative boundaries other than of watershed boundaries and the best practice will recognise the realities of water catchment areas.

While we should beware of technical fixes as the way to resolve our problems, there is a need to develop and harness new technologies for conserving, harvesting, transporting, recycling and safeguarding our water resources. We must ensure that once these innovative systems and practices have been successfully developed, they are widely disseminated and the participating process is able to assess their relevance for other areas.

Most responses to water problems require finding a balance among uses and among traditional and technological solutions and will differ according to region. However, among the participants influencing regional management are powerful international corporations whose agendas must be adjusted to serve rather than dominate regional needs. Data is essential: more data, better use of data and public access to water data are all ethical imperatives. This is particularly true in order to anticipate and mitigate floods and drought, which kill more people and incur more costs than any other cataclysms, and to prevent these natural hazards from turning into humanitarian disasters. While conflict over water can lead to violence, the history of water management records much more often the establishment of practical communitarian ethics. This subsumes both the private and public aspects of water management, making necessary a new sense of water ethics at the personal and social level. Most of the earth has been built and rebuilt and today the fundamental need of water managers is for an ethic of ecological design and not only preservation.

The control of water is the control of life and livelihood. Over the last two decades, several important international conferences have called for an ethical commitment to provide for humanity's basic water needs: Mar del Plata in 1977, the Dublin Conference on Water and the Environment and the Rio Earth Summit in 1992, the UN sponsored comprehensive assessment of the world's freshwater resources in 1997, and others. Linkages between water policy and ethics are increasingly found throughout the world. For example, the new South African constitution ties

the availability of water directly to human dignity when it speaks of how the failure to provide access to sanitation and water to many in the majority significantly impacts on their right to dignity and their right to life. Indeed, recent challenges to traditional engineering approaches to water management have gained prominence primarily through ethical and moral appeals, usually driven by ecological or environmental values.

World water statistics are becoming familiar. According to the Water Supply and Sanitation Council, roughly 1.4 billion people (25% of world population) still have no access to water supply and 2.9 billion people (50%-60% of world population) are deprived of basic sanitation services. World Bank estimates show that current spending on water and sanitation in developing countries is approximately \$28 billion per year; based on present approaches, estimates by various international organizations for additional funds needed are between \$9 billion and \$24 billion per year. The costs of not fixing this are real but hidden, representing about three times this figure in health and disease alone. In the developing world 90% of such diseases are related to water. The UN agencies' collective declaration on the occasion of the 1999 World Water Day (22 March) stated that the amount of donor money necessary to bring low-cost, safe water and sanitation to those who need it over the next eight to ten years was equivalent to the money spent on pet food in North America and Europe.

Debates on water resources management mirror broader debates on social ethics and relate to what many consider universal ethical principles, for example, the UN Universal Declaration of Human Rights of 1948 and the proclamation of the 1977 UN Water Conference which claimed that 'all peoples ... have the right to have access to drinking water in quantities and of a quality equal to their basic needs.' These principles are directly applicable to the issue of water and may be summarized as follows:

- the principle of human dignity, for there is no life without water and those to whom it is denied are denied life;
- the principle of participation, for all individuals, especially the poor, must be involved in water planning and management, and gender and poverty issues recognized in fostering this process;
- the principle of solidarity, for water continually confronts humans with their upstream and downstream interdependency and current calls for integrated water management may be seen as a direct offshoot of this realization;

- the principle of human equality, taken to mean rendering to all persons their due and which describes perfectly the challenges in river basin management today;
- the principle of the common good, for by almost everyone's definition water is a common good and without proper water management human potential and dignity are diminished for all and denied to some;
- the principle of stewardship, which teaches respect for creation and for wise use and not extreme reverence for nature; indeed, much of water management is about finding an ethical balance among using, changing and preserving our water resources and land.

Encouraging and securing capital investment to solve these problems is now an ethical as well as a political challenge. The cost of building and operating water infrastructure is so high that many developing countries cannot make adequate provision for much of the population. Increasingly, capital will have to come from the private as well as the traditional public sector, raising serious ethical issues such as transparency and openness of information to the public, compatibility with basic values and beliefs concerning resource ownership and rights, appropriateness and effectiveness of requisite regulatory structures and many others. Hand in hand with privatization, and in the face of the growing scarcity in the availability of clean fresh water, some countries have already opted to develop a water market. In such cases, what is an effective pricing system for fresh water which would assure both availability to all segments of society and conservation of this finite resource? Would one, for example, assume that industry should be allocated more of this commodity simply because of the experience in some countries that industrial uses of water generate more than 60 times the value of the same quantity of water used in irrigation?

Clearly, there are conflicting factors which make it difficult to set out universal ethical principles. There will always be tensions rising from legitimate demands for development, for conservation and preservation of the environment, for company shareholder profit in a world dominated by the market, and from corruption and ignorance of decision makers, nationalism... the list is long. Specific local conditions also come into play, for example, geography: in arid countries with limited available water, agricultural clearing and the over-utilisation of land assisted by damming and irrigation often result in salinization. In tropical countries with poor topsoil in rain forests, clearing for timber production results in runoff of the soil and flooding and pollution of the ocean, with reduction in fishing resources and dependence on foreign aid for food. In high rainfall lowland,

the clearing of waterlogged regions to produce agricultural land results in aerated soils, reduction of bauxite and release of aluminium ions that are after a short period toxic to crops, eventually rendering the land useless. As hydrological engineering projects proceed on a massive scale, nascent industries can intensify water pollution. Irrigation produces one third of our food from about one sixth of our land, however, as population and food needs grow, the amount of irrigated land per-capita decreases and irrigation infrastructure degrades, leaving communities vulnerable to food insecurity. As one writer puts it: 'All these issues boil down to a single question: who, if anyone, owns the water? ...In trying to apply our concept of ownership to a resource whose very nature runs contrary to the idea, we have a recipe for conflict.'⁵

Nevertheless, the interplay between these conflicts sheds light on where we can begin to identify some ethical issues that are indisputable. First, the ethics we require should be built on a sense of shared purpose and in harmony with nature. Second, ethics must be based on a balance between traditional human values regarding conservation and the use of new technological advances. Rarely have either worked alone and it is time to stop pitting one against the other. Third, ethics, even in our advanced technological age, should seek to find a new harmony between the sacred and utilitarian in water, between the rational and the emotional. Water resources managers need to understand the wisdom encoded in traditional religious and secular symbols and rituals surrounding water.

Today, our technology tells us that there is enough water -- if we co-operate. One of the most important elements for co-operation is something that experts in negotiation call 'superordinate values', meaning those that are beyond immediate utilitarian benefits and to which competing parties can subscribe. Rekindling the sense of the sacred in water, unquestionably a superordinate value, is one way to move the debate to higher levels and thus bear on the capacity to manage conflict and reach agreement. This balancing is not new -- it is what humans have been doing throughout history as they constantly learn how to deal with environmental uncertainty. Talking of such a balance means to appreciate the intrinsic and profound value of water that is not captured in the traditional utilitarian calculus of transactions. It is to recognize that water is not only a means to other goals, it is essential as an end in itself.

5. Philip Ball, *H2O: A Biography of Water*, London, Weidenfeld & Nicolson, 1999

CONSUMING WATER

*'The frog does not drink up the pond in
which he lives.'*

Native American proverb

AGRICULTURE AND FOOD SECURITY

Since the 1940s the world has been grappling with the question of food security as a human right. The 1943 food conference at Hot Springs (US), at which the 44 Allied governments met, addressed agriculture and the question of food systems as a whole and put the concept of food security as a human right on the table. The participants believed in government intervention to guarantee a basic minimum standard of living to all citizens and in building diversified, farmer-oriented, domestic agricultural systems for putting into practice the right to food. Nevertheless, the political will to implement these proposals was never mustered. However, the 1948 Universal Declaration of Human Rights states the right to food and the 1966 International Covenant on Economic, Social and Cultural Rights commits states to take steps to 'improve measures of production, conservation and distribution of food by making full use of technical and scientific knowledge and by developing or reforming agrarian systems.' The World Food Summit in 1974 vowed to eradicate world hunger in a decade and in 1996 considered it intolerable that more than 800 million people throughout the world, and particularly in developing countries, do not have enough food to meet their basic nutritional needs. It pledged political will and national commitment to achieving food security for all, meaning access to food that was safe, nutritious and adequate enough to fulfill the dietary needs and food preferences required for a healthy, active life.

Agriculture produces by far the largest share of the food consumed by humanity. There is simply no other path to the future but to continue cultivating the planet, and managing plants and animals for food production. Yet agriculture is also the largest user of fresh water, accounting for some three-quarters of global water consumption. If, as is

almost certain, population increases by 65% over the next 50 years, around 70% of the population will face water shortages and 16% will have insufficient water to grow their basic food requirements. The necessary increases in food production cannot be achieved without higher productivity on existing land and with existing water resources.

Water for agriculture is provided directly by rainfall replenishing soil moisture or artificially through irrigation. Somewhat more than 60% of global food production is attributed to rain-fed agriculture, and nearly 40% to irrigated agriculture abstractions. Improvements in water use efficiency in irrigation are necessary and technically possible; they would also have to bear on the twin problems of waterlogging and salinization, which are usually caused by excessive use of water and a poorly designed drainage system. Greater rainfall uptake is also technically possible but because the renewable water resource is limited, this could result in less runoff and water availability downstream.

According to experts, rapidly growing urban and industrial demands in the developing world will need to be met increasingly by transferring water from irrigated agriculture and managing this reallocation could well determine the world's ability to feed itself. But this could result in a sharp increase in the prices of staple cereals, with a negative impact on low income countries. Measures would have to be put in place to mitigate this through establishing secure water use rights, transferring small amounts from a large number of irrigators, promoting irrigation water efficiency and inducing conservation measures, reinvestment of gains from trade in the rural communities and adequate compensation of sellers and affected third parties.

In strictly economic terms, agriculture is generally considered a low-value water user. Other users may add a higher value and be more effective in removing poverty and increasing wealth, raising the question 'can irrigation practice remain unchanged and justified in situations of scarcity where the economic return to industrial water use is often 200 times greater than irrigation, or where upwards of 70% of available fresh water accounts for around 1-3% of GNP?' The case for reallocation of water appropriated by agriculture to other users has been made under conditions of scarcity, however it often requires a thorough review and reform of existing water policies, a process that can be highly political and loaded with special interests. Thus, reallocation of water involves not only the giving and the receiving parties but also third parties, such as local business and labour, that benefit from the current pattern of use and who are prone to suffer negative effects.

In the 1970s the OECD adopted the Polluter-Pays Principle (PPP), which requires that polluters pay for the cost of meeting the level of environmental protection decided upon by government. The PPP is one of the criteria that can guide the allocation of the environmental costs of agricultural activities, and the design and implementation of policies. However, application of the PPP to agriculture can be impeded by practical problems, such as identification of the polluter or the choice of reference standards of environmental quality and good farming practices.

Water scarcity can translate into a national food production constraint, to which countries with a high rate of population growth and strong development expectations are vulnerable. Most countries, even those where water scarcity has already set in, still maintain a regime where users simply withdraw as much as they wish. Dealing with scarcity, however, requires viewing it in relation to present use practices and the choices that need to be made among the economic sectors that benefit from the resource. Once again, the case can be made for efficiency improvements in the agricultural use of water and in the way it is made available for economic use and development.

Seen in this light, water scarcity is not an absolute constraint but a driving force for changes in the structure of society and of the economy. Such changes, however, imply social stress and bear a potential for internal conflict. Countries unable to face the changes in water management imposed by scarcity may choose to confront neighbours to increase or safeguard quotas of imported water, raising the spectre of international tension around national food security.

Ultimately food security comes from the elimination of extreme poverty. Indeed, some of the poorest countries with food security issues have hardly initiated their water development potential because of lack of resources. Food security does not mean self sufficiency for that could lead to human induced disasters; food can be traded and thus virtual water can be imported or exported if stable trade relations exist. When competition sharpens, if farmers have an opportunity to sell their land to the cities rather than continue to grow food, they will take the opportunity. The belief that there will be insufficient water to support the necessary increases in food production is true only if one assumes that significant changes in agricultural and trade practices will not be forthcoming. However, the now almost universal realization that water is a scarce and vital resource has already begun the process of change which the present generation has a duty to carry out on behalf of future generations.

INDUSTRY

The industrial applications of science and technology are growing at such a pace that we cannot always fully apprehend their repercussions. The compound effects of new industrial products, by-products and their wastes can no longer be totally and precisely understood before their possibly adverse effects become apparent. The complexity of the process makes it difficult, if not impossible, to identify specific single causes, and agents and victims of environmental pollution are no longer as clearly distinguishable one from the other as they may have been in the past. The victims of one phenomenon may well be the inadvertent agents of other negative phenomena.

Water is a vital component of the industrial chain, being used for such purposes as processing, washing, and cooling in facilities that manufacture products. A number of major industry groups account for most of the water used; they include food and kindred products, paper and allied products, chemicals and allied products, petroleum refining and related industries, primary metals industries.

Industry can innovate water-friendly improvements to current approaches, as well as help develop wholly new procedures, products, and services such as more affordable desalinization, more efficient irrigation, etc. However, the process of innovation implies that choices often have to be made among competing methods and technologies, as well as in defining the basic goal of such innovations. Industry and other players must weigh information on the costs, benefits, and performance of alternatives, and to do so wisely industry is bound to devote resources to research and development, and share the resulting information with the marketplace.

The 'hydro-myth' that developing industry inevitably leads to polluted rivers or aquifers has to be refuted. In fact, during the last two or three decades, in many industrialized countries, the water volumes used for industry and the related pollution have diminished with no significant economic impact on the sectors involved. In many developing countries the same could happen if social awareness is created and if there were greater use of the clean industrial technologies developed in recent years.

Industry can make positive contributions by, for example, locating water intensive operations in areas of sufficient water supply, introducing conservation practices such as use of graywater in processes that do not need high quality water, and improving discharge quality. Recycling alone could reduce the consumption of many industrial users by 50% or more,

with the additional benefit of decreased pollution. Industry can promote the social management of water by working with appropriate stakeholders on the basis of mutual respect of the needs and values of all the different parties and by opening an ongoing dialogue concerning water resource issues and information sharing.

However, it cannot be denied that in market economies where the industrial norm is profitability, industrial water use will become more ethical only if it is demonstrated that being ethical does not rule out being profitable. This is not necessarily a contradiction since efficiencies such as saving water can also be environmentally less costly. But as yet this is the exception rather than the rule and it is generally agreed that the ethical use of water in industry must be buttressed by clear-cut standards, law enforcement and, if necessary, economic subsidy. Nearly all environmental protection programmes have become possible by a legal framework and institutional arrangements.

As the aim of ethical industrial water use is to prevent the degradation of nature and the spread of adverse effects, responsibility resides with private companies, individuals and, most importantly, governments. Since water pollution often accompanies water use, any impact on the process of the hydrological cycle propagates downstream and the source of water pollution cannot always be identified. Because of this, industry has the responsibility to save water and use it efficiently, to avoid discharging contaminated water, to bear in mind the needs of those who live downstream, to conserve and restore nature, to observe the Polluter-Pays Principle, and, perhaps above all, to take pre-cautionary action to prevent possible tragedy.

Water is so precious that in the long run pollution should approach zero. Industrial products may be a bit more expensive but the consumer benefits from a better environment and also seems willing to pay for this. International markets could very well deny access to products that are cheaper because in some countries they can escape environmental discipline.

Mention must also be made of the special case of dam construction. Once the symbols of the nineteenth-century triumph of machines and technology, dams took on an almost metaphorical importance beyond their impact and performance. They were also among the first targets of recent growing environmental awareness. From being a solution to most water needs, dam construction and control of nature became synonymous with civil engineering and water management. No longer simply a means, dams became ends in themselves. Indeed, the essence of this 'ends --

means' confusion now appears in some extreme ecological appeals in many current debates wherein any proposal which includes taking out a dam -- the means -- is seen as a social good -- the desired end.

In 1986 there were 36,235 large dams (defined as higher than 15 meters) in the world, with an average of 267 built annually. By 1994 the number under construction was about 1,242. Many dams provide clean and renewable energy, enhanced ability to manage extreme fluctuations, greater capacity to generate economic development and multiple use of water, and improved predictability, which offers more protection for human lives. However, they come at socio-economic and environmental expense that is frequently unacceptable. While many criticisms are valid, the focus on cost without consideration of social trade-offs and benefits is unethical.

So too is the all too familiar pattern where constructors proceed without the active participation of those whose lives will be changed by the dam and sometime even with intimidation. The negative impacts of development on traditional communities and the poor must be clearly defined and fairly dealt with. Discussions must move beyond the question to dam or not to dam and embrace such issues as size, site selection, managerial procedure and efficiency, all of which have a decisive impact on society.

GROUNDWATER

Groundwater development has significantly increased during the past fifty years in most semi-arid or arid countries. This has been brought about by a large number of small (private or public) developers, often with poor scientific or technological control by the responsible water administration. In contrast, the surface water projects developed during the same period (dams, canals...) are usually of larger scale and have been designed, financed and constructed by government agencies that normally manage or control the operation of irrigation or urban public water supply systems. This historical situation has led to most water administrations having limited understanding and poor data on the groundwater situation and value, resulting in such drawbacks as depletion of the water level in wells, decrease of well yield, degradation of water quality, land subsidence or collapse, interference with streams and/or surface water bodies, and ecological impact on wetlands or gallery forests. These problems have frequently been magnified or exaggerated and a prevailing myth is that groundwater is an unreliable and fragile resource that should only be developed if it is not possible to implement conventional large surface water projects.

The term over-exploitation has often been cited, despite the fact that most experts agree that the concept is poorly defined and that misconceptions are still pervasive. What is clear is that the terms related to over-exploitation have in common the idea of avoiding 'undesirable effects' as a result of groundwater development. However, this 'undesirability' depends mainly on the social perceptions of the issue, which are more related to the legal, cultural and economic background of aquifer development than to the hydrogeological facts. What may be perceived in one area as a benefit, for example, by developing much-needed irrigation, may well cause conflict elsewhere if the degradation of wetlands is viewed by conservationists as a serious threat to the environment.

Some specialists consider that groundwater mining (or development of fossil aquifer or of non-renewable groundwater resources) works against sustainable development and should be socially rejected, if not legally prohibited. Nevertheless, there are those who posit that, under certain circumstances, groundwater mining may be a reasonable option. It might be said that fossil groundwater has no intrinsic value if left in the ground except as a potential resource for future generations, but that raises the question of how to determine if they will need it more than the present generation.

The crucial importance of preventing groundwater pollution in order to avoid a future water crisis has begun to be understood in only a handful of countries. The old proverb 'out of sight out of mind' is very apt in this case. A strong educational effort must be implemented in order not to bequeath to posterity aquifers that are almost irreversibly polluted. This is the real problem in most countries, be they humid, arid or semi-arid. The depletion of groundwater storage (classical over-exploitation) is not generally as serious a problem as groundwater quality degradation and it often may be solved without great difficulty, e.g. if water-use efficiency is improved.

Real or imagined ecological impacts are becoming an important new constraint in groundwater development. These effects are mainly caused by water table depletion, which can culminate in decreasing or drying up of springs or low flow of streams, diminution of soil humidity to an extent that prevents the survival of certain types of vegetation, and changes in microclimates because of the decrease in evapotranspiration. In some cases, the ecological result of such changes is obvious. For instance, if the water table that was previously at land surface is lowered by more than 10 meters during more than twenty years it is clear that the peatland or gallery forest that might exist on that aquifer is not going to survive. But if the water table is depleted only during one or two years and not more

than one or two meters, it cannot be assumed that the ecological impact will be irreversible. Unfortunately, quantitative and detailed studies of this type of problem are still rather scarce.

Another proverb that comes to mind is 'Prevention is better than cure'. But here, too, the precautionary principle should be applied with considerable prudence. In general, groundwater development should not be rejected or seriously constrained if it is well planned and controlled. During recent decades, groundwater withdrawal has made possible undisputed socio-economic benefits, particularly in developing countries. It is a major source of potable drinking water, with 50% of municipal water supplies worldwide depending on it, as do many rural and dispersed populations. Irrigation with groundwater has been crucial to increase food production at a greater rate than population growth, and 70% of all groundwater withdrawals are used for this purpose, particularly in arid or semi-arid regions. It should also be pointed out that using groundwater for irrigated agriculture is often more efficient than using surface water, primarily because farmers typically assume all abstraction costs (development, maintenance and operation). Groundwater abstraction usually produces significantly more income and jobs per cubic meter than surface water.

Most countries consider that groundwater abstraction should not exceed renewable resources. Others -- mainly the most arid ones -- find that groundwater mining is an acceptable policy, as long as available data assure that it can be economically maintained for a long time, for example, more than fifty years, and that ecological costs are compensated by socio-economic benefits. With careful management, many arid countries will be able to utilise resources beyond the foreseeable future without major restructuring. Clearly, it is not easy to achieve a virtuous middle way and there is a tendency to move from one extreme to the other, however, the tempting solutions put forward by those who call for the reduced exploitation of groundwater could prove just as damaging to the development of society as certain types of excessive pumping.

Despite the complexity of the question and the variety of responses according to place and time, there are, nevertheless, several overarching issues that have ethical implications in trying to achieve sustainable, reasonable groundwater use. Firstly, the hidden or open subsidies that have traditionally been a part of large hydraulic works projects for surface water irrigation are perhaps the main cause of the pervasive neglect of groundwater problems among water managers and decision makers. More

careful consideration of cost and benefit could reveal that many of these projects are economically unsound, thus fostering serious consideration of groundwater planning, control and management.

The question of public, private or common groundwater ownership is also important. Some people consider that the legal declaration of groundwater as a public domain is the necessary foundation for acceptable groundwater development. This assumption is far from evident and there are examples where groundwater has been a public domain for many decades and has been subject to somewhat chaotic management. Nevertheless, there is no disputing that promoting solidarity in the use of groundwater as a common good is vital, particularly in view of the fact that thousands of stakeholders may exist on a single aquifer of medium or large size. Groundwater management should be in the hands of these stakeholders, under the supervision of the corresponding water authority.

Availability and consistency of information is a prerequisite to successful groundwater management. Adequate hydrogeological knowledge has to be a continuous process in which technology and education improve stakeholder participation and a more efficient use of the resource.

There is an urgent need to create appropriate institutions to manage aquifers so that all who benefit from them are made aware that if they pump permanently in excess of the renewable recharge of groundwater, they may run into serious problems for themselves and for their children and grandchildren. Considering the aquifer as a shared common good brings with it the obligation to manage it in a participatory and responsible way.

PROTECTING WATER

'Filthy water cannot be washed.'

West African proverb

ECOLOGY

Water is the lifeblood of our planet. It is fundamental to the biochemistry of all living organisms. The Earth's ecosystems are linked and maintained by water; it drives plant growth and offers a permanent habitat for many species, including some 8500 species of fish, and a breeding ground or temporary home for others, such as most of the world's 4,200 species of amphibians and reptiles described so far. These ecosystems give humankind environmental security by providing staples, such as fish, medicines and timber products, services, such as flood protection and water quality improvement, and biodiversity.

The 20th century has witnessed an unprecedented rise in population: from 6 billion in 1999, it is expected to reach between 7.9 and 9.1 billion by 2025. Consequently, human demands for water for domestic, industrial and agricultural purposes have also increased rapidly. The amount of water that people use varies, but tends to rise with living standards. In general, 100 litres per person per day is considered a minimum threshold for personal use. However, according to the World Bank, when agricultural and industrial uses are included, countries with less than 1,700 m³ per person per year are considered to experience water stress, those with less than 1,000 m³, water scarcity. Because of the spatial mismatch between water resources and people, it was predicted that in the year 2000, twelve African countries with a total population of approximately 250 million would be suffering severe water stress. A further ten countries containing some 1,100 million people, or two-thirds of Africa's population, will be similarly stressed by the year 2025, while four (Kenya, Rwanda, Burundi and Malawi) will be facing an extreme water crisis.

With such a catastrophic situation, it seems an immense task simply to manage water so that there is enough for people to drink, let alone for agriculture and industry; in this light, providing water to other users such as the environment must be given a low priority. Indeed, the situation is often presented as a conflict of competing demand, as though it were a matter of choosing between water for people and water for wildlife. This ignores the indirect benefits to humanity of functioning ecosystems.

The Bruntland Report, *Our Common Future* (World Commission on Environment and Development, 1987), *Caring for the Earth* (the 1991 report of The World Conservation Union, the United Nations Environment Programme and the World Wide Fund for Nature) and Agenda 21 of the United Nations Conference on Environment and Development (Rio, 1992) marked a turning point in our thinking about water and ecosystems. A central principle that emerged was that the lives of people and the environment are profoundly inter-linked and that 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.

The sustainable development of water was the focus of the Dublin Conference (a preparatory meeting for Rio). It concluded 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.' For example, upstream ecosystems need to be conserved if their vital role in regulating the hydrological cycle is to be maintained. Downstream ecosystems supply valuable resources, such as fish nurseries, floodplain forests or pasture, but these must have access to fresh water and be seen as legitimate water users. Agenda 21 states clearly that 'in developing and using water resources priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems.' Thus, whilst people need water directly to drink, irrigate crops or supply industry, ensuring water for the environment means using 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 preserved so that the human use of water does not individually or cumulatively compromise the long term sustainability of aquatic and associated ecosystems'.

Natural ecosystems, such as forests and wetlands, play a valuable role in managing the hydrological cycle. Vegetation encourages infiltration of water into the soil, aiding the recharge of underground aquifers, lowering flood risk and anchoring the soil, thus reducing erosion. Forests also take up water and release it into the atmosphere. A rain forest tree can pump 2.5 million gallons of water into the atmosphere during its lifetime, but much of this is recycled and not lost from the forest.

Ecosystem conservation can be a cost-effective solution to water management. For example, it has been shown that the cost of establishing protected areas, of reforestation where necessary and of other measures to protect the catchments of 11 irrigation projects in Indonesia ranged from less than 1 to 5% of the development costs of the individual irrigation projects. This compares very favourably with the estimated 30-40% loss in efficiency of the irrigation systems if catchments were not properly safeguarded.

Many ecosystems support a wide range of species and a large number of individuals. Water availability is often a key controlling factor in maintaining biodiversity. The important question is at what level to maintain the Earth's ecosystems. The concept of sustainability suggests that the answer is so that they yield the greatest benefit to present generations, whilst maintaining the potential to meet the needs and aspirations of future generations. The problem is to decide how much water should be utilised directly for people for domestic use, agriculture and industry and how much water should be used indirectly to maintain ecosystems that furnish environmental 'goods' and elemental services. It is essential, therefore, that the costs and benefits to society of allocating water to maintain ecosystems and those involved to support direct use be quantified.

In many parts of the world, the limited availability of clean, fresh water is now seen as a major constraint to further social and economic development. In responding to this growing crisis, *Caring for the Earth* has called for 'better awareness of how the water cycle works, the effect of land uses on the water cycle, the importance of wetlands and other key ecosystems and of how to use water and aquatic resources in a sustainable way.'

In view of society's increasing need for water for domestic use and for the basic necessities produced by agriculture and industry, the idea that water should be used to support ecosystems rather than withdrawn directly to support people may be seen as extravagant and wasteful. Allowing rainfall to 'run away' to the sea, or be taken up and released into the atmosphere by forests, might appear as bad management of the water

resource. Indeed, as consumers of water, the landscape and plants and animals can appear as competitors with people. However, although it is true that ecosystems, such as wetlands, may lock up water, and that plants and animals consume water which can not then be put into direct use by people, 'expending' water in this way may, in many cases, offer greater benefits than those afforded by directly using it for agriculture, industry or domestic use. Making sound decisions about water allocation requires details of the water needs and the value of ecosystem functions to human life. Assessing the economic costs and benefits of ecosystems and comparing them with alternative uses of water provides one framework for decision-making. However, this only considers the economic security gained from water allocations. Social and ethical security also must be considered, requiring a multi-criteria approach.

There is also a dichotomy within water ethics. Scenes of starving and thirsty people remind us of a basic altruistic need to share resources with other members of the human race. At the same time, we feel that other species have a right to fresh water and should be given sufficient quantities to conserve the biodiversity of the planet for future generations. It is not easy to develop consistent measures of ethical justice that can be used for determining water allocations. But it may be worth the effort if we are to avoid the conclusion that perhaps ethical security is merely a luxury that can only be afforded by those who have already achieved economic and social security.

HEALTH AND SANITATION

Clean water is life, contaminated water is disease and often death. Human health depends on providing safe, adequate, accessible and reliable drinking water. Throughout history people have equated clean water with health even before the relationship was fully understood towards the end of the nineteenth century; indeed, several ancient religious codes included rules for hygienic practices that remain appropriate today. Human populations were also acquainted with the notion of using water only once and then discarding it; if the water supply became tainted, it was always possible to turn to a nearby clean source.

With the tremendous increase in world population, the provision of safe and clean water and the maintenance of sanitation systems have become more difficult to achieve. The shift in population from rural to urban areas has also put pressure on already inadequate structures. In 1955, 68% of the global population lived in rural areas and 32% in urban areas. By 1995

this had changed to 55% rural and 45% urban and it is foreseen that by 2025, the balance will be 41% rural and 59% urban. In almost all of the developing world the rate of water supply and investment falls behind urban growth. Within cities, mortality rates are higher in low-income settlements due to poor housing, high population density and lack of basic services.

Sanitation can reduce the incidence of infectious diseases by 20% to 80% by inhibiting disease generation and interrupting disease transmission. From 1990 to 1994, approximately 800 million people gained access to safe water, however, because of population growth, the number of those unserved decreased only from 1,600 million to 1,100 million. During the same period the number of people without sanitation increased by 300 million. In 1994, they numbered 2,900 million and this was expected to grow to 3,300 million in the year 2000. These were the results after a global effort promoted by the United Nations with the International Water Supply and Sanitation Decade (1981-1990). The ambitious goal was to achieve worldwide availability and use of readily accessible, safe, reliable and adequate community water supplies and sanitation by the year 1990. During the decade, significant improvements were made, as the population served with safe drinking water increased 240% globally and in rural areas by 150%. On the other hand, the percentage of urban population with sanitation increased only from 69% to 72%. Sadly, the goal was not met.

A recent UN report states that more than 5 million people die annually from diseases caused by unsafe drinking water and lack of sanitation and water for hygiene. According to the World Health Organisation, billions of people are at risk due to water-borne diseases. In 1997, 33% of all deaths were due to infectious and parasitic diseases. Diarrhoeal diseases caused 2.5 million deaths, typhoid fever caused 600,000 deaths and dengue and dengue haemorrhagic fever caused 130,000 deaths. By 2025 there will be 5 million deaths among children under five years of age and 97% of these will occur in developing countries, most of them due to infectious diseases combined with malnutrition.

Safe drinking water means that it will cause no damage to human health, that it is free from organisms capable of causing diseases and from other substances that potentially induce physiological damage. Drinking water must be aesthetically acceptable as well: colourless, odourless and flavourless. These conditions form drinking water standards and when they are met the water is considered potable. In 1925, the United States

established standards for physical (aesthetic) and bacteriological conditions and for four chemical constituents. In 1980, the European community set 66 standards and by 1993 the United States had identified more than 130 drinking water standards, the major part related to maximum concentration of toxic chemical compounds. Despite the development of new standards, the health risks due to chemical compounds are greater today than in 1925. And while such risks may seem insignificant when compared to the health hazards of viral and bacterial contamination, the fact is that the increasing magnitude of chemical pollution is leading towards an even more critical problem in the future.

Sanitation procedures should go hand in hand with any plans to expand the water supply and financing for both aspects guaranteed. This is vitally important in developing countries where large numbers of people rely on water vendors and have no access whatsoever to sanitation and where some 90% of wastewater is left without treatment. But the costs can often be prohibitive: the per capita, simple water supply investment in many parts of the world ranges from \$10 for hand pumps to \$200 for piped water delivered to houses. Adding basic sanitation services costs about \$100 per capita and piped sewage with treatment about \$3,500 per capita. In other words, lack of access to safe drinking water and sanitation is directly related to poverty and poor health.

And yet it is true to say that the very poor actually pay a great deal for water but these costs are often hidden. Moreover, while they may be constrained to pay a high unit cost as individuals, it is not clear how they could contribute to the heavy capital investment required for large supply systems which would, in the long run, reduce their individual unit costs. It is inevitable that huge social dislocations will occur as water is priced differently, making clear the need for an ethical compass to set a proper course of action.

In sum, the issue of water and health must focus on a number of basic conditions: supplying water in adequate quantity and quality; conserving water by promoting policies to 'reduce, reuse and recycle'; establishing 'highest priority use' to buttress the concept of the right to clean water; making public participation work; ensuring equity in access to water supply and sanitation services; placing health and well-being at the forefront in setting out efficiency indicators for water projects, and searching for alternative water treatment approaches which are affordable in developing countries and which reflect cultural practices.

NATURAL HAZARDS AND DISASTERS

Hazards may be man made or natural; all hazards are not disasters nor all disasters the result of natural hazards. The link between them is the degree of vulnerability, which is generally defined as the capacity to anticipate, cope with, resist and recover from the impact of the natural hazard. The variation of vulnerability between countries and between socio-economic groups in the same country is a major factor in any consideration of ethical questions arising from disasters, for some population groups are far more defenceless than others: the poor, women, children and youth, the elderly and some minorities are the most disadvantaged. Women in particular are more exposed to immediate disaster impact, more affected by household disruption and more likely to have no access to resources during recovery than men. Because they play a key role in the area of water, their vulnerability is a vital element in dealing with disasters. It is only by taking steps to relieve this situation before disaster strikes that long-term solutions may be found. As stated in the message of the World Conference on Natural Disaster Reduction (Yokohama, May 1994), 'Disaster prevention, mitigation and preparedness are better than disaster response... [which] is not sufficient, as it yields only temporary results at a very high cost.'

Average annual losses due to natural disasters are growing and their costs as a percentage of GNP are vastly higher in the developing world. For example, floods in Bangladesh in 1988 affected 48 million people, destroyed 1 million homes and wiped out six months of economic growth. More than 70% of the world's poorest people are thought to live in ecologically sensitive areas that are subject to disasters such as drought and floods. These are usually dealt with together because both are extreme hydrological events and both cause thousands of deaths and significant material damage each year. Nevertheless, procedures for foreseeing and alleviating them are different, for flood forecasting today is much more reliable than drought prediction and floods are usually phenomena of short duration, lasting from a few hours to several days while drought is a longer process, with disastrous consequences emerging after several years. Controlling floods may require structural solutions (dams, dikes, etc.), non -- structural approaches, (water markets, insurance, restriction regulation, etc.) or mixed conjunctive uses of surface and ground water. In some countries, the lack of planning to temper the impact of floods and droughts is a result of poor institutional capacity, improvisation and negligence.

The problems associated with droughts and floods are integrated, that is, they emerge as a result of a system of behaviour around the river basin. However, institutions to deal with them, even in the developed world, are fragmented and solutions tend to be ad hoc, partial and reactive. A more seamless web between the agencies responsible for anticipating and sensing disasters and those charged with response, planning and relief needs to evolve, and nowhere is this more clear than in the collecting, processing and use of hydro-meteorological data. But it cannot be overlooked that although adequate information is of the utmost importance, it is not the whole story -- professionals have a responsibility not only to provide and share data but to recognize the equal importance of ethical principles in using such information to benefit those who are at greatest risk so that natural hazards do not automatically trigger humanitarian disasters.

DISTRIBUTING WATER

'You don't miss your water until your well runs dry.'

An old country proverb

MANAGEMENT

Water management is fundamentally a question of environmental justice based on three essential concepts: equity, fairness and access between and across generations. Its ethical dimension may be perceived in the way answers are found to the following questions: who participates in the decision-making process; what are the decisions they act on; are they involved in formulating options or are they expected only to react to proposals that are already well-developed; how and what type of opportunity costs are considered; what is the basis of ascribing the value of various decisions that may have to be played one against the other; what kind of information is open to the public; to what extent are impacts taken into account and how are they characterized; how do professionals interact with non-professionals and how is technical and professional information used.

The linkage between development strategies and conflicting issues of water allocation, supply and pricing must be seen in the context of macro-economic national and regional approaches. The current debates over private versus public roles in water management are too narrowly focused and frequently ignore important historical realities. Privatization is often seen as a way to increase efficiency and to bring more and safer water to more people. However, it also raises questions of open information channels and transparency. Profit-making organizations are not necessarily as prone to share critical information on water flow or quality as their public counterparts, particularly where there is a weak regulatory environment. Moreover, privatization of the vendible aspects of water can result in single-purpose planning and management, which contradicts the ethic of integrated water resources management. Some water services such as flood control cannot be privatized; others, such as navigation, may be only to a degree. Thus, attempts to privatize may encourage the fragmentation which integration seeks to overcome.

There is a difference between a public good and a common property under public trust. The evolution of water law and institutions historically has been inspired far more by the latter than by issues of private or public ownership. Indeed, the debate in Europe is moving from private versus public to one that focuses on public regulation on the one hand and, on the other, a form of common-property based governance whereby water is held in trust by the state, but managed at more adapted subsidiary levels. This is often called 'municipalism' and it moves from the concept of ownership rights to that of user rights. Even in this context, state intervention is vital to ensure equity among users and to introduce needs outside the municipality such as those demanded by the river basin or watershed. International water law is also moving in this direction by increasingly referring to transboundary and international waters as common waters and thus subject to ethical and legal norms beyond those generated by the nation-state.

Privatization often evolves not for positive reasons but because public procurement could not generate important investments or because elected officials do not want to appear responsible for water price increases. But other options exist, such as managing utilities services together and pooling financing needs or temporal averaging of interest rates to lower the cost of money required for water investment. In this regard, we should not forget that the initial infrastructure investment in Europe was based on massive subsidies. Thus, in those places such as southern Europe and the developing world where the basic infrastructure is not yet complete, the principle of full cost recovery takes on a different ethical meaning, handicapping those who are striving to achieve water security.

Recognizing water as an economic good, now expressed in many declarations and in the policies of major lenders and donors, has generated heated political debate, much fear and revealed fundamentally differing cultural values associated with water. Some claim that fostering the notion of water as a commodity moves public perception away from the reality of water as a common good and from a sense of shared duty and responsibility. In other words, there are profound ethical implications in perceiving ourselves as water citizen as opposed to water consumers. Seeing water as a common good focuses on the former while the question of private or public ownership rights emphasizes the latter.

Of course, the reality is that water is an element of production and managed as a commodity in some degree by all societies. Whether explicit or not, it is valued and it clearly incurs opportunity costs. However, all the costs and benefits are not and cannot be reduced to a quantifiable

currency. Water is priced in some way by all societies and the poor often have no choice but to pay high prices, spending between 5-10% of their income, and in some places as much as 20%, buying water on the streets. In contrast, in most industrialised countries lower-middle class families only spend 1-3% of their income on potable water and sanitation.

Clearly, if water is not priced correctly it will be wasted. However, the reverse is not true: if water is simply just another consumer good, it will also become too expensive. Proper management requires good data on use and this has come to mean metering in many places. This is not without risk, for if pricing and allotment are determined by a meter and not on a per capita basis we can easily end up subsidizing the rich along with the poor. In fact, water demand is actually falling in many developed societies for a variety of reasons, but when this happens unit prices often increase to cover debts. For the public to accept such a situation, it has to be convinced that authorities are legitimate and trusted and that transaction costs are being kept as low as possible. If this is not perceived to be the case, public support can dwindle, as indeed happened during droughts in England when the public responded positively at twice the rate to the appeals for demand reduction emanating from municipal authorities than to those coming from private companies.

The power to use water for economic development or as an avenue to redistribute income and wealth is a significant political and social tool. Thus, effective government, or legitimized governance, is central in any use of markets as it guarantees secure user rights, assures low transaction costs, assesses and attenuates third party impacts, and provides the means for consensus building and conflict resolution not found in the market. All varieties of public and privatization policies to deal with water require significant ethical responsibilities for enhancing public institutional capacities. Just as we need better water pricing, we must realize the role that subsidies have played and are realistically going to play in the future. In this light, clarity of information and in decision making and broad user participation are key ethical imperatives for water management.

Traditionally, cost-benefit analysis and more recent risk assessment have been central to procedures for deciding on water investment. Since these tools favour quantified data, they can inadvertently be biased. For example, cost-benefit analysis for flood control is often property based. Thus, those without property become less valuable to protect and public expenditure begins to favour the rich. So, too, with ecology, which, since it cannot easily be quantified, may be relegated to secondary importance or,

on the contrary, valued to such an extent that reasonable priorities cannot be established. New investment decision tools which take such bias into consideration and help us to compare the incommensurate must be developed and used. The relation of the flow of money and the flow of costs and benefits must become more transparent. To the best of our ability, we must know the consequences of our actions as a precondition to ethical decision-making. Thus, impact assessments are crucial to ensure that the choices made are both technically informed and morally sound.

All of this implies that information is available commensurate with the emerging needs for decision making. As we increase efficiencies and operate water systems (urban and irrigated) closer to their margins, risk-based management will become more prominent. However, such management requires good hydrological, social, economic and other data -- and such data is all too sparse, despite the fact that it costs less to develop an acceptable data base than to build a medium-sized dam.

Special consideration must be given to the role of women, who are the principal water managers in many small villages and communities. As such, they become the keys to maintenance and operations and frequently have the greatest impact on water procedures. Nevertheless, although they furnish twice the amount of work in irrigated agriculture than men and are more concerned with improved domestic water supplies, women are rarely involved in strategic decision-making processes regarding water resources management. Yet studies continually show that the participation of women is not only ethical but pragmatic as well -- those projects involving women are more likely to be sustained and to generate expected benefits. Guaranteeing women's rights to fresh water has a direct impact on the community and this was formally acknowledged at the Rio Conference.

In sum, it is clear that the democratic management of such a particular common property as water requires a complex institutional arrangement. Simple and straightforward solutions designed for the sake of pure economic efficiency, such as privatization of water rights and their transferability, may well end up as unsustainable. If water management is moving towards a balance between the traditional role of the state and the re-emerging communitarian ethic, we must broaden our knowledge of what each of them can bring to achieving the goal of equitable policies and management.

INTERNATIONAL CO-OPERATION

Almost everyone lives downstream. An estimated 40% of the world's population depends for drinking water, irrigation, or hydropower on the 214 major river systems shared by two or more countries; twelve of these waterways are shared by five or more countries. In some countries, almost the entire flow of surface water originates beyond their own borders -- 98% in Turkmenistan, 97% in Egypt, 95% in Hungary, 95% in Mauritania, and 89% in the Netherlands, for example. Disputes between upstream and downstream riparians over water use and quality simmer in virtually all parts of the world. These involve reduced water flow and siltation because of dams, water diversion for irrigation, industrial and agrochemical pollution, salinization of streams due to unsound irrigation practices, and floods aggravated by deforestation and soil erosion.

Most scholars agree that outright conflict has the greatest potential to emerge when the downstream (most vulnerable) nation is militarily stronger than the upstream (water-controlling) nation and feels that its interests are threatened. When downstream countries are relatively less powerful than water-controlling upstream countries, conflict may be less likely, but social and economic insecurity -- which in turn can lead to political instability -- may be great. However, not all water resources disputes inevitably lead to violent conflict; on the contrary, it may be said that most lead to negotiations, discussions, and non-belligerent resolutions. In some parts of the world, river commissions with representatives of riparian countries provide a forum in which disputes can be addressed adequately. Elsewhere, however, adversarial relations among riparian states make for a much greater challenge and it is not certain that existing international water law will be able to handle the strains.

Measures that historically have been used to promote water-sharing equity include rights-based measures, largely addressed by the international legal community; needs-based measures, particularly using population, arable land, or historic use parameters; and measures based on economic definitions or efficiency. None of these alone, however, can incorporate all of the physical, political and economic characteristics that are unique to each of the world's international waterways. A process for co-operative watershed management is vital and international lenders and donors must create the incentives for such an approach and encourage the development of social organization around river basins.

Numerous agreements have been hammered out in the attempt to define what constitutes fair sharing of a particular waterway. The Food and Agriculture Organization (FAO) has identified more than 3,600 treaties related to non-navigational water use between the years 805 and 1984. Since 1945 approximately 300 treaties dealing with water management or allocations in international basins have been negotiated. None of the various and extensive data bases on causes of war have indicated water as the primary factor. Even in the highly charged Middle East, the first paper signed by three major parties during multilateral peace negotiations concerned water. Indeed, water agreements have actually prevented major conflicts, such as on the subcontinent between Pakistan and India.

Nevertheless, it is clear that the increased competition for water both within and between countries as supplies increasingly fall short of needs could pose a major threat to human security. Of the three principal forces which conspire to create scarcity and its potential to incite conflict -- the depletion or degradation of the resource, population growth and unequal distribution or access -- it appears that unequal distribution often plays the most important role.

This means that the question of 'equity' is at the heart of water conflict management and that the solution to water scarcity lies not necessarily in building water markets but in consolidating the rules for sharing found in customary international law, which develops through a process of claim and counterclaim, with the nations making the claims appealing to legal rules to establish their rights. Customary law does something that the market cannot: it recognizes the unique nature of water. Instead of trying to determine who 'owns' what proportion of a river, it lays down a set of rules for sharing, among them equitable and reasonable use, obligations not to cause appreciable harm, commitment to co-operate, regular exchange of data and information and recognition of relations between users.

The international community took a major leap forward in 1997 by approving the United Nations Convention on the Non-Navigational Uses of International Watercourses by a vote of 104 to three. It will unquestionably be the leading law governing internationally shared fresh waters once it is ratified by 35 nations -- a process that could take many years. The convention provides a set of standards in codifying the rule of equitable utilization based on a long list of diverse factors -- from geographic and ecological considerations to the economic value of existing and potential uses of the waterway. The aim is to help arbitrators and judges determine 'equitable' sharing, which does not necessarily mean equal shares.

Water is forcing us to rethink our notions of security, dependency, and reciprocal obligations. Although water sharing plans and infrastructure networks are viewed by some as increasing vulnerability and reducing security, there is an alternative way to look at interdependence: it can be seen as a means of providing safeguards by boosting our flexibility and capacity to respond to exigencies of nature such as droughts and floods and of fostering a climate of mutual respect and rapprochement.

Water can be an overarching value capable of coalescing conflicting interests and facilitating consensus building within and among societies. The symbolic content of water as cleansing, healing, rebirth and restoration can provide a powerful tool for co-operation and for promoting acts of reconciliation so necessary to conflict resolution in other areas of society. In a sense, negotiations over water use in themselves may be seen as a secular and ecumenical ritual of harmony and creativity.

GUIDING PRINCIPLES

If ethics are to be the basis for resolving intricate questions involving a multiplicity of often conflicting perceptions, a foundation of agreed upon principles must underpin public policy. The following Guiding Principles thus address the need to contribute to the water debate by identifying a number of fundamental concerns that go beyond science and to find ways of putting people at the heart of an increasingly complex, fragmented and impersonal vision of the world. The emphasis is on the notions of solidarity, social justice, equity, water as a common good and ecological stewardship that have emerged as the principle issues of our time. They are in no way exhaustive but should be viewed as opening, rather than concluding, the international dialogue on the ethical dimension of freshwater resources that is so vital for human development.

WATER AS AN ETHICAL ISSUE

- Ethical considerations cannot be viewed as part of a linear model, to be spliced somewhere into the water chain; they are not a discrete process but must inform each and every aspect of freshwater use.
- Basic underlying principles begin with the notion that human beings have the right to clean drinking water, water for food, health and development; fostering notions of water as a primarily economic commodity shifts public perception away from a sense of water as a common good.
- Ethical guidelines should reflect the concepts of sustainable development and environmental justice, which are underpinned by equity: equity between geographical entities, between the industrialized and developing world, between rural and urban populations, between generations and between the managed and the managers.

- Governments should set out clear guidelines of environmental standards for water and put in place the laws, regulations, subsidies, taxes and incentives to achieve them; an important element is the Polluter-Pays Principle (PPP) enunciated by the OECD, which requires that polluters pay for the cost of meeting these norms.
- Transnational corporations are often more powerful than individual countries and must be held accountable and bound by ethical guidelines.
- Water scarcity is not absolute but is frequently a function of inequities of wealth, knowledge and resources; alleviating it depends in large measure on tapping the potential of local communities and making maximum use of their skills and experience.

CONSUMING WATER

Agriculture and food security

- Food security is a moral imperative and the demands of industry and the needs of irrigation should be co-ordinated so as to ensure that subsistence farmers have the right to water, which includes full use of rainfall, rainwater harvesting and adequate sources for irrigation.
- More efficient use of water for agriculture should be encouraged to increase soil production and crop yield and to avoid waterlogging and salinization. Incentives might be offered to farmers to obtain the necessary -- and not necessarily costly -- equipment and capacity, and a more equitable distribution of irrigation networks organized so as to allow greater tracts of land to be irrigated with the same amount of water.
- Traditional and modern technologies are there to complement each other; the use of local agricultural expertise and techniques should take precedence over imported methods that may be inappropriate and not adapted to community needs.
- Partnerships should be established between rural and urban areas for recycling organic waste.

Industry

- The important contribution that industry makes to national development should go hand in hand with the need to take into account prevailing socio-economic conditions and to manage the water required for its operations, products and services in relation to the available local supply.
- Industry can contribute to water sustainability by utilizing renewable flows and avoiding withdrawals that are not replenished, conserving water to reduce the volume of withdrawals, returning water that is not used to natural flow basins for use by others, discharging waste water only after treating it to environmentally safe quality, taking responsibility for downstream effects, and continually monitoring practices and operations to seek improvement in the overall use and safety of water resources.
- The water needs of local ecosystems should be included in any assessment of industrial and commercial operations, discharges, products, and services.
- The ethics of dam construction call for avoiding or minimizing adverse environmental and social impacts and for using existing reservoirs at maximum efficiency before building new ones; all possible alternatives should be considered, including legal arrangements, modification and restructuring of available water resource systems, exploitation of existing as well as new sources, more efficient water distribution and use. Reservoir development should be based on local participation in the decision-making process and full information disclosure of the proposed plan; the people involuntarily displaced should be cared for until they and their community regain their existing vitality and viability.
- Industry, along with governments, should invest in educating the public to adopt habits and practices that foster water sustainability.

Groundwater

- The contradictions between nature conservation and groundwater development will be different from country to country and over time. Nevertheless, for arid regions which have very small amounts of renewable water resources but huge amounts of fresh groundwater reserves, groundwater

mining may be a reasonable action if various conditions are met: the amount of groundwater reserves can be estimated with acceptable accuracy; the rate of reserves depletion can be guaranteed for a long period, e.g., from fifty to one hundred years, and the environmental impacts of such groundwater withdrawals are properly assessed and considered clearly less significant than the socio-economic benefits from groundwater mining, bearing in mind that the resources will be exhausted at a certain point.

- Aquifers are a shared common good and must be the object of careful management plans, especially where they are the major resource for large-scale irrigation.
- Good, reliable information is crucial to facilitate co-operation among aquifer stakeholders, who should have ready access to data on abstractions, water quality, and aquifer water levels; in many countries this could mean changing the traditional attitude of water agencies unaccustomed to facilitating public access to water data.

PROTECTING WATER

Ecology

- Maintaining ecological sustainability is one of the primary objectives of water ethics; in other words, the natural environment has a right to water.
- Environmental values should be a fundamental element in decision making with regard to water resources and ecological health seen as a vital factor in production.
- Many ecosystems are of direct benefit to humanity and should be treated as legitimate water users, receiving adequate amounts to remain healthy; methods need to be developed to determine the water needs of other species and ecosystems and to assess the impact of insufficient water allocation.

Health and sanitation

- Drinking water standards should be established and enforced to ensure adequate quality, and water sources protected from pollution, particularly from industrial residues.

- Equity in access to water supply and sanitation services may require that specific action be addressed to the needs of lower income populations.
- Public participation in rural water supply projects is the most significant factor in ensuring their ultimate viability; improvement in health and well-being should be included as measurable indicators of the success of a water project rather than relying solely on cost recovery results.
- In cases of drought, supplying water for domestic needs should take priority over other uses.

Natural hazards and disasters

- Human behaviour, often the result of extreme poverty and few options, is increasingly a major cause of natural disasters; to prevent such emergencies, prior planning and co-ordination is vital. Thus, the various agencies responsible for collecting and analysing hydrological data must co-operate so that disaster preparedness and early warning systems may be established for flood and drought.
- Scientists, engineers and other experts should provide the best possible estimates of risks and local vulnerability to a specific type of hazard, based on reliable data and coherent interdisciplinary conclusions; local and national authorities must make the concerned public aware of this information.
- An essential policy imperative for preventing humanitarian disasters is to find ways to regulate human settlement on flood plains; the participation of local communities is key to creating flood policies whereby the concerned populations know what to expect and are able to develop contingency plans.

DISTRIBUTING WATER

Management

- Decision makers must understand the linkage between development strategies and conflicting issues of water allocation, supply and pricing; certain choices may have negative implications for people whose poverty deprives them of full rights, and action should be foreseen to mitigate their impact.

- Adaptive water management institutions are those that develop persistent, long-term strategies, guided by widely supported principles and the need to strike a balance between tradition and innovation, making the most appropriate use of new technologies while at the same time maintaining established practices that have proved their worth; they are information rich and able to communicate their knowledge to the public; they are multidisciplinary, fostering co-operation between social scientists and engineers; they are regularly monitored and participatory; their decision-making processes are well-defined, with full disclosure of the criteria used.
- Guaranteeing women's rights to fresh water has a major impact on the community; thus, the participation of women in water management decisions becomes an ethical imperative for social development.
- The debate over organizing water distribution must move beyond choosing between the poles of privatization or public administration to explore the myriad options that lie between them; it is essential to avoid imposing policies based on experiences not shared by those for whom they are being prescribed.
- Water price has a strong impact on access to food and while it is acknowledged that water cannot be free of charge, it must be made available at a fair price that does not provoke social unrest.
- Renewable resources should not be consumed faster than their regeneration rate; waste discharge should be maintained at or below the assimilative capacity of the environment.
- Water management requires good data, which, unfortunately, is sorely lacking in much of the world; efforts should thus be made to develop a comprehensive, regularly updated global set of hydrological data.
- Data that has been collected at public expense, for example, on resources, monitoring, and long-term records, should not be regarded as intellectual property that may be exploited for gain by any particular group.

International co-operation

- Water should be recognized as a tool for community development, peace building and preventive diplomacy.

- Trans-regional management should be encouraged for all countries that share water resources, be they riverine or groundwater; those who claim upstream or downstream rights to water should share data and information with other users.
- Ethical considerations should underpin the decisions of international lenders and donors who should aim to foster co-operation among water stakeholders within and without national boundaries.

LOOKING TO THE FUTURE

Water is definitely a crucial issue that needs to be urgently addressed. During the Second World Water Forum the message came through loud and clear and received a positive international response through the «Ministerial Declaration of The Hague on Water Security in the 21st Century» which is the start of a long-term political commitment to solving global water issues in developing collaboration and partnerships and building a secure and sustainable water future. To those ends the contribution of society as a whole is required. The Ministers stressed the necessity 'to work together with other stakeholders to develop a stronger water culture through greater awareness and commitment' to 'identify best practices, based on enhanced research and knowledge generation capacities, knowledge dissemination through education and other channels and knowledge sharing between individuals, institutions and societies at all appropriate levels'.

The elaboration of a certain number of guiding principles thus cannot be considered as an end in itself but should be seen as a commitment for action to spearhead and share cutting-edge water research so as to provide a model for science in the new century -- science that is dedicated, ethically motivated and trans-disciplinary, integrating the work of social scientists, economists and moral philosophers along with scientists and engineers. To do so requires a major effort at international co-operation that would bring within its sphere scientists and researchers from both industrialized and developing countries and engage them in an ongoing dialogue with the general public as well as with each other. In essence, it would function as a clearing house for information, acting as a network of networks and seeking to identify and attract potential partners the world over.

COMEST thus proposes to sponsor a global Research and Ethical Network (RENEW), which will first identify and endorse examples of best ethical practice in all aspects of freshwater use. The organisations so recognized will be invited to participate in the Network, where collaboration and cross-fertilisation will be fostered among members. This proposal is made in the conviction that there will be inestimable benefit to humanity by bringing to the fore the best exponents in various water related disciplines.

Research centres, education and training facilities, water suppliers and regulators, industrial and agricultural users, organizations concerned with information transfer and exchange, as well as with promoting the empowerment of all water stake-holders, will be among the disciplines and interests eligible for membership of RENEW. The network will include a number of regional centres selected on both geographical considerations and, where appropriate, on the strength of their ability to contribute most effectively to innovation and dissemination of best ethical practice. These centres will provide facilities to host visiting researchers, students and workshops on all aspects of the ethical use of fresh water. They will be selected by COMEST/UNESCO trustees who will also be responsible for drawing up detailed guidelines for each sector. The trustees will be required to co-operate with all other relevant international agencies to ensure that the network benefits from the widest possible spread of expertise.

The concerns of the research members of RENEW will range from science and engineering to the social sciences, education and training. Links with industry, agriculture and other water users must be forged at all levels; industry, in particular, will be encouraged to apply for membership. A primary goal is to promote public awareness, education relating to water conservation and protection, and dissemination of knowledge and information about research findings and methodology to improve freshwater quality, as well as on best practices and technology. Special attention will be paid to the role of women as decision-makers and managers in acquiring and using water.

It is anticipated that this initiative will attract national and international funding and support from governments, agencies, industry and universities that acknowledge the benefits to be derived from recognition as members of the network.

RENEW would work in tandem with a parallel UNESCO proposal to create a Global Organization of Universities for Teaching, Training and Ethics of Water (GOUTTE), which is conceived as a large, global, water-oriented umbrella organisation of universities and university institutes

active in teaching and training and willing to contribute to shape a 'New Water Ethics' in academia and, subsequently, in future practice. The ethical dimension of this partnership lies in the explicit commitment to provide moral leadership in forming and educating professionals and scientists sensitized to the accepted principles of sustainability, environmental consciousness and equity. GOUTTE would act as a forum where collaborating entities and their programmes can be discussed, compared and concerted. It would function through state-of-the-art communication and regular conferences, providing global exchange opportunities for ideas, concepts and results.

By linking these two projects, RENEW and GOUTTE, UNESCO would play an indispensable role in ensuring that best ethical practice is widely and effectively promoted on a global scale.

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Freshwater mussels are an important component of the biodiversity of Michigan's aquatic ecosystems. They have a unique ecological role in both rivers and lakes and are valuable indicators of ecosystem integrity and function (Adkinson et al. 2013). Mussels are of significant value to the health of aquatic ecosystems (Vaughn 2017). Regardless of quadrat size used, survey results should adequately represent the total survey area. Blocks will be arranged in a continuous manner to provide bank-to-bank coverage. Quantitative samples to be collected shall be 3 quadrats per 3m by 5m block.

Earth's Freshwater: Full Teacher Guide Chapter 1: Biodiversity in Freshwater Chapter 2: Water Cycle and Water Reservoirs Chapter 3: Changing Natural Flows of Water Chapter 4: Water Quality in Freshwater Systems Chapter 5: Water Concerns for Wildlife and Humans Chapter 6: Water Rights and Human Communities Chapter 7: Water Solutions for Our Future. Students explore the distribution and uses of fresh water on Earth. They explore models of porosity and permeability, run experiments with computational models, and hear from a hydrologist working on the same question. View Unit. Using Fresh Water. Household water withdrawals. Freshwater use for households and public services. Share of freshwater withdrawals used in households. Water stress and scarcity. How much renewable freshwater resources do we have? What share of freshwater resources do we use? What determines how much water we use? Poorer countries used more water for agriculture. Ethics of Freshwater Use: a Survey. Lord Selborne is the chairperson of COMEST's sub-commission on the Ethics of Fresh Water. The author begins by laying the groundwork for an ethic of the use of freshwater. The field of Ethics is essential to matters of freshwater use because the world's water problems are mainly related to poor distribution of water, knowledge and resources, not to absolute quantities. Therefore, the goal of this discussion should be to guide sustainable and equitable development. The various uses of water are discussed in light of the ethical questions that they raise. There can be no ethical distribution of water if the needs of all stakeholders are not considered.