ARTIKEL

WATER

Water today and tomorrow

Prospects for overcoming scarcity

1998, in 'Futures'

This paper provides a general overview of the fresh water scarcity that parts of the world are facing today and will increasingly face in the coming decades. It demonstrates why and how many countries, especially developing and newly industrialized regions in the Middle East, Africa, Asia and South America will be vulnerable to lack of water. It shows how this will affect health, mortality and the prospects for peace if nothing is done to correct the imbalance between supply and demand. It is argued that scarcity is largely the result of poor water management and that with the implementation of proven methods of raising the efficiency of water withdrawal, use and consumption on the one hand, and of more efficient and integrated water supply on the other, the problem could be solved.

Water is a unique natural resource with intriguing qualities; it is weak but at the same time very strong, it can be still or turbulent, it invokes spiritual reflections and rituals, but on a scientific level is the main source of oxygen and carbohydrates, both essential for maintaining life on earth.

Water provides resilience, flexibility and flow in natural organisms, but also serves maritime transportation and industrial processes. Water is both the habitat of a stupendously rich and colourful marine population and an irreplaceable resource for domestic use and hygiene.

There is no substitute for water. It is the most vital component of the earth system: about 70% of the world's surface consists of water. Nearly 70% of worldwide fresh water resources are used in agriculture and water comprises roughly 70% of the human body. In the history of our planet water has played a crucial role not only in the emergence of life some 3.5 billion years ago, but also in the birth of the first great civilisations that sprang up in the major river basins of the world, in Egypt, Mesopotamia, India and China, between 3000 and 1500 BC.

In the second half of the 20th Century we have observed a rapidly growing scarcity of fresh water with all its attendant stress. It has manifested itself in an ever greater number of countries and regions as populations and consumption scale heights that surpass the rate at which fresh water is renewed by its one and only resource: rain.

The availability of clean fresh water is one of the most basic conditions for achieving sustainable development in the 21st century. Sustainable development implies that future generations should have the same opportunities of enjoying a decent quality of life as does the present generation.

When there is not enough water, there is insufficient food regardless of how clever we are at increasing crop yields. It makes sense, therefore, to investigate the past, the present and the future of fresh water availability and to assess the role our present generation must play in order to achieve that desired sustainability.

What is at stake here is more than preserving quantity and quality. We are facing the challenge of preventing massive migrations and conflicts, large-scale famine and epidemics and staggering mortality rates. The tragedies we have recently seen in Somalia, Sudan and Burundi are but minor and incidental examples. The possibility of this menace becoming reality in the short term is more predictable than the still unclear long-term threat of global warming. Presenting the water issue is not a matter of doom thinking, but of facing realistic scenarios that should inspire us to change the present course of events by improving, indeed sometimes revolutionizing, the way we handle one of the most precious resources on earth.

The overview starts with chemistry and spirituality and finishes with technology and business. This is symbolic of the changes that have occurred in human society over the ages. The more we have been able to manipulate nature, the more we have lost respect for it; and so it has happened with water. Water has in our day and age become a purely technical and material thing, assumed to be freely and abundantly available. Now, however, we are experiencing the limit to this paradigm.

The question is whether we can repair the damage and pre-empt the threats solely by financial and technical means. Such means are vital but they may not be sufficient or in time. In addition, therefore, we need to rediscover respect and humility towards this, billions of years-old, life-giving and life-supporting resource and treasure every drop of it. If this is taken to heart by every living individual, there will be no scarcity and no threat.

What is water?

In the disciplines of chemistry and physics water is a molecule consisting of two hydrogen atoms and one oxygen atom, a strong trinity symbolized in the chemical formula H_2O; under atmospheric pressure it is liquid between 0 and 100°C, vapour above and solid below this range. An exceptional quality of water is that it expands when cooling down below 4°C before turning into ice. The result of this quality is that ice always floats to the top of the water level and the water under the ice remains above zero, which is necessary for the maintenance of under water marine life. Essential for life on earth, water would not have been able to develop its unique function if not in liquid form and this was made possible by the extraordinary and relatively

stable range of temperatures on the surface of our planet.
It is the very simplicity of the chemical composition of water that makes it so strong a molecule. Usually, the more complex the chemical compound, the more fragile it becomes and the shorter the lifetime it enjoys, as manifested at the extreme end by living organisms.
Water must have emerged at an early stage of the evolution of the universe and most existing water molecules must have survived more than 12 billion years. One of the components of water, hydrogen, was the first atom to emerge from subatomic particles immediately after our universe was born as part of the endless cycle of eternity. It is still one of the most robust atoms in creation. It is not surprising, therefore, that the most powerful weapon in our high tech age is the hydrogen bomb; splitting the hydrogen atom releases incredible energy. In fact, the alternative peaceful use for this power, i.e. the employment of hydrogen as a fuel for electricity generation and transportation, will probably be a major factor in solving the growing world population's energy needs of the 21st Century. Interestingly enough the source of hydrogen, and probably the exclusive source, will be water which can be split into oxygen and hydrogen through electrolysis using, preferably, solar energy.
When in the early stages of life on earth, 3.5 billion years ago, the food needed to nourish the growing population of monocellular organisms began to run short, the 'invention' of photosynthesis around a billion years later solved the problem in a simple and elegant chemical concept:

$$\mathbf{H_2O + CO_2 — CH_2O + O_2}$$

CH_2O, in common language carbohydrate, synthesized in this way through the beneficial influence of solar energy, has ever since that revolutionary innovation been one of the vital building blocks of food in the world. And just as simply as the concept works in one direction, it does the same in the reverse:

$$\mathbf{CH_2O + O_2 — H_2O + CO_2}$$

releasing the stored solar energy by 'burning' the carbohydrate with inhaled oxygen to keep organisms alive.
The by-product CO_2, carbon dioxide, becomes available again for the reaction in the other direction. If the balance is not maintained and the energy is directed to other uses, we get a surplus of CO_2 in the air. Today we are uncertain and worried about what the extra 'greenhouse' effect thus created will do to our climate and habitat.
In order to complete this simple and short history of the basic chemical role of water in life, it should be mentioned that it was through the process of photosynthesis that, within a relatively short space of time, the oxygen (O_2 in the equation) content of the atmosphere was raised from almost zero to about 22%, where it has remained ever since. The ozone layer, made up of molecules containing three oxygen atoms was also formed. Both are vital for the living conditions of the natural world today.
So much for the story of the chemistry and physics of water. It is a story of simplicity and elegance with far-reaching consequences for the evolutionary pattern of the past and, as we will see, of the future.
In the realm of the **physical**, the story starts with water providing a fluid and harmonious continuum for the emergence of life on the planet, the so called 'soup' in which presumably the first DNA molecules came into existence. Water is the medium within which cells and cellular components can enjoy flexibility and easy interaction in order to pursue their long and adventurous evolutionary journey, leading up to complex organisms which can maintain their own flexibility and internal metabolism only through the presence of water in their bodies and organs. Water also means the rivers, the lakes and the seas in which the living organisms can thrive, swim, wash and bathe and on which they can gather, migrate, sport and reflect.
Finally, humanity aspired how to harness the power of water by constructing dams and canals and to initiate the industrial revolution, starting with steam engines and progressing to hydro-electric power stations and 'heavy water' based nuclear reactors.
And this is not all, because ever since recorded history and on into our present times the **spiritual and symbolic** perceptions of water have been profoundly embedded in the religions and cultures that accompanied the evolution of human societies.
Examples of how water was perceived in antiquity are found in some Chinese sources from around 300 BC.
In the **Kuan Tzu** book we find the following text:

Now water is the blood and the breath of the earth, flowing and communicating as if in muscles and veins. Therefore we say that water is the preparatory raw material of all things.

How do we know that this is so?

The answer is that water is yielding, weak and clean, and likes to wash away the evils of man — this may be called its 'benevolence'. It sometimes looks black, sometimes white — this may be called its 'essence'. When you measure it you cannot force it to level off (at the top), for when the vessel is full it does that by itself — this may be called its 'rectitude'. There is no space into which it will not flow, and when it is level it stops — this may be called its 'fairness'.
People all like to go up higher, but water runs to the lowest possible place. This principle of going down to the bottom is the 'Palace' of the Tao, and the instrument of true rulers. The bottom is where water goes and lives.
The Taoist quotation above gives an indication of the inspiration the phenomenon of water presented to spiritual thinkers in ancient China. Of course in the history and practice of all world civilisations one can find numerous different spiritual perceptions of water, such as Thales from Milete's view of water as the original stuff of the universe, the ritual of baptizm in Judaeo-Christian worship, the cleaning in the Ganges river in the Hindu tradition and the reference to water as the source of life in the Koran.
Although it would seem that the spiritual associations of water are being lost in our modern world, strong mystical, intuitive and instinctive roots remain identifiable in plants, animals and human beings, especially when the quality or availability of fresh water is at risk.
Also at a scientific level, new discoveries concerning the qualities of water have led to a revival of interest in the energies inherent in pure, untreated and unused fresh water from natural sources. Recently the German Institut für Strömungsforschung has published interesting results from observing energy fields in various water samples. It recorded emerging patterns when the samples were subjected to a standardized method of disturbance from outside. The consistent findings from some of these tests on water taken not only from rivers, water treatment plants and groundwater boreholes, but also from pure unspoiled natural sources are that pure water contains unknown energies that get lost in the process of the water being used, treated or handled. These energies have also been shown to relate to the position of the moon in relation to the earth at the moment of observation. The researchers have decided to investigate further the nature of these energies and their influence on the health and wellbeing of living organisms.
After having explored in this chapter certain aspects of the nature of water, the next question to be addressed is what water will mean for the sustainable future of life on the planet.

Present and future fresh water scarcity

The issue today, put simply, is that while the only renewable source of fresh water is continental rainfall (which generates a more or less constant global supply of 40 000 to 45 000 km3 per year), the world population keeps increasing by roughly 85 million per year. Therefore the availability of fresh water per head per year is decreasing rapidly. There is also a (minute) input, recently discovered, from water fallout arriving on Earth via comets and other small bodies from outer space. But periods of geological time are required before this influx raises water levels on our planet to any significant degree.
If we break down the global macro picture into regions, great differences become apparent due to substantial geographical variations in population density and growth, and in volumes and periods of rain precipitation. Clearly, if nothing is done about it, a number of areas of the world are heading for serious trouble within the coming decades. In fact, some 80 odd countries and regions, representing 40% of the world's population, are already experiencing water stress and about 30 of these countries are suffering water scarcity during a large part of the year and are tapping reserves that are not or not sufficiently being replenished.
Some energy- and/or cash rich countries take resort to investment in recycling and purification and desalination technologies, but these options are too expensive for most countries, where income is low and population density high.
The issue outlined above will now be treated in more detail in order to give a better idea of the mechanisms involved.
In Figure 1 (futher on in this article) is a schematic representation of the global hydrological cycle, with quantitative estimates. That indicated as 'run-off' is the estimated 45,000 km^3 annual availability of fresh water. (In literature estimates vary between 40,000 and 45,000 km^3.) Not all experts agree on the accessibility of these quantities. Some of the run-off flows back into the sea where there is no population and no way of retrieving it. For instance, from the Amazon river alone an estimated 5,500 km^3 is lost this way. On top of that, geographical conditions and seasonal climatic cycles are such that accessibility does not always equal possible and steady use. In recent literature the estimates for global accessibility range from 9,000 to 14,000 km^3, indicating how little we really know about the actual potential supply.
With respect to our actual use, or withdrawal as it also called, Figure 2 gives an indication of the estimated quantities involved. At around the year 2,000 this amounts to about 5,000 km^3. If we assume an average accessibility of 12,000 km^3, this means that, on a global scale, we are using at present about 40% of the accessible amount of water.
This does not seem too alarming, but the experts point out that a substantial volume of water should be left alone 'to run its natural course in order to protect wetlands, deltas, lakes and rivers, as well as safeguarding water quality'. Inefficient water management leads to more withdrawal than actual use, while on the other hand unused water, unless polluted, can be used further along in the chain between withdrawal and reaching the sea.
All these different aspects are not conducive to the formulation of neat equations. Nevertheless, the need to reserve part of the available water for preserving the environment, the limited accessibility and the need to allow for ineffective human use of accessible water have led hydrologist Falkenmark to devise a rule of thumb approach. According to this rule, countries or regions with annual available supplies of less than 1,000 m^3 per person per year are designated as water-scarce; those with between 1,000 and 1,700 m^3 as water-stressed and those with above 1,700 water-sufficient, although preferably the amount should be between 5,000 and 10,000 m^3.
With a world population of about 6 billion in the year 2000, this order of sufficiency would mean that, on a global scale, water availability should roughly amount to a minimum of 10,000 and preferably 30,000 km^3 per year. Again, compared with the 40,000 to 45,000 available, this does not seem worrying. However, as Figures 3 and 4 show, the national picture for a great number of countries does look bleak. It should be added that for regions such as northern China, south and west India and parts of Pakistan and South America, notably Mexico, the situation is just as bad.

The rules of thumb used in these illustrations do not take account of the very specific conditions prevailing in the countries or regions involved with regard to accessibility, climate, water management and water demand. For a more realistic picture of a certain area it is obviously necessary to take these factors into account. Still, the illustrations are a valid indicator of present and future problem areas.

The reality of the scarcity of renewable fresh water due to the limits of the hydrological cycle is leading to the depletion of existing reserves in aquifers, lakes, rivers and groundwater in various parts of the world. In effect this means that, instead of living on water income, water capital is being consumed and irreversibly diminished. In order to understand what this means, Figure 5 illustrates the water reserves on earth. From this it is evident that only 0.3%, or about 93,000 km^3 of fresh water reserves on earth are accessible in rivers, lakes and renewable groundwater reserves, i.e. groundwater that is sufficiently near the surface that rain can replenish it if not overdrawn. However, if these fresh water reserves, including deeper aquifers, are being depleted without being renewed, at some point in time bankruptcy due to a lack of liquidity – to make a metaphor with the business world – will inevitably result. We are already experiencing this state of affairs to a limited extent, but present estimates point towards the first quarter of the 21st Century as the time of serious crisis for many identifiable, highly populated parts of the world.

Reviewing the consequences

The consequences of regional and national water scarcity will lead, as mentioned earlier, to a depletion of reserves. But it will also give rise to competition for water between nations and regions, as well as between sectors such as agriculture, industry and municipalities, especially large cities. Estimated global water demand by sector in 1990 was 65% for agriculture, 22% for industry, 7% for municipalities, with the remaining 6% reservoir losses. Table 1 shows the differences in spread over these sectors for various countries.

The fight for fresh water will be about who takes how much for what purpose, out of the rivers and out of the ground, and at what price. In general, rapidly growing urban centres, in which more than 4 billion people will live by 2025 (see Figure 6), will cause a major shift of water use from agricultural to municipal sectors, a reallocation that will probably result in more efficient irrigation methods. Tensions between the need for municipal water and the necessity of water for food will also lead to improvement in water demand management and to water market economies.

With regard to rivers there are already mounting problems. Due to the tapping of water at ever more points upstream, the Colorado in the United States, the Huang He (Yellow River) and the Yang Tse in China, the Ganges in Nepal, India and Bangladesh, and soon the Nile, bordered by 10 nations in Africa, are examples of large rivers not reaching the sea any more for part of the year or not at all. The highly polluted Dnipro in Eastern Europe, the Jordan in the Middle East and the Mekong in Laos, Vietnam and Thailand are all facing serious downstream conditions before the year 2000. The Amu Dar'ya in central Asia no longer flows into the Aral Sea. This was once the world's fourth largest lake, but is now gradually disappearing from the map. Figure 7 shows the multinational dimension of some major rivers.

When rivers do not reach the seas anymore there are various consequences. In the first place the river deltas are becoming arid, silted and inhospitable to human, animal and vegetable life, disturbing social and ecosystemic conditions. These adverse changes will continue to move upstream as tapping higher up increases. As a result, the ecosystems in and along the rivers will be disrupted. Dams will disturb breeding areas and there will be less nutrients from the river to serve irrigated agricultural land and fisheries in the sea. All this will lead to less food for more people and subsequent deterioration of living conditions.

This is not theoretical doom-thinking. Matters are already reaching crisis proportions in the above-mentioned river basins.

It would be ironical if the very rivers and deltas with their plenteous waters that were the birthplaces of the first civilizations and nation states were today to become the cause of poverty and war due to lack of water. But such tragedies can happen, witness the disappearance around 1500BC of the Sumerian civilisation in Mesopotamia partly due to over-irrigation and the resulting silting of farmland.

As tensions in river basin areas rise, they could lead to two different scenarios: power game or consultation. Looking at power games, we already have examples in the Nile basin with Sudan threatening to cut off Egypt and with unilateral decisions by Ethiopia to capture more of the flow, it being at the source of 85% of the Nile's water. As Egypt's whole population of 60 million and growing by 1 million every 9 months is sustained by the Nile's water, these are serious threats to the nation.

Figure 8 shows the renewable fresh water availability in the Nile basin from 1955-2050.

Coming to consultation, in February 1995 the water affairs ministers of most of the 10 countries bordering the river met in Tanzania and agreed to form a panel of experts to develop a framework for 'equitable allocation of the Nile waters'.

Similar initiatives for multinational consultation and cooperation have been undertaken since 1994. These include plans for the Aral Sea situation, development of the Mekong, equitable allocations of the Ganges, and last but not least, the Palestine-Israel Peace Treaty of which an agreement on water allocation was a major element.

If these initiatives lead to positive results and durable settlements, which is by no means certain nor easy to achieve, crises concerning water would be transformed into opportunities for peace and affluence instead of threats of war and poverty.

There are of course examples of rivers having been the subject of successful multinational consultation: the Rhine, the Senegal and the Danube, to name but a few. Tensions prevail, however, between Slovakia and Hungary over the rerouting of Danube water. Apart from rivers being tapped and drying up as a result of water needs upstream, another area of potential conflict or consultation is where a country rich in water seeks to assume commercial or political bargaining positions relative to neighbouring countries.

A case in point is Turkey, the source of the Euphrates and Tigris and one of the best-watered nations in the world.

The 32 billion dollar Turkish Great Anatolia project, providing for 22 dams for irrigation and 19 hydroelectric power plants in both river basins, poses a great threat to Syria and Iraq. The complex could be used to cut off the flow to these countries completely for up to 8 months without adversely affecting operations. Furthermore, backed by the former president Turgit Ozal, himself a hydrodological engineer, Turkey's government water company started construction of a $100 million pipeline and harbour project in the early nineties with the object of selling water to Cyprus, Malta, Libya, Israel, Greece or Egypt by diverting water from the Manavgat River to the Mediterranean Sea. Due to political tensions and the potential clients' lack of port facilities, the project lies unfinished and idle for the time being.

As regards to **underground water**, there are two kinds. The first is ordinary **groundwater**, relatively evenly distributed and not too deep under the surface; and the so-called **aquifers**, huge subterranean reservoirs, usually originating from having being trapped during the earth's last glacial period around 15,000 to 30,000 years ago, and sometimes called 'fossil' groundwater.

Ordinary **groundwater** is extracted all over the world by private, agricultural and industrial users and by national and local water authorities. All over the world, too, water tables are falling because, increasingly, more water is being withdrawn from the ground than is being replenished by rain. The most serious cases are obviously those where the gap between accessible availability and need is the largest. In northern China, for example, 10% of the cultivated area is irrigated by over-abstracting groundwater, but the most serious shortages are found in urban areas. Two thirds of China's cities, which number about 300, are short of water. Groundwater levels in Beijing have dropped from 5 m deep in the fifties to 50 m on average today and they are still going down. In other parts of northern China water tables are falling at a rate of 0.5 to 3.0 m per year. In India most wells in the northwest state of Gujarat have experienced a decline of more than 9 m during the eighties. Similar falls are noticeable in Maharashtra, Punjab, Haryana, Rajastan and Tamil Nadu. In Mexico's capital, groundwater supplies 70% of the water consumed and an overdraw of between 50 and 80% is leading to ever more salty water and to instances of land subsidence of up to 30 cm per year in the eighties. In many other parts of the world falls in water tables are less dramatic but the trend is downward; even a country like the Netherlands, known by many people including the Dutch themselves as a 'waterland', is facing declines in water tables of 10 to 20 cm a year. Although two-thirds of water needs are met by the rivers Rhine and Maas, the other one-third withdrawn from the ground is resulting in a slow but steady decline in water tables. The Netherlands has less available rainwater per person per year than it needs; availability is between 600 and 700 m^3 per capita and use over 1,000 m^3. Statistics do not always reveal the truth, however. In the Netherlands, the farmers' lobby has achieved that with heavy rainfall, rainwater is discharged into the sea within 48 hours. On the other hand the industrial water use consists for a large share of cooling water for electricity generating plants, discharged again into rivers for reuse.

The other source of underground water, as mentioned above, is aquifers. Major aquifers currently being tapped for irrigated agriculture are located in the High Plains of the United States, in Saudi Arabia, in Libya and in Israel. The aquifer under the High Plains, called the Ogallala, extends from South Dakota to Texas, is 150 to 300 feet thick and holds more than 4,000 billion m^3 (or 4,000 km^3) of water. It has been tapped since at least 1945 for irrigation to transform 7 million acres of arid prairie into a huge agricultural belt. Water was pumped at a rate of 22 km^3 per year in the eighties by the various states involved. Since then, water consumption has been declining due to the cost of pumping from ever greater depths, and this has led to economic decline in some areas. By 2040 the aquifer is expected to have been depleted beyond the level of practical use in Kansas and Texas.

The aquifers in Saudi Arabia hold about 2,000 km^3 of water and they provide some 88% of the country's water needs. About 7 km^3 are pumped annually for agricultural irrigation and municipal use. Ninety percent of these aquifers are non-renewable and at the present rate of abstraction and assuming an increase in use of 50% over the next 15 years, they are running towards total depletion in the first half of the 21st century. This puts the very substantial investments in growing wheat, barley and vegetables, and consequently the desired food security in Saudi Arabia, in a vulnerable position.

The most dramatic and costly new aquifer depletion venture in the world at present is a $25 billion project in Libya. It links 500,000 hectares of farmland in the north of the country through a 1,860 km pipeline to fossil aquifers in the Sahara to the southeast, 'The Eighth Wonder of the World', according to Qadaffi. Experts are not sure about the size of the aquifers' resources but there seems no doubt that depletion will reach unsustainable proportions in the course of the 21st Century. Economic collapse and food scarcity could result. Figure 9 gives an impression of the nature of the water deficit problem in Libya.

The aquifers in Israel are of a smaller size, one along the coastline and one under the mountains. Their total renewable capacity is about 850 million m^3 per annum, while present annual water needs are about 1.6 billion m^3. As a consequence, over the past 25 years abstraction has exceeded replacement by 2.5 billion m^3,

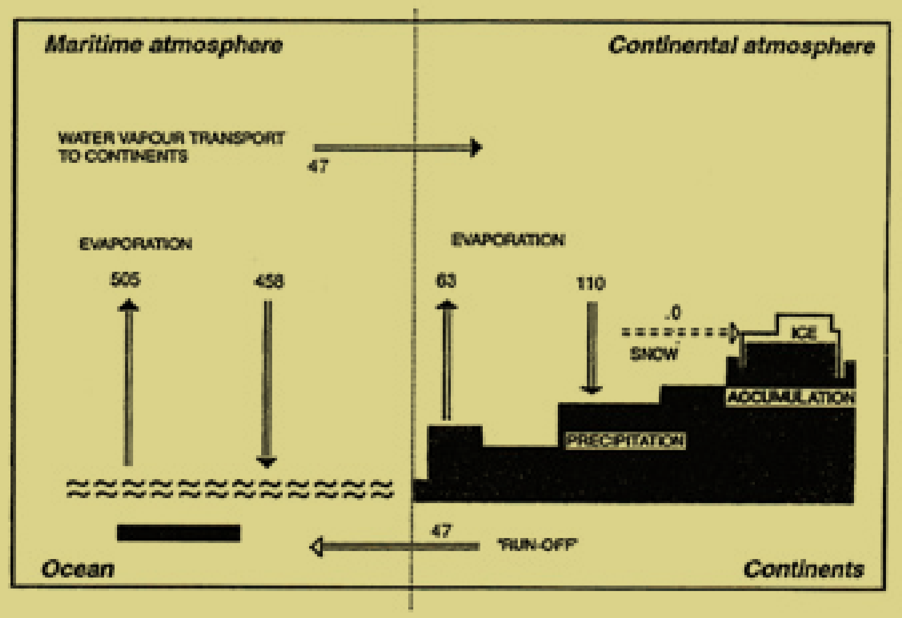


Figure 1. Global water balance estimates (1000 km³).
Source: UNESCO, 1978.[1]

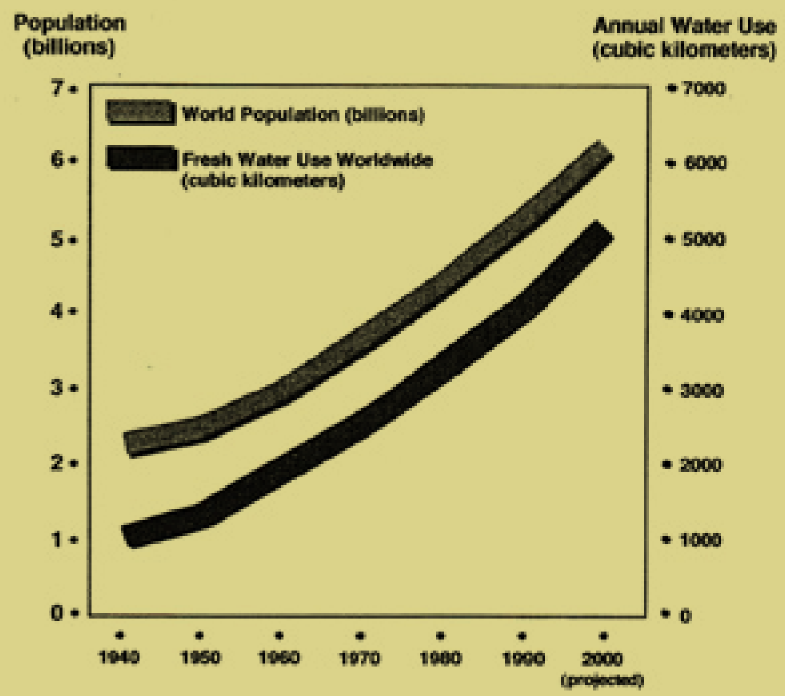


Figure 2. World population and fresh water use, 1940–2000.
Source: Peter H. Gleick, Pacific Institute for Studies in Development, Environment and Security.[2]

Countries experiencing water scarcity in 1955, 1990 and 2025 (projected), based on availability of less than 1,000 cubic meters of renewable water per person per year

Water-scarce countries in 1955	Countries added to scarcity category by 1990	Countries added to scarcity category by 2025 under all UN population growth projections	Countries added to scarcity category by 2025 only if they follow UN medium or high projections*
Malta	Qatar	Libya	Cyprus
Djibouti	Saudi Arabia	Oman	Zimbabwe
Barbados	United Arab Emirates	Morocco	Tanzania
Singapore	Yemen	Egypt	Peru
Bahrain	Israel	Comoros	
Kuwait	Tunisia	South Africa	
Jordan	Cape Verde	Syria	
	Kenya	Iran	
	Burundi	Ethiopia	
	Algeria	Haiti	
	Rwanda		
	Malawi		
	Somalia		

** Cyprus will have more than 1,000 cubic meters of renewable fresh water annually per person in 2025 if it follows either the UN low or medium population growth projection. Zimbabwe, Tanzania and Peru will avoid falling below 1,000 cubic meters per capita only if they follow the UN low projection.*

Figure 3. Countries experiencing water scarcity in 1955, 1990 and 2025 (projected), based on availability of less than 1000 m³ of renewable water per person per year.[3]

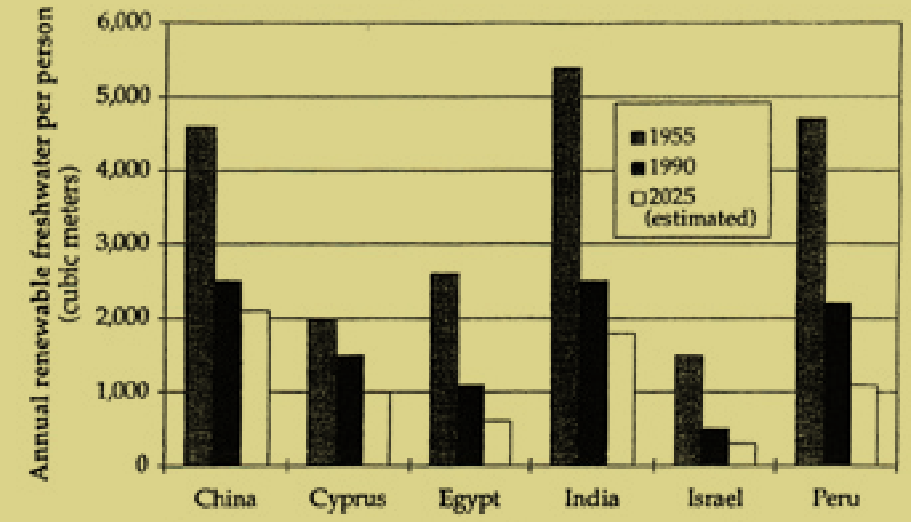


Figure 4. Annual renewable freshwater per person (m³).[4]

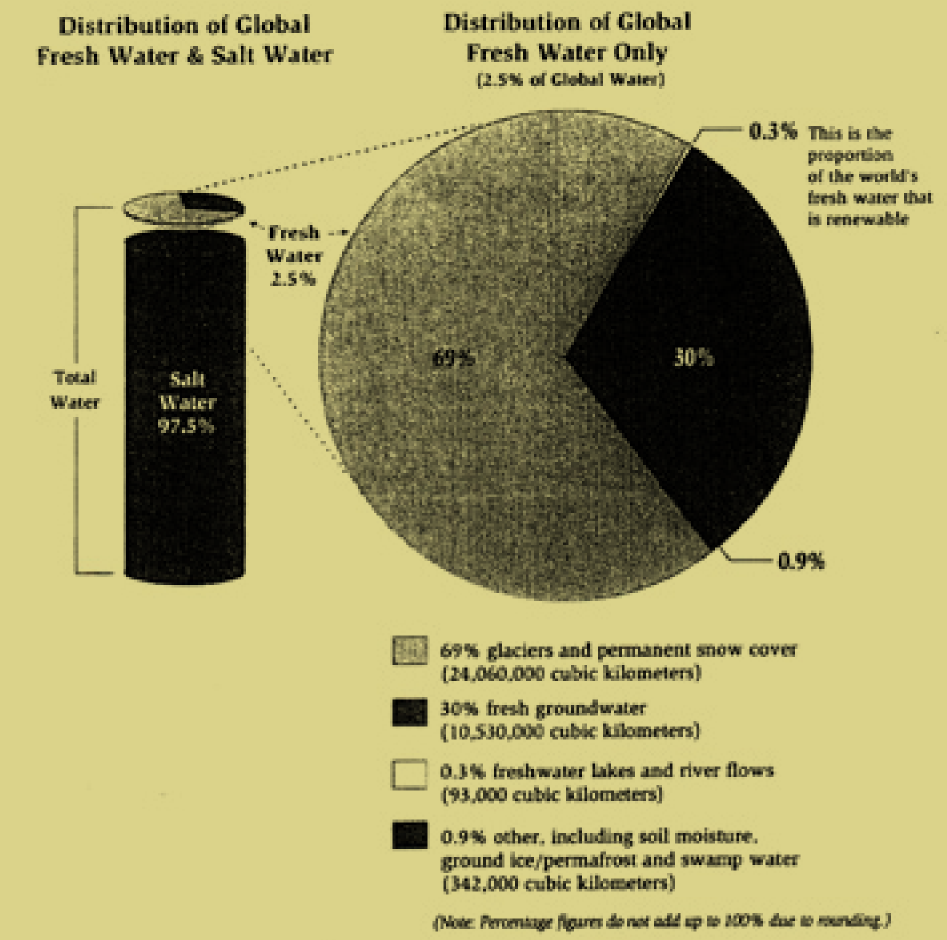


Figure 5. The world's water.[5]

TABLE 1. SECTORIAL USE OF FRESH WATER PER COUNTRY (% OF TOTAL USE).[6]

Country	Domestic/commercial	Industrial	Agricultural
Developing countries			
Algeria	23	5	72
Botswana	8	17	75
China	6	7	87
Cape Verde	8	0	92
Egypt	7	5	88
Ghana	44	3	54
India	4	3	93
Mauritania	2	0	98
Turkey	24	19	58
Uganda	43	0	57
Developed countries			
Albania	30	60	1
Austria	20	77	3
Bulgaria	14	15	71
Belgium	11	88	2
(former) Czechoslovakia	24	72	5
Finland	12	86	1
France	17	71	12
Ireland	11	83	6
Netherlands	5	64	32
Poland	17	62	21
Switzerland	37	57	6
United Kingdom	21	79	1
(former) Yugoslavia	17	75	8

Projected urban population

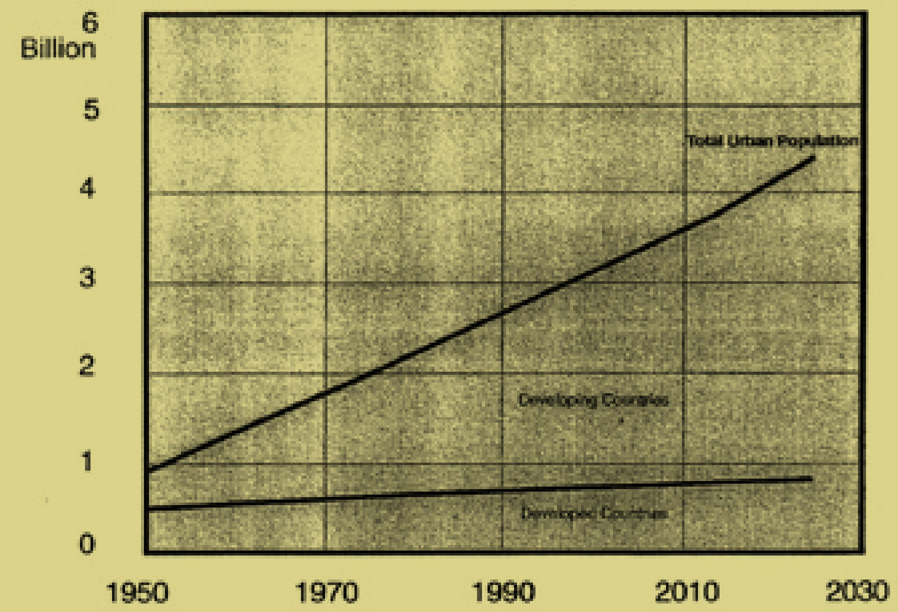


Figure 6. Projected urban population.
Source: UN Centre for Human Settlements, Global Report on Human Settlements, 1986.[7]

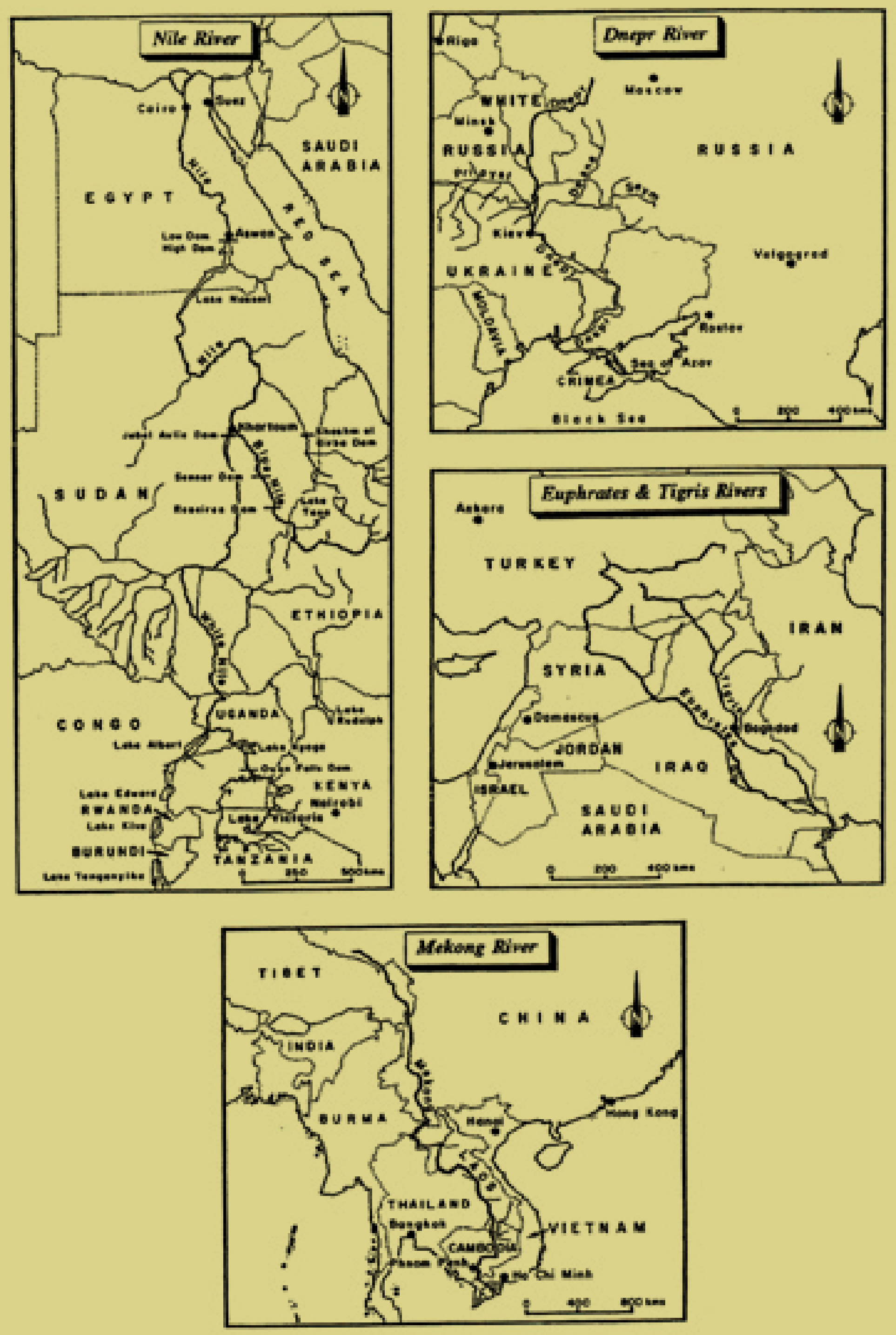


Figure 7.

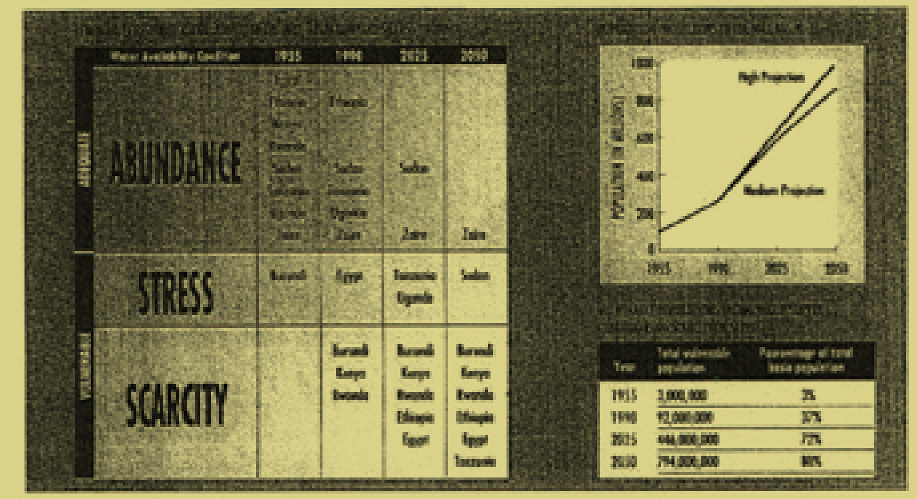


Figure 8. Renewable freshwater availability in the Nile Basin countries (1955–2050).[8]

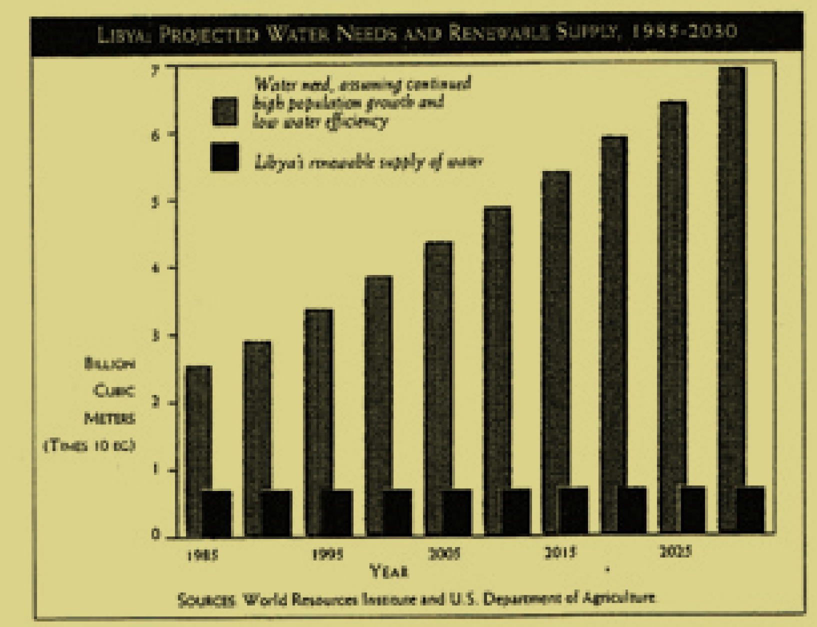
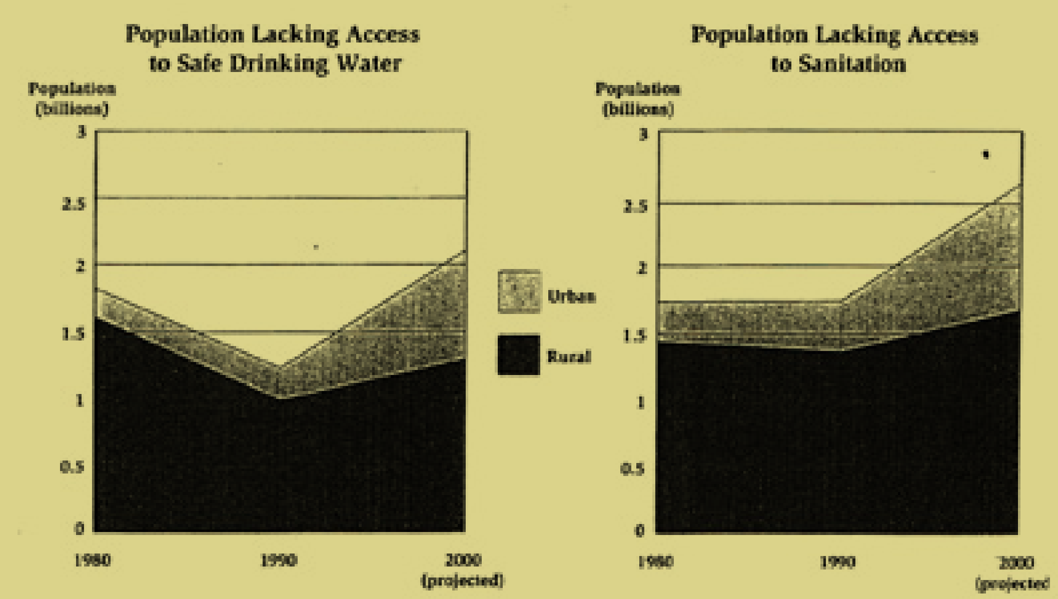


Figure 9. Libya: projected water needs and renewable supply, 1985–2030.
Sources: World Resources Institute and U.S. Department of Agriculture.[9]



While the number of people with access to safe and sufficient water and adequate sanitation increased between 1980 and 1990, population growth erased any substantial gain, especially in urban areas. Between 1990 and 2000 an additional 900 million people are projected to be born in regions without access to safe water and sanitation.

Figure 10. Access to safe drinking water and sanitation in developing countries, 1980–2000.[10]

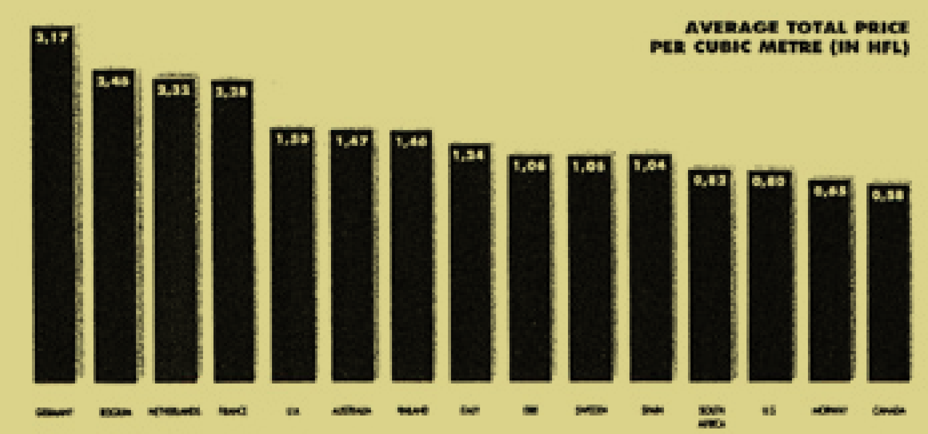


Figure 11. International water price survey, July 1994–July 1995.[11]

resulting in silted water, in depleted resources and in taking drastic measures, necessary to diminish aquifer tapping, develop new sources of water and cut back consumption.
Fresh water shortages stem not only from a linear relationship between growing population and use per capita. Other factors in the complex dynamics of water availability versus water needs, apart from climatic, are cultural, technical, political and institutional.
Cultural in the sense that water use per capita does not follow global average rules, but depends greatly on customs, standards of living, gender relationships and social conditions.
Technical in the sense that winning, purifying and distributing water can be done in more and less sophisticated ways and at very different costs depending on the needs and wishes of consumers, which relates in part to the cultural factor.
Political in the sense that the allocation and pricing of water to the three sectors main end users: agricultural, urban and industrial, are political decisions. Realistic pricing and the responsible allocation of water would relieve the scarcity problem because it would improve efficiency and effectiveness.
Institutional in the sense that at present the national, regional and municipal control of water is mostly in the hands of public authorities and burocratic organisations. Such bodies do not necessarily coordinate, or integrate their policies and investments in the fields of water resource management, purification, distribution logistics, environmental protection, pricing and administration.
Apart from the consequences of insufficient quantities of fresh water being available in various regions of the world, the quality of fresh water is an equally important consideration.
With the growth of big urban areas and the increased use of chemicals in agriculture, rivers and groundwater will become ever more polluted. This means on the one hand that the cost of cleaning water will steadily increase, and at the other that when there is no cash or capacity to clean sufficiently, the quality of water will become a problem. It is estimated that today throughout the world more than 5 million people (mostly children) die annually from illnesses caused by drinking poor quality water.
The need to improve accessibility to safe drinking water was recognised during the UN Water Resources Conference in Mar del Plata, Argentina in 1977, which instigated a water and sanitation programme for the eighties. Figure 10 shows that these programmes started to have a positive impact effect, but that due to the continuing substantial increase in world population, mainly in developing countries, the number of people lacking access to safe drinking water and sanitation will increase again to between 2 and 3 billion in the year 2000.
At the UN conferences on environment and development in Rio in 1992 and in New York in 1997 water was again seen as one of the major issues to be resolved.
In conclusion, the shortage of clean fresh water is a complex issue for the coming decades and the way it is addressed will have a profound influence on security and sustainable development in the 21st Century for a great number of the densely populated regions of the world.

Looking at solutions

So far, presenting problems and seeking solutions on the subject of fresh water has been mainly the work of public authorities such as the United Nations Agencies UNEP, UNESCO, ECOSOC, and UNICEF, Food and Agricultural Organisation (FAO), World Health Organisation (WHO), World Bank, national governments, governmental agencies, European Union, Non Governmental Organisation (NGOs) and research institutes such as World Watch, World Resources, Population Action International, Food Policy Research, Water Supply and Sanitation Collaborative Council, Global Water Policy Project and, recently, Global Water Partnership and the World Water Council.
At the UNCED conference in Rio in 1992 the water issue was dealt with in Chapter 18 of Agenda 21, called ‘Protecting and Managing Fresh Water’ and setting 17 interim goals for the year 2000 in order to achieve universal water supplies in 2025. At present it seems unlikely, however, that the goals set for the year 2000 will be attainable in the projected time frame. The political, social, cultural, institutional, technological and educational and financing innovations required will take more time. At the Rio + 5 conference in New York not much progress was reported and a new assessment is planned within the next 3 years.
The whole proces may indeed take more than 20 to 25 years, which is not unduly long when compared to other major social and technological revolutions of the 20th Century. Another factor is that financing the required changes, estimated by the World Bank to be at least $ 600 billion for the next decade, will be very difficult, given all the other, partly short term, priorities to be resolved such as poverty, unemployment, armed conflicts, environment and education. In addition to all the efforts that have been initiated by the public sector, therefore, it is also necessary for the private sector to take initiatives within the framework of Agenda 21.
It should be possible in theory to reduce water use in agriculture, industry and the domestic sector by about 50% through better management and techniques.
Many of these techniques, such as surge-, drip- and micro-irrigation, membrane purification and recycling technology as well as household saving devices are already operational today in incidental applications, but could and should be used to a much greater extent.
Where there is no water there is no food, no consumer and no business activity. So, apart from the obvious humanitarian and security concerns, for the private sector to thrive and survive, the water issue presents a challenge that needs to be addressed in its own interest.
At the same time, scarcity of any commodity presents, by definition, a business opportunity. Opportunities are interesting to the business community if it can make use of experience and capabilities to produce an acceptable return on risk capital investment. Such opportunities exist for example in the following areas:

- efficient water management through the improved exploration, exploitation and distribution of surface and groundwater;
- the implementation of demand rather than supply policies;
- integrated river basin projects;
- pollution prevention techniques;
- linking treated municipal waste water with water demand for agriculture;
- improving irrigation water loss by 80% (from 50% loss to 10%);
- technology transfer not only of sophisticated industrial processes, but also of small scale water saving techniques for rural and the domestic applications as well;
- the commercial marketing of water at a price below the cost-price of inefficient conventional and supply;
- technological innovation in the field of desalination, with the object of reaching cost-price levels close to the real costs of efficient conventional water supply;
- technological innovation to develop crops that need less water or can grow in salt water.

Two important conditions must be met to facilitate private participation in water management and water marketing: conventional water supply must be sold at real cost price, including return on investment, and water rights must be obtainable and tradeable.
In order to initiate the process of transition from public to private it will be necessary for the private sector to provide convincing evidence that real cost **prices of water** can decrease while quality and availability increase. Privatisation of water companies in the U.K. has so far not yet convinced consumers that they will be better off. Because of the lack of investment to eliminate chronic leakage problems, incidental shortages still occur. Increasing competition and stricter government regulation should lead to improvement in the future.
In the rapidly growing international market for water projects mostly water companies from France, the United Kingdom and Germany have been active until now, but there are and will be many more opportunities for other countries with experience in water management and in dealing with the complex conditions in developing countries.
With regard to the price of water the picture is very differentiated depending on the region or country and the user sector involved.
A recent review of World Bank financed projects shows that the effective price charged for water is about 35% of the average cost of supplying it. In general the price paid by farmers for irrigation water is far below costprice, while large investments in logistics, including canals, are not taken into account. At the same time the worldwide irrigation efficiency is estimated to average less than 40%.
Proven alternative techniques in the United States, South Africa, Israel and Cyprus show that efficiency can be improved to between 80 and 95%. Application of such techniques in other areas of the world is still uncommon, mainly because of lack of know how and money, although payback periods are short. Charging higher prices for irrigation water will boost efficiency of use, substantially reduce consumption, improve crop yields and make more water available for urban needs. For industrial and domestic use, developed countries usually charge cost prices, but Figure 17 shows considerable variations from country to country. The definition of cost-price is probably not uniform, although these prices include distribution costs, which can vary substantially. In the Netherlands the typical cost price ex drinking water production plant is in the order of one guilder per cubic metre.
When reviewing various worldwide statistics, very different numbers are often reported for the same end user. In general the price of water for industrial and domestic use is steadily increasing due to higher costs of purification, disposal, energy, levies and groundwater taxes. In the Netherlands for instance, prices doubled on average between 1990 and 1994 and are expected to have doubled again by the year 2000. This has had, and will increasingly have, an impact on efficient water use, first of all in the industrial sector through better control and more recycling, which can lead to savings of up to 50%.
But in the domestic sector, too, where the average individual in western society and Japan now uses between 125 a 200 L per day (50 to 75 m^3 per year) for showers, toilet flushing, cleaning, laundering and drinking, savings of at least 50% can be achieved with new economical devices.
Japan has ‘reinvented’ installations to capture and recycle rainwater for domestic use and is testing these in various cities, aiming at a 30% saving in drinking water demand.
In the field of commercial water trading, apart from the Turkish example given earlier, various initiatives showed up in the last few years. They vary from trading water rights in Chile, the USA and Australia to a project for supplying water from Norway by the Nordic Water Company to continental Europe by sea in huge floating plastic bags. A licence has been granted to the Canadian Global Water Corporation to ship 17.5 million m^3 of drinking water annually out of a lake near Sitka in the northwest of Alaska to Tianjin, a major city and harbour on the east coast of China.
From the scarce data available on these projects it is difficult to judge price levels and what they include, but the impression is that they probably range from 75 to 100 US cents per m^3 delivered to port. In literature this order of magnitude of price, before distribution, seems to be a good indicator.
Obviously, with mounting scarcity, taxing and the pollution of conventional water sources, new commercial and technical opportunities will continue to arise. It could very well be that in the beginning of the 21st Century clean water will start to become a major regional and interregional commodity, being produced and traded in volumes undreamt of today.

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