IS THERE A WORLD FRESHWATER CRISIS?

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(This article is based on an unpublished report on “Rehabilitate Aquatic Ecosystems to Resolve Freshwater Crisis” that the author had prepared for World Wide Fund for Nature (WWF) in March 1998.)

The article summarizes the current debate on existence of a freshwater crisis. It then examines the dire consequences of the current and predicted freshwater crisis on prospects for survival of nature in general and preservation of the ecosystems in particular, and to explore the ways for giving a practical shape to findings and recommendations of the international community taking into account many pragmatic approaches described in numerous publications and based on actions already being taken by many countries

Table of contents

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1. A WATER-STRESSED WORLD

1.1 Assessment of global freshwater situation

There is hardly a recent report on freshwater resources of the world which does not claim that there is a serious freshwater crisis, that the ecosystem will shrivel to an unsightly and unproductive waste, that the food

producing land will parch and crackle and as a result, human beings in over 60 countries are destined to perish or nearly so before the year 2050. Heavy-weight reports of the UN Conferences on Water (Mar del Plata, Argentina, 1997), the International Conference on Water and Environment (Dublin Ireland, 1992), UN Conference on Environment and Development (Rio de Janeiro, Brazil, 1992)**(1)**, Ministerial Conference on Drinking Water and Environmental Sanitation (Noordwijk, Netherlands, 1994), and many others preceding and following them have generated a formidable world-awakening outpour on this issue. More than twenty Intergovernmental Organizations (IGOs) have been the most vociferous in propagating the message of the impending apocalypse but using a milder term: "water stress". A number of Non-Governmental Organizations (NGOs) and national groups, on the other hand, tended to portray a more realistic and balanced picture of the situation often proposing viable pragmatic solutions.

In response to the twenty-year old frenzy of concern for the increasing number of water-short countries, the UN Commission on Sustainable Development (UNCSD) prepared a "Comprehensive Assessment of the Water Resources of the World**"(2)** (hereafter Assessment Report) which was considered at the Nineteenth Special Session of the General Assembly of the United Nations in June 1997, probably a culminating point in the history of water. The venerable General Assembly agreed with the findings, spirit and sentiment of the Assessment Report presented under the seals of nine IGOs including the World Bank. However, it has not come up with practical measures that would save the humanity from shortage of freshwater. The General Assembly has summarized what has been said many times before in a pile of agendas, statements, resolutions and recommendations. It disposed of the "urgent need for action" by calling Governments "*for a dialogue under the aegis of the Commission on Sustainable Development aimed at building a consensus on the necessary actions*". The review then ends with a caution: "*This intergovernmental process will be fully fruitful only if there is a proved commitment by the international community for the provision of new and additional financial resources for the goals of this initiative*" (**3**). This brings international action back to "square one"!

1.4 Global water scenario

Extensive literature exists on global water scenarios giving detailed analysis of real and hypothetical situations. This paper will frequently refer to conclusions of these analyses and to propose feasible solutions and actions. The following publications that are extensively referred to here, should provide readers with valuable background information:

- *Comprehensive assessment of the freshwater resources of the World (**2**),*
- *Report of the United Nations Conference on Environment and Development (**1**)*,
- *The last oasis – Facing water scarcity* (**23**)*****,
- *Global freshwater biodiversity – Striving for the integrity of freshwater ecosystems (**13**)****,*

- *Water in crisis: A guide to the world's fresh water resources (in particular chapters by Falkenmark, M. et al and by Shiklomanov, I.A.) (**4**),*
- *Water futures: Assessment of long-range patterns and problems (**5**)*

[**Since this article was written the UN, its Specialized Agencies and Nongovernmental Organizations (NGOs) collaborated to compile in 2006 a comprehensive report on the state of world freshwater: *Water, A Shared Responsibility* (43). The report places greater emphasis on governance issues. Chapter 4 outlines the state of the resource and Chapter 5 makes an assessment of the coastal and freshwater ecosystems. The UN report does not invalidate the findings of this article.]**

1.2.1 Water withdrawals and ecosystems

"No scenario is inevitable, the future is determined, at least in part, by actions that are taken to avoid unsustainable futures"(**5**). Many papers presented in recent meetings on water resources have arrived at similar conclusions because they have used common sources of data. They tend to conclude that ecosystems and water resources in countries with a high percentage of water withdrawal are under more stress than those of countries with a lower percentage of water withdrawal. In fact the reverse may be more correct. A country can be using more than 40% of its water but still it might be keeping its ecosystems in relatively good shape. On the other hand, using less than 10% (e.g. in Africa) does not mean their aquatic ecosystems are healthy. For example, Germany, classified under 20-40% withdrawal in the Assessment Report (2) has made tremendous progress in rehabilitating the ecosystems compared with Morocco or Algeria which fall under the same water supply class (see **Table 2.1**). On the other hand, countries withdrawing the least might be damaging the ecosystems most or may be very little because they are still at very low level of development. A country's capacity to use relatively more water and to safeguard ecosystems is a function of level of people's economic wealth.

The Assessment Report recognizes that the use of data for whole countries, big or small, and interpreted on *per capita* basis taking no account of population distribution and the state of ecosystems or that of watersheds, has resulted in contradictions. Almost all countries have great internal disparities. For example, more than 80% of Kenya's population is concentrated in about 9% of its area. Data on water withdrawal in this part of the country is meaningful for generating global scenarios. Consequently solutions proposed in the Assessment Report that are based on the concepts such as "use less water", are not applicable for safeguarding ecosystems and freshwater resources in a large majority of countries or for promulgating realistic and helpful actions programmes by international organizations. The Report admits, "There is a very large uncertainty about future water needs"

Any amount of effort by international institutions to help third world countries to alleviate their water stress is bound to fail in the long-term

unless the quality of life in terms of wealth of people is improved first. We should not continue putting the cart before the horse. Probably for this reason international organizations have failed to implement oracular decisions taken in numerous meeting ranging from Mar del Plata Action Plan of 1977 to Agenda 21 of Rio Summit in 1992 and UNCSD meeting of experts in Harare, Zambia (1998). Unless poverty alleviation is approached in an integrated manner, interventions through a single sector like water will not be fruitful (**6**). International agencies helping countries to develop a national water policy and its implementation need to take a fresh look at their approaches because the institutional structure they collaborate with is not equipped to deal with poverty alleviation, equity and rights to resources (**7**).

LESSON FROM RICH COUNTRIES

Create wealth (jobs, foreign earnings) to provide resources to improve and maintain water supply and sanitation facilities and the long-term health of ecosystems and thus improve the quality of human life (food security and basic needs)(8).

The Assessment Report states that many economic decisions and forecasts “do not currently account for the amount of water that will be required to achieve their goals”. Another factor which is side-stepped is disturbance in traditional ecological balance caused by open market economy and demand for primary products in urban markets, internal and abroad (see **Box 1.2**).

Box 1.2

WRATH OF NATURE:
FLOODS, DROUGHTS AND WATER CRISIS!

From 1978 to 1984, the flood-prone areas in India had almost tripled. During the same period, in almost the same areas, drought proneness had also increased. These contradictory conditions have resulted from removal of forests and associated consequences therefrom: washing of top soil, over-exploitation of grazing land, inequitable distribution of irrigated water, and above all neglect of traditional tanks or water reservoirs. Contrary to popular belief that the water crisis is due to overuse by indigenous population, it has resulted primarily from the consumption demand associated with indiscriminate commercial exploitation (some for foreign markets). The traditional balance between the forest and its native dwellers was disturbed (9).

Almost invariably water experts and water development aid programmes of rich nations appear to be convinced that provision of water supply to the poor at some remote locations would improve the quality of life of those people. They forget or side step the vital principle that delivering economic growth and tackling poverty is pre-requisite for sustainable

water supply and sanitation facilities. Gordon Brown, Britain's chancellor of exchequer, in his laudable article in *The Economist* **(10)** concerning debt relief and development, has solutions, one for the rich and another for the poor. He recommends that in the area of structural reform "we need to act to improve employability … by ensuring that our welfare states are equipped to meet challenges of the 21st century". But for growth and poverty reduction in developing countries he recommends "investment in education and health". Promotion of investment in water resources, health, education and other social services is not wrong; but is it correctly placed in time and space?

Improvement of social services must accord with income-generating productive investment. The need of poor countries for creating employment, the motor of demand for these services, is many times greater than that of rich nations. It is not conferencing but economic growth in East Asia during the last two decades that has reduced the proportion living in poverty from six out of ten to two out of ten (10).

1.3.1 Change the vision

The Assessment Report is caught in the same trap when proposing strategies in the low-income countries with high water stress: "develop the educational and information infrastructure" and "shift to more high-value, less water-intensive crops," and then asks the international community to provide financial resources to treat the stress. We are treating symptoms not the disease. The approach of international water development agendas, usually formulated by non-economists, has been to apply what has been achieved in water sectors of developed countries but without putting these achievements in the context of income-generating economic growth and almost complete annihilation of ecosystems that preceded them. If we really want to implement Dublin and Rio recommendations and stop repeating them in meetings, we must change our vision. Rich countries might wish to join Britain that has "announced that for the next two years, our export credits to heavily indebted poor countries will be confined to support productive expenditures only".

> **"Humanity's condition will improve in just about every material way" and "Humans will continue to sit around complaining about every thing getting worse"** Julian Simon (11)

2. IS THERE A REAL GLOBAL FRESHWATER CRISIS?

2.1 World's water: Is there enough?

Water experts, are talking about the emerging freshwater crisis. They are also predicting that during the next decades, freshwater not oil, will define the peace/conflicts in many parts of the world particularly in developing countries. Whether next wars will be fought on water is questionable

because this has not happened so far. Nevertheless, neighbouring parties within countries continue to wage legal and political battles over riparian water rights.

The term “freshwater crisis” is meaningful only in the context of water availability and demand as explained in **Box 2.1**. Before creating a panic situation, it is important to examine whether water scarcity in various parts of the world is absolute, needing drastic reduction in demand, or can be adequately addressed through new holistic management strategies and restrained consumption patterns (**12**).

Box 2.1

A freshwater crisis!

The term “freshwater crisis” has been used in recent literature to express almost any type of water problem. A freshwater crisis might arise in distinct situations of:

“Water scarcity”- a relative concept intended to convey the imbalance between supply and demand under the prevailing legal, institutional, regulatory, and where applicable, price arrangements.

“Water shortage”- an absolute concept indicating low level of water supply (availability) relative to minimum levels necessary for basic needs.

“Water stress” – an acute water shortage for prolonged periods (15).

It would be pretentious to claim that a global-scale freshwater crisis is imminent. According to estimates made by water experts - the modern water diviners - the amount of freshwater that is readily accessible for human use is about 9,000 cubic kilometres per year (**see Figure 2.1**). They add another 3,500 cubic kilometres of water that is stored in reservoirs. Currently humans are using about half (6,250 cubic kilometres) of this amount. Owing to the growing world population, this represents a drop from about 3000 to 2140 cubic metres of water per person per year since 1970. World’s population is expected to increase about 50% in the next 50 years. Statistically speaking this does not leave much room for increased consumption. For this reason doomsayers claim that freshwater is a finite source that is a half-truth because they ignore the 99.7% of untapped water on Earth stored as salt water in oceans and freshwater frozen in polar ice caps. We might not be able to use water from these sources through the natural water cycle, but technologically there is an almost unlimited potential, provided such use does not create ecological problems.

Figure 2.1 – Global distribution of the world’s water
Source: reference (**43**)

Overkill might have ended the life cycles of many species of animals and plants, but humans have not yet conceived a way of ending the Earth's water cycle, which will continue to generate freshwater beyond human time-scale. There is a big gap in our knowledge of groundwater that is estimated to be about 66 times more than water on land and in atmosphere **(13**). We do not yet know about the revived hypothesis that much of the planet's water supply may have come from out space delivered by occasional comets (**14**).

The reason for freshwater scare and the ensuing gloomy prediction of doom does not reside in the fact that less than 1 per cent of the world's freshwater, or about 0.007 per cent of all water on Earth is readily accessible for direct human use. Water crisis arises from the interaction of human individuals and communities with water. Special environmental conditions, natural or human-made, in a specific area cause water crisis with its own characteristics and possible solutions.

2.2 Doomsayers

It appears that doomsayers of global water crisis have forgotten similar forecasts made in the past. Forecasts of freshwater supply, which have been made on the basis of global water and economic indices and not on assessment of actual water resources in specific situation, cannot be expected to be more reliable. Impeccably logical predictions of scarcity of natural resources, starting from the population expert, Thomas Malthus in 1798 to the ardent environmentalist, Dr. Paul Ehrlich in 1970s, have yet to be proven right. New developments have overtaken the deadlines of prophesised calamities. Prognosticated global starvation or ecological catastrophes have been largely averted, even for the finite, non-renewable resources like oil. In 1972, "Limits to growth" (**16**) estimated total global oil reserves at 550 billion barrels, which, according to President Jimmy Carter, should have been used up by about 1982. However, by 1990 reserves amounting to 900 billion barrels were discovered, not counting more than 550 billion barrels locked in the tar shales in USA, alone.

The prognosis made as recently as 1980 (**17**) for food production was even more spectacularly wrong. According to the Food and Agriculture Organization (FAO), calories consumed per capita per day in the Third World are 27% higher than they were in 1963. Deaths from famine, starvation and malnutrition are fewer than ever before. The price of food in real terms has fallen by more than 50% since 1960.

Those who declined to be educated are called "doomsayers". (Julian Simon)

Finiteness of freshwater resources is markedly, if not incalculably, less than that of mineral and food resources. Most discussions on freshwater tend to be based on the assumption that water is being overused and misused on a *per capita* basis. The crisis now becoming apparent in many parts of the world is not due to a decline in the resource as such, in absolute and *per capita* terms. More than half of he countries use less than 1% of their annual renewable freshwater resources.

Table 2.1 lists countries that have a similar amount of water supply (144 000 – 270 000 million m^3), but their *per capita* GDP, population and withdrawals do not have any similarity. Industry and irrigation might be the big consumer of water in France; it is irrigation in arid Turkey and Sudan. Different withdrawals reflect different levels of economic situations. Globally out of 152 countries, 124 are using less water than the global average. Therefore, the prescription – use less water – is definitely not a good universal solution.

2.3 Accuracy of assessment of water resources

Although the Assessment Report gives the best available assessment of water resources, the current regional evaluations are at best "educated guesses" because of a lack of readily accessible hydrological data in many places and a proper assessment of the uncertainties of those data which do exist (18).

Scarcity of freshwater has been an age-long nightmare of water managers in Mediterranean countries bordering the Sahara Desert. Climatic extremes produce many beneficial and hazardous effects for the whole socio-economic spectrum and development; but the tradition of economical and efficient use of the limited water resources is often considered to be a moving force of the multiple cultures and civilizations that have arisen in this region from the very distant past. One major way of meeting demands has been the continued re-assessment of available water resources. Hydrologists have lengthened data time series and increased the number of observing stations. In this way they were able to estimate the renewable water resources more realistically. The example of the Maghreb countries (**see Table 2.2**) shows why a water crisis has to be viewed at a scale smaller than even a country (19).

Table 2.1 – Relationship of water supply and withdrawals (Source: (5))

Country	GDP/cap.1994 $	Supply 10^6 m^3	Withdrawal 10^6 m^3	Population 10^6
France	23420	198000	38570	57.2
Iceland	24630	168000	167	0.3
Sweden	23530	180000	2990	8.6
Turkey	2500	193100	36237	58.4
Kazakhstan	1560	169400	44138	16.7
Angola	900	184000	628	8.5
Gabon	3880	164000	78	1.2
Sierra Leone	160	160000	445	4.2
Sudan	300	154000	17800	25.9
Nicaragua	340	175000	1688	4.0
Panama	2580	144000	1975	2.3
Laos	320	270000	1260	4.3
Nepal	200	170000	3284	19.4
Thailand	2410	179000	35042	56.1

Table 2.2 – Results of re-assessment of water resources

Country	Year of estimate	Amount (billion $m^3 year^{-1}$)
Morocco	1955	13.2
	1968	25.0
	1969	30.0
Algeria	1972	14.0
	1987	19.0
Tunisia	1970s	3.0
	1980	4.1
	1985	4.35

The hydrologists' understanding of the climatologic and related hydrologic factors has improved thus enabling the managers to ward off the hazard of extreme water scarcity. But the improvement in estimates is bound to level off and the future water demand in many regions appears ominous.

2.4 Predictions are well-meaning

Assessment Report's predictions are well meaning. So are those for global warming which might influence in some yet unpredictable way the production of freshwater by the natural water-cycle generator. It concludes that "the prognosis is bleak, but a crisis is not inevitable". At the same time, it admits that to draw implications for water-use patterns for the span of the next generation (up to the year 2025) is difficult "because of many of the uncertainties in political and economic developments". Thus the case for major water crisis is not proven.

For this reason, the General Assembly did not adopted a forceful resolution containing provisions for funding, preparation of legal instruments e.g. a new Freshwater Convention, or restructuring IGOs involved in the water sector in order to remove wasteful duplication within the international community. It seems to have recognized that water stress is an age-old phenomenon that humans have encountered since the dawn of history and that developmental forces would automatically impel us to adjust to the changing conditions.

2.5 Root causes

The crisis is not the result of natural factors such as droughts. Mainly humans induce it (**12**). By "globalizing" the water stress situation, water experts in international fora have neglected the root causes and chose to deal with the consequences or symptoms. Is it because the root causes lie outside their sphere of responsibility? Unless they deal with the root causes which can be found only within the countries and provide their considered advice to their water managers, economists, sociologists and others, the effects of remedies proposed mostly in general terms by them may be nullified by local driving forces. It is difficult to imagine how global responses can provide clear description of local problems and propose practical and imaginative solutions that governments, otherwise, would

pick up willingly. "*The lie of the land*" (**20**) documents just how damaging the myth of deforestation and population pressure has been in parts of the Sahel. Westerns have forced inappropriate measures on puzzled inhabitants in order to meet activists' preconceived notions on environmental change.

2.6 Water and climate change

Unusual weather in many parts of the globe, flooding in Poland and Eastern Africa, freak snowstorms in eastern Canada and central USA, are attributed to long-term climate change. Increase in Earth's temperature might have increased evaporation by about 10% in the last 20 years causing more intense precipitation or drought situations, but the scare of warming-up has made some water forecasters and people in general to believe that soon polar ice caps would start to melt and submerge many coastal cities and densely populated lowlands.

Climate change can disturb the freshwater regime; but experts are still uncertain of the impacts (good or bad, when and where). The predictions agree on the global-scale, but not yet on the regional and local level. India might get heavier and more intense rain; but whether it will ameliorate the water stress situation is questionable. According to some agronomists doubling of carbon dioxide level might reduce loss of water through transpiration by a third to half and thus easily counterbalance possible reduction in rainfall (**22**). High uncertainty of climate change and its impacts make it difficult to decide on the future of water and ecology. Nevertheless, the global community has been alerted of mainly the negative outcomes. There is good reason to take precautionary measures and continue monitoring and research on sensitivity of freshwater resources and related ecosystems to possible climate change, but not by diverting funds urgently needed to save them.

2.7 Quiet revolution

While many international and other organizations have been preoccupied with ominous prognostics of global domestic and agricultural water supply, and sanitation, not much consideration has been given to forecasts of industrial water in the third world. It is true that world-wide agricultural water withdrawals account for about 70%, the picture is the opposite in industrialised countries where industrial water use amounts to 50% - 80% and agriculture 10% - 30% depending on the level of development. Many of the developing countries are soon expected to experience a similar changeover. This unavoidable change, rather "another quite revolution" (**22**), is critically important from the ecological view point: agricultural water use is less environmentally damaging than industrial pollutants which can have major environmental and health effects particularly in most of the tropical countries experiencing high seasonal variations in river flows. A mitigating factor is that physical loss of water (e.g. evaporation) in industry is much less than in agriculture. Greater possibility of water reuse gives it an added value and enhances its economic value in national planning.

Water, in the third world, is rapidly becoming a vital, if not critical, factor in national economic framework especially with value-added, endorsing Peter Roger's **(22)** view that the entire hydrological cycle forms a unitary resource that must be considered within the framework of the *hydro-economic balance.*

2.8 Scarcity is the motivator for correction

Without publicising what doomsayers preach, it would be difficult to promote corrective measures. In large part, it is as a result of efforts of such people and institutions that we do not hear much about issues like acid rain, ozone depletion, species extinction, dying European forests, deserts swallowing productive land because these issues are now being tackled successfully through major programmes or nature itself is giving a helping hand. It is therefore not incorrect to exaggerate the impending water scarcity gloom if we want to accelerate implementation of corrective measures.

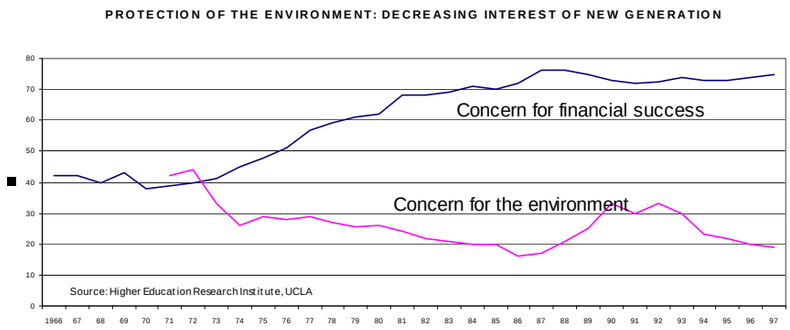
Speculative scenarios of the state of freshwater in the year 2050 **(5)** serve a useful purpose of alerting human beings to tighten the belt, but they cannot be used for taking action for salving the ills now. Past experience with non-renewable relatively finite resources such as oil, coal and other minerals has shown that scarcity would be preceded by more active exploration, more efficient use and development of new technologies – all accelerated by increasing prices. Mankind's greatest resource is inventiveness, which is never in short supply. Every time some natural resource has become scarce, humans have been able to perfect a technology that can leapfrog the old and bring about big improvements in quality of life and output often cheaper and environmentally friendlier. Would this be the case when new technology would enable humans to convert seawater into freshwater on a massive scale?

2.9 Current social attitude

Water scarcity, a common way of expressing a crisis, is understood differently in different places, at different times. Lack of safe drinking water is as critical during a sever flood in parts of Spain as during the infrequent drought situation in Zimbabwe, or discharge of industrial waste in the Grand Canal in China. Economic development is usually associated with large-scale water use. For water experts, use of less water is attributed to low quality of life. Traditionally, environmentalists would support reduction in human water use; but it is well known that increased use of water can be good for nature. For example, while development in USA and Europe has cleared 85% of wetlands, irrigation has increased wetland in India.

When is a crisis situation felt? Invariably when humans, specifically the richer section of the population, are adversely affected. It is rather disturbing for guardians of our natural heritage to learn that the young of this section of the society are in no rush to save nature. In a recent survey on college freshmen, the Higher Education Research Institute, UCLA (USA), found that percentage of students who intended to become involved in cleaning up the environment fell from 42% in early 1970s to

less than 15% in mid-1980s and now stands at 20%; whereas the number of those who consider financial success to be essential or very important goal of education has increased from 42% in late 1960s to 75% in 1997 (see **Figure 2.2**).



Future prospects for increased dedication of the rich society to issues of freshwater-stressed developing countries are not encouraging. The way is arduous to convince and engage this society in inter-governmental programmes for protection of the environment. The only objective option left is what the societies that suffer water and environmental stress can do for themselves. There is little hope of mobilizing effective large-scale external assistance at least until societal globalization would take place and a genuine concern would be felt in the water-rich advanced societies for the protection of freshwater world-wide to save the ecosystems at par with needs of humanity.

The question of water shortage will continue to prick public consciousness and some quarters of political power. Unlike the issue of the environment as a whole, water has always been a part of short-term decisions. Nature also largely depends on water. But in the context of long-term sustainability, humans and water resources are both dependent on nature and not vice versa. Every year, distress signals from ecosystems become more hurtful and people are beginning to revive an understanding of old traditional wisdom that environment degradation mortgages their future generations. The issue before us is whether freshwater crisis will determine the agenda of conservation of nature or will conservation of nature set the agenda for resolving human water needs.

Scarcity of water has usually led to environmental degradation. Has humanity reached a turning point? Surely, our present understanding of water crisis is an opportunity to the international community to initiate practical measures which can lead to environmental regeneration and with it freshwater supply.

2.10 Time for a balanced overture – multiple strategies

Fortunately, pessimists and optimists have one goal: protection of the environment. The present state of the environment does not leave us any option but to make room for those who think that technology and economic freedom will make the world cleaner and will take the pressure off endangered species. Some might have vested commercial interests. Environmentalists might also mislead the populace by supporting alarming environmental scares. Time has come to:

- To use the wisdom of old cultures which considered human societies, like indigenous Americans, to be part of mother nature and not above it, i.e. foster respect of nature,
- To evaluate the situation in an ecologically balanced way and make new overtures using multiple strategies,
- To develop a modern ethic to guide our relationship to the Earth's natural systems, to other spices, and to each other (**23**).

There is a water crisis or not will be a debate both academic and social for some time. It may well be a matter of interpretation. But the present "water crisis" scenario leads us to two objectives:

- **Improving the ecosystems in general, and aquatic bio-diversity in particular while improving the quality of life.**
- **Taking up the challenge not to prove or disprove the existence of water crisis, but devising suitable actions to achieve natural balance.**

3. FRESHWATER AND STRESSED NATURE

3.1 Nature is the loser

More water used to meet human needs means less for survival of ecosystems. An ecosystem is a biological community of interactive organisms, including humans, and their physical environment. Having "civilized" themselves out of the ecosystems, humans have usurped natural water rights of ecosystems. By taking away about 54% of the planet's accessible water, environment's life-giving circulatory system, humans are largely responsible for destroying, shrivelling and permanently disabling ecosystems. They "have driven one quarter of the world's species of birds into extinction" (Peter Vitousek, biologist, Stanford). Humans are the judge and prosecutor. By 2025 AD, human use of water will conservatively grow to 70% (**13**). Nature has always been the loser (see **Box 3.1**).

Box 3.1
WHY FRESHWATER STRESS?

1. **Disruption of watershed processes**
2. **Misuse and disrespect of ecological integrity**
3. **Over depletion and contamination of groundwater**

Share increasing
BY HUMANS

Agriculture
Hydroelectricity
Industry
Sewage and sanitation
Urban withdrawal
Fisheries
Aquaculture
Transportation
Drinking
Recreation
Spiritual

Share decreasing
BY NATURE

Sustains freshwater and its ecosystems
Underpins ecological functions
Maintain integrity of river/lake beds deltas, and quality of river/lake water masses

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Human interventions

QUANTITY	**QUALITY**
Dams and reservoirs	**Point sources – domestic & industrial**
Flood management	**Diffuse agricultural pollution**
Water transfers	**Diffuse rural settlement**
	Atmospheric fallout

Source: (13) (24)

Water stress is a product of uneconomic inequitable use of freshwater creating an environmental misbalance in numerous parts of the world. For example, the National Water Policy of India gives primacy to drinking water for both humans and livestock over programmes which would safeguard water resources for future generations, such as water conservation, water reuse, prevention of water pollution, efficiency in domestic water supply in urban areas, sustaining natural ecosystems of wetlands, lakes, traditional water regeneration practices e.g. small tanks **(12)**.

3.2 Freshwater ecosystems: benefits and threats

It is now generally accepted that the environment and ecosystem (E&E) have dual functions: water supplier and water user. We cannot now afford to overlook the two functions in the planning and management process for sustainable use of water resources. Unless E&E concerns are met, there will be ever decreasing water quantity and quality available for the other users (**24**).

- Evening out seasonal flows
- Leading to higher dry season flows
- Fewer wet season floods
- Reduction of surface runoff
- Maintenance of aquifer recharge
- Protection of ground cover
- Reduction of sediment load in runoff
- Leading to better water quality
- Macro and microclimate benefits.

There is a great variety of freshwater ecosystems. Hence the aquatic environment is poorly understood. Increased understanding of the aquatic realm would strengthen opportunities to soundly manage and conserve this liquid world. The number of species in the small area that surface freshwaters occupy is higher than one would expect (see **Box 3.2**). Loss of bio-diversity is a loss to mankind. Healthy freshwater ecosystems have as much to do with what we do on land as what we do in freshwater bodies (**13**) (see **Box 3.3**).

3.3 Where is freshwater crisis?

3.3.1 Hot points

Forty per cent of Earth's land area has always been and will remain under water stress often aggravated by transferring the little amount of water that this area has to quench the thirst of more densely populated areas hundreds of kilometres away. Where water is plenty, it is being wasted, mismanaged and polluted on a big scale. It is estimated that the world water use has tripled just between 1950 and 1990.

Box 3.2

VARIETIES OF FRESHWATER ECOSYSTEMS

- I million lakes (>1 km^2)
- 10 million ponds (> 1 hectare <1 km^2)
- Ephemeral pools
- Seasonally flooded areas

Environment	Relative species richness (% Species /% area)
Freshwater	3.0
Terrestrial	2.7
Marine	0.2

Source : (**13**)

There is no denying that there is a freshwater crisis, but it is not global. While global demand projections are useful for awakening people's

conscience, what matters to individuals is the local availability of water. Overall, there is no severe water shortage problem in Europe (**17**). "Although water is part of the global system, how it is used and managed locally and regionally in what counts" **(7)**, and those are the places where water crisis are truly emerging if not already there.

The well publicized hot points of existing or near chronic water-stress and/or harmful to ecosystems are shown on page 116 of (**43**).

3.3.2 Ugly pictures

- Industrialized but economically less advanced countries of Eastern Europe have an alarming number of water bodies that are ecologically dead or dangerously polluted.
- The situation in the populous China is equally bad if not worse. Almost 78% of the water in rivers flowing through Chinese cities was no longer drinkable according to a 1996-report by China's National Environmental Protection Agency.
- Of 30,000 rivers in Japan only 2 are neither dammed nor modified.
- Aral Sea ecological tragedy.
- Half of the world's wetlands have been lost this century (**26**).
- The Mekong River system provides the ultimate example of impacts of deforestation which have resulted in increased runoff, soil erosion, and river, lake and swamp silting, threatening river fisheries and the existence of the Great Lake in Kampuchea, one of the world's most productive fisheries (**27**).

Box 3.3

FRESHWATER ECOSYSTEMS: BENEFITS & THREATS

BENEFITS

- **Fisheries wild capture** — **12 million tonnes**
- **Fisheries aquaculture** — **12 million tonnes (together ¼ of planet's yield)**
- **Other major resource** — **Rice**
- **Scientifically described species** — **45,000**
- **Undescribed species** — **about one million***
- **Provide water**
- **Regulate water quantity and quality**
- **Provide habitat**
- **Provide recreation, aesthetic experience and reflection**

THREATS

Water-based:

- **Dams**
- **Introduction of exotic species**
- **Over harvesting and aquaculture**
-

***Land-based with water as main agent*:**

- **Agricultural practices (pesticides, fertilizers, manure and sediments)**
- **Forestry**
- **Industrial and municipal discharge, etc.**

Others:

- **Population growth**
- **Increased per capita consumption**
- **Power of international trade organizations and agreements diminishing the capacity of governments to protect the environment**
- **Modification of the water cycle by anthropogenic changes in vegetation and climate**
- **Climate change.**

***Most freshwater species occur in rivers, rather than lakes despite the higher volume of the latter.**
Source: (9)

World-wide there are more than 40 000 large dams 15m or more high holding 6000 km^3 of water and inundating more than 400 000 km^2 transforming running to still ecosystems; fragmentation of habitat; changing seasonal flow and temperature cycle, turbidity and sedimentation patterns; reducing fish yield 1.5 to 4 times of that from natural river-flood plains; increasing evaporative loss especially in tropical regions **(13).**

- The Yangtze receives 40 million tons of industrial and sewage waste a day. 79% of China's people drink contaminated water. Incidence of water pollution going above danger level has increased.
- Africa has more daunting water stress problems than any other region. Some 19 countries have the least access to safe water. Not surprisingly, Africa also suffers most from water-borne diseases.

The task is gigantic: local infrastructures are weak and are not capable of handling the problem. Economies are poor. Public enthusiasm for tackling water pollution cannot precede their need for food and survival. No matter how much external aid is given to improve safe drinking water supply to such countries, a sustainable situation can come only when people will start to earn a reasonable income.

The poor consume or degrade ecosystems in order to survive, as opposed to others who may draw upon ecosystems to increase their wealth. It is easy to say that poor should be involved in decision making about conservation of supplies of water; but how to do it is the root problem. Their capacity has to be strengthened, and more sustainable ways of securing food and livelihood have to be developed. In order to attain this objective let the international goodwill contribute to increase global, national and community equity of income, improvement of general quality of life of poor communities by diversifying their livelihoods. By addressing water stress problems, many environmental and social ills would be cured.

Engineering projects and technologies give people access to and control over nature's water supply all too often without regard for harmful side-effects, and ecological services of rivers, lakes, and wetlands **(23)**. There is little hope of respite from river development: Hydrovia (South America), Three Gorges (China), Bakun (Sarawak) projects are mega constructions which will disturb ecosystems in a major way. But there is some hope that greater and wiser water use might lead to protection of watersheds and their ecology.

3.3.3 Proposed water schemes with major ecological implications

- Diversion of north European lakes and rivers into River Volga mainly to stabilize the Caspian Sea level.
- Reverse a portion of northward flowing Siberian rivers to parched land of central Asia and stabilize the shrinking Aral Sea.
- Okavango Delta
- White Nile, Jonglei Canal.
- Florida's Everglades are being lost in one of the wealthiest countries in the world. What realistic hope is there for survival of nature elsewhere? (**23**).

- GRAND (Great Recycling and Northern Development) Canal: blocking of James Bay and diverting water southwards to the Great Lakes and thence to the water-short American West.
- NAWAPA (North American Water and Power Alliance): siphoning water from Alaska and western Canada to the Canadian prairies, American Southwest and Mexico thousands of kilometres away.
- Large-scale transfer from Yangtze River to Yellow River to feed the dry northern plains requiring pumping 20 billion cubic metres of water.
- Narmada Valley Development Programme – 30 large dams, 135 medium-sized and 3000 small ones.

3.4 Signs of water stress

Water the life-giver

- Falling groundwater tables,
- Drying rivers and streams: dammed and diverted, some like Colorado and Yellow rivers reach the oceans in a trickle,
- Shrinking lakes,
- Disappearing wetlands,
- Deteriorating quality of water (arsenic poisoning of groundwater in Bangladesh),
- Slowdown in irrigated cropland,
- Decrease in crop yield (1 billion people now subsist on less than $1 a day).

Water the bearer of disease and death

- Increasing contamination with pesticides from agriculture,
- Mounting load of industrial waste,
- Increasing untreated sewage,

At any given time, half the people in the developing world are suffering from a water related disease, and 25 000 die.

3.5 Major areas of water use

	Developed	**Developing**	**World**
Farming and ranching	10 – 33 %	70 - 90%?	70%
Industry	50 – 80 %	10 – 30%	25%
Community			5%

About 80% croplands are rain-fed crops and 36% of global harvest comes from 17% of the world's irrigated cropland. Again, these global figures do not convey a balanced picture of the real situation of water use. Only about 25 per cent of the water abstracted in Europe, as a whole, is used for agriculture. Industrial water use varies widely between countries. In

FRESHWATER IS NATURE

- **Do not view water only as a resource that is there for the taking, rather than a living system that drives the workings of a natural world we depend on.**
- **Use and manage water with the aim of harmonizing human needs with those of a healthy environment.**
- **Adjust production and consumption patterns so as to remain within ecological limits. (23)**

Finland, Germany and Belgium, industry accounts for some 80 per cent of all water abstractions.

4 DEALING WITH THE CRISIS

Air the Guru, Water the Father, great Earth the Mother:
Day and night, the two nurses, in whose lap the world plays.
(Adi Granth-p.8)

4.1 Solutions are in our hands

"Recognizing ourselves as part of the life-supporting network we depend on and learning to live within water's limits are integral aspects of creating a society that is sustainable in all respects"(**23).** "Rivers, lakes and wetlands are daughters"; with our ecologically sound and economic practices we can restore our ecosystems and freshwater supply. "What we do to the ecosystem we do to ourselves" (WWF)

It is estimated that an injection of $36 billion per year, equal to roughly 4% of world's military expenditure, could bring clean drinking water and waste disposal facilities to all humanity (23). Regretfully, this will not happen. So the solutions are in people's hands.

4.1.1 Basis of solution

The ecosystem approach to integrated water resources management is the right basis for redressing freshwater problems. This approach embraces water use ethics of efficiency, equity, conservation, ecological integrity, the way to long-term sustainability. Ecosystem management "integrates scientific knowledge of ecological relationships within a complex socio-political and values framework towards the general goal of protecting native ecosystem integrity over the long run". It addresses "large-scale, long-term, complex problems by blending ecological, economic, and social goals, and by acknowledging that people are

integral, interacting parts of nature." (**28**). Help or rather means given to improve the quality of life of a region's people and economy, will enable them to adapt to the ecological needs of a healthy aquatic system.

4.1.2 Positive pictures

"The ray of light amidst the gloom, is that ecologically sustainable agriculture, forestry, industry and urban practices" are on hand to help restore the diversity and functioning of not only land, but also freshwater (**13**). Rich countries of the Western world and Japan did not have to wait for global conferences and prompting from international organizations to start managing the ecology of their water bodies. Local communities have been educated and mobilized to aggregate their effort to save local streams. Even the waters of major lakes and river systems such as the Rhine, the Chesapeake Bay basin, Thames, the Great Lakes and Colorado have been cleaned to a standard so that they are rapidly becoming alive again and give pleasure to the eye and nose. Swiss waters, which suffered from fish kill and odours, are now potable. Western Europe has probably crossed the threshold into healthy nature and clean water. Trend shows that humans can now redress the harm being caused to all freshwaters and establish some degree of equity and environmental equilibrium. Even at the global-scale, the Assessment Report **(2)** shows that global municipal water withdrawal has levelled of in the 1990s and that for industry and agriculture are close behind. Is this levelling of due to shortage of water and a sign of water crisis or an indication of humans adjusting to forces of nature? That we could be on the right track of adjustment is confirmed in the same report, which shows that the amount of irrigated land in the world is increasing while consumption of water has not increased much. Some "blue" points below illustrate the emerging change of vision.

- " Within the context of the Canadian Water Quality Guidelines, we find no clear evidence on the prairies of wide-spread contamination of surface and ground waters from agricultural activities" (**14).**
- In Yahagi, near the industrial city of Toyota, there is an exceptionally clean river. Its condition is the result of a twenty-year effort. Farm runoff had badly polluted the river, with a major impact on fish. So a coalition of fishermen and farmers was formed to elect a person to visit all of discharges into the catchment followed by action. Now the river is a model of healthy water (**29**).
- In the USA and other developed countries, days of large water projects appear to be over. The authority of The US Clean Water Act has been used to stop mega water engineering projects such as the Two Forks Dam to ensure that environmental values would no longer be wantonly sacrificed at the alter of water development (**23**).

4.1.3 New technologies

Water stress, especially in water-short countries, is being reduced using new methods and technologies, e.g.:

- Growing salt-tolerant (e.g. tomatoes and wheat in Israel), drought-resistant and water efficient crop varieties.
- Using more efficient crop irrigation (drip or micro-irrigation).
- Turning to smaller scale projects (shallow groundwater wells, garden irrigation, local runoff storage). In fact, with new perception of environmental costs, decommissioning of dams is beginning to be promoted.

4.2 Conservation and efficient use

Water demand in developing countries is projected to grow rapidly for urban and industrial uses. The additional water demand will need to be met increasingly from water transfers out of irrigation and ecosystems. The management of this reallocation ecologically sound and without causing negative socio-economic effects could determine the world's ability to feed itself (**9).**

> **"Measures to conserve water and use it more efficiently are now the most economical and environmentally sound water supply options available for much of the world – and they have barely been tapped. Together, they constitute our *last oasis*"(23).**

A combination of engineering, socio-economic, ecological, management, legal and public education measures can enhance efficiency of water use by reducing use and increasing re-use and re-cycling. By doing this we are creating a new source of water supply without loss of quality of life.

Possible water need cuts:

Farmers	**by 10 –50%**
Industry	**by 40 - 90%**
Cities	**by over 30%**

Table 4 – 1 lists the principal measures already being taken to conserve and use water efficiently as well as their relief effect on our water stress.

4.2.1 Engineering measures

Engineering solutions have become expensive because they have to make allowance for environmental consequences. But adding previously unaccounted ecological returns in the long-term makes them affordable now, if not cheap. Although industrial wastewater reclamation requires costly high technology, it is still cheaper than developing new water sources including desalination. Pollution is the major culprit for defiling nature and water is the principal carrier. By controlling this carrier, we can keep our Planet "blue" and green. Some topical engineering-based measures are listed below.

Desalinization: If humanity could find an inexpensive way to extract freshwater from the oceans, that achievement "would dwarf any other scientific accomplishment"(John F Kennedy, 1961). Thirty-five years later, the world has more than 7500 desalting plants, collectively turning 4.8 billion m^3 (1% of total water use) of salt water to freshwater. Because of extreme water shortage and abundance of available energy, Gulf States have 60% of all such plants producing a cubic metre of freshwater at $1 to $2. This is about 8 times more expensive than the cost of urban water in many countries, but almost the same as consumers pay even in water abundant countries like Switzerland. Desalination of brackish estuarine flow or groundwater, for example in Florida, costs $ 0.40 – $0.70 per m^3 which is affordable even in many third world countries provided that such source exists. Egypt has two ambitious desalination schemes to make its desert bloom.

Others: The other main practical engineering measures to conserve water and increase efficient use are:

- Treating wastewater as resource and changing from linear approach – "use, collect, treat thoroughly, and then dispose of" – to closing the cycle – "use, collect, treat partially, and then use again".
- Providing for seasonal storage for treated domestic wastewater e.g. recharging a nearby aquifer or deep ponds.

The idea of "sewage farms" has been in operation since 1650 in Great Britain and in other countries since then. This practice is being actively pursued in Israel where 70% of the nation's sewage gets treated and reused to irrigate 19000 hectares resulting in reduced use of additional chemical or organic fertilizers. (also in parts of Portugal, USA, and Brazil). Combining low-cost sewage treatment with irrigation would "go a long way towards solving the vexed triad of pollution, scarcity, and health problems now plaguing so much of the world" (23).

- Repairing of leaky pipes and curbing water losses in the distribution system itself is rewarding with quick payback on the investment especially in developing countries.

Reducing leak-loss from 51% to 31% in Jakarta would, for example, retrieve 45 million cubic metres annually, enough to supply 800,000 people

- Recycling of wastewater for urban irrigation.
- Conservation in households e.g. smaller toilet flush tanks.
- Setting up "Water Factories" as in Los Angeles and Tucson, and as in St. Petersburg (Florida) where the water cycle has been closed by reusing all wastewater and discharging none to surrounding water bodies. (In Windhoek, Namibia, water is reused even for drinking)

Industry has made the biggest leap forward in water conservation and pollution abatement. Only small fraction of industrial water is actually consumed. Closed-cycle reuse saves from 27 to 90 percent of water, and the payback period on the conservation investment can be less than 12 months (of the seven countries California may be the leader). Unfortunately, few developing countries are yet giving industries the incentives they need to become more water efficient.

4.2.2 Ecological measures

Ignoring the environment and ecosystems has been the root-cause of present day water stress. We must increase investment in our natural capital through programmes of reforestation, restoration of ecosystems, water conservation, prevention of water pollution, sustaining natural ecosystems of rivers, wetlands, lakes, and traditional water regeneration practices. The measures listed below pertain more to change of habits and practices than to major engineering inputs.

- Improving capacity to track water resources.
- Fostering styles of living that do not rely on high rate of consumption.
- Decrease water loss through evaporation (irrigation).
- Restoring traditional small-scale water storage and regeneration devices such as ponds and village tanks, but managed in a modern integrated manner.
- Biologically removing harmful constituents using low-tech means of ponds and reservoirs with adequate sanitary controls.
- Changing from furrow system of irrigation (30% water use efficiency) to surge techniques (15 – 50% reduction in water use).
- Changing from old-tape high-pressure sprinklers to low-pressure ones can increase water use efficiency by 10 – 20% and even by 35% depending on sprinkler design.
- Using drip and other micro-irrigation techniques can achieve water-use efficiencies in the range of 95% compared with 20% in traditional irrigation, resulting in unparalleled production increase in water-short countries e.g. in the Jordan River valley.

Table 4.1 – CONSERVATION AND EFFICIENT USE CAN REDUCE OUR WATER STRESS

SOLUTION	EFFECT	STATUS	COMMENTS/ACTION
1.Desalination	Yield 4.8 billion m^3 1% of total water use. 60% of total water	7500 plants	Cost : \$1-2 per m^3 (8 times cost of urban water supply today); \$0.40-0.70 per m^3 for brackish water. Becoming affordable
2.Indusrtial water closed circuit reuse, with incentives	in Gulf States Saving 27-90%	Most advanced in seven countries (California in the lead)	12 month payback period on the conservation investment
3.Change furrow-to surge- irrigation			
4. Change high-to low-pressure sprinkler	Saving 15-50%		
5. Drip irrigation	Saving 10-20% up to 35% depending on sprinkler design		
6.Metering households	Saving 95% and unparalleled production increase		
7.Improving canals and management	Saving 10-15% Increase in irrigated land, doubling yield		India could allow 8 million ha of additional irrigated land i.e. 19% increase and double yields.
8- Conjunctive use of canals & groundwater	Saving 10-50% and decrease in ecological damage		
9.Reducing distribution loss	Quick payback		Reducing leak loss from 51% to 31% in Jakarta would retrieve 45 million m^3 annually, enough to supply 800 000 people
10.Stone or grass bunding, terracing, soil covering	Yield increase 30-60%		
11. Household water saving devices.	Saving 10-20%		

Drip and micro irrigation is still only 0.5% of irrigated area worldwide. It is 3% in USA and 70% in Cyprus, a sign that its use will increase fast especially in market gardening sectors of developing countries that are receiving important investment from rich nations.

Climate change and its possible impacts cannot yet be interpreted into meaningful or quantifiable benefit or loss to ecosystems in general and water resources in particular. Most countries have adopted a wait-and-see approach and seem to have chosen to do nothing with regard to taking corrective measures.

4.2.3 Management measures

Probably the major reason why ecosystems and water resources have remained separated is the missing link of integrated management. Integrated Water Resources Management (IWRM) is a process that aims to ensure the co-ordinated development and management of water, land and related resources to optimize economic and social welfare without compromising the sustainability of vital environmental systems (30). In this refined concept of IWRM, cross-sectoral environment and ecosystems (E&E) has been rightly placed as an over-arching entity.

- Introducing corrective measures through pricing, metering, incentives, maintenance services and community participation in those countries where water supply systems are already managed and public are educated, as it is being done in many developed and some developing countries.
- Metering household water use (10 % – 15 % reduction in water use).
- Improving canal systems and their management. For example, in India, improved management of canal system could allow 8 million hectares of additional irrigated land i.e. 19% increase, and double the yields without developing new water resources. Some progress in this direction has been made in Sri Lanka, Nepal, and Mexico.
- Making conjunctive use of rainfall, surface water, and groundwater, using weather and watering forecast services can save 10 to 50% of water and decrease ecological damage.
- Taking measures to achieve a balance between groundwater pumping and recharge within a fixed period.
- Sparing water to restore ecosystems to health.

4.2.4 Hydro-economic measures

Valuation of ecological-service benefits is a relatively new tool. Methodologies for its application are being developed. Cost water (full supply cost, full economic cost, and full cost by adding environmental externalities) should result in a sustainable value of water in use **(31).** Getting water resources properly assessed in the broad context of economy should take precedence over even important issues such as

integrated water resources development. Equipped with such information, hydro-economic measures listed below can be applied beneficially.

- Taking investment and management decisions within the framework of the hydro-economic balance, assuming the entire hydrological cycle to be a unitary resource.
- Pricing of water judicially, the main tool of a water conservation strategy invariably produces beneficial effect.
- Giving suitable incentives to industry can cut water needs 40 – 90 %. For example, a dairy, a pharmaceutical company and a food processing plant in São Paulo, Brazil, reduced their water use by over 50%.
- Freeing more agricultural water supplies by increasing irrigation efficiency and crop selection, and trading it with urban centres.
- Governments and funding agencies can help to put in practice new water ethic by placing ecological sustainability at the core of their investment policies, agreements and decisions **(23).**
- Establishing the value of water resources as a function of hydrological/ environmental variability and economic uncertainties, which are by far more important determinant of system behaviour than even variability in the political variables (**31) (see Box 4.1).**
- Imposing fines for water waste.
- Applying more efficiently the user-pays and the polluter-pays practice.

Box 4.1
UNCERTAINTIES ON THE POTOMAC WATERS

In 1963 the US Army Corps of Engineers recommended that 16 major reservoirs costing $400 million and 418 headwater reservoirs costing $100 million be built in the Potomac Basin. Nine of the new reservoirs were recommended for immediate authorization in order to meet the flow requirements and water quality improvements by 1985-90. Eventually only one small water supply reservoir was built. The water supply goals and greatly improved water quality goals were met mainly by operating the existing separate systems more efficiently as one large system, and by implementing the Federal Clean Water Act of 1972. This is a cautionary note that should be closely examined by those who would have us make important decisions before we have fully understood the implications of relative uncertainties in the overall system (30).

4.2.5 Small-scale measures

Nearly 84% of agricultural land produces food without irrigation. In Sub-Saharan Africa only 4% is irrigated. However to increase non-irrigated production of food there is a desperate need for traditional and new small-scale approaches. These approaches usually do not increase water loss significantly, and if managed correctly, they can lead to optimal use of available water without causing serious damage to nature. The underlying idea is to conserve or channel rainfall water to enhance the amount of moisture available to crops. Some such water conservation and augmentation measures are:

- Micro dams, shallow wells, and low-cost pumps.
- Moisture conserving land technique such as stone bunds or grass hedges and *zai* can increase crop yield by 30 – 60 % (e.g. in Yatenga, Burkina Faso).

- Rainwater / runoff harvesting, runoff agriculture, and gardening in *dambos* (seasonally waterlogged land).
- Improved land-use practices such as terracing (e.g. in Kenya and Peru) and erosion control and sand dune fixating
- Cutting down evaporation by covering the soil between crop rows with polyethylene (crop yield can be doubled).

4.2.6 Legal Measures

Legislative and regulatory measures emanating from balanced management and hydro-economic decisions form the driving force for attaining ecologically sound water use. The role of NGOs such as WWF and IUCN becomes primordial in educating people and guiding authorities towards enforcement of legislative and regulatory measures. A considerable body of water related laws already exist in many countries. Some of them can be adapted for use in other countries. Only a sample of legal measures is listed below.

- Adopting laws and regulations specifically designed to control land use in watersheds.
- Enacting and enforcing pollution control regulations to clean up water bodies and to promote conservation and efficient water use.
- Obligation to install standard water-efficient fixtures and appliances in all new homes and gradually in all homes.
- Obliging new factories to incorporate conservation and recycling of water from the outset.

4.2.7 Public education measures

"*With public sentiment nothing can fail; without it nothing can succeed*." (Abraham Lincoln)

There is a wide scope of measures for educating public and private institutions and public in general ranging from local community groups (social, cultural, educational and religious) to trade and professional organizations and the political leadership. One can only suggest emulating countries like Canada whose praiseworthy public education campaign has produced very positive results. We need an antidote to school textbooks many of which "…are counsels of despair and guilt which offer no hope of winning the war against famine, disease and pollution, thereby inducing fatalism rather than determination. …" **(32**)

A few measures are listed below as an example.

- Promoting water ethics: right to use of water should be accompanied by recognition of obligations to preserve and protect it, the central goal in all what we do.
- "Living within our means" a door-to-door campaign for introducing water saving devices. For example, n San Jose (USA) in 1986, 90% of targeted households co-operated and water use in homes dropped 10 – 17% and after a similar but much bigger public education campaign in Greater Boston, water use dropped more than 16 % between 1987 and 1991 (23).
- Reconnecting modern society to water's life-giving qualities.

- Encouraging governments to apply the option of water reallocation among different sectors e.g. urban use and irrigation, with active participation of concerned parties thus avoiding social and political confrontation and tension.
- Overcoming the psychological barrier to water reuse

4.3 Area-specific actions produce results

The World Bank has estimated that investment of $600 billion in water infrastructure will be necessary in the next decade alone to provide freshwater for all. This overall figure has little impact unless accompanied by a more detailed regional breakdown linking area-specific action programmes with sources of finance. In the end, integrated water resources management is a political issue **(27**) and it is not meaningful if it does not address a specific affected community.

It is not uncommon that action is taken when the people in power in a national political set up are directly affected by water stress resulting from shortage or degradation. Not long ago, River Thames was ecologically dead. It is said that the problem did not concern the leadership until the *stench from the river made the peoples' representatives sitting in British House of Parliament to pinch their noses*. Quickly adopted legislation was steadfastly enforced with government providing subsidies to help polluters treat their affluent. The Thames is alive again and fish are back.

Similarly, a crisis situation in 1995 in the Huaihe River basin in China forced the Chinese authorities to take draconian measures. More than 1100 paper mills and 400 other industrial plants that dumped refuse into the river were shut.

4.4 Actions already being taken

Drop by drop oceans are made. Numerous corrective measures are already being taken in many rich countries and they are being actively emulated in many others. The progress and impact of these measures is tangible and recognized by all parties depending on development level of national institutions and wealth of local communities. A few of the noteworthy actions or trends that have helped to safeguard our freshwater resources are given below.

- About 5.2 % of the Earth's land area (7.7 million km^2) falls under protected area management for conserving bio-diversity and ecosystems, including wetlands protected under the Ramsar Convention (**33**). Assuming that these areas are properly managed and guarded, freshwater in these areas is also protected. There are many other protected river reaches and lakes; but an accurate figure is not available for the total global area of water that is protected. However, it should be kept in mind that all these protected areas are subject to aerial pollution and runoff pollution from adjacent lands.
- Countries are abandoning plans for environmentally harmful dams in favour of modest water resources development projects.
- More and more countries ranging from USA (Texas) to Sri Lanka are applying new strategies and irrigation technologies to stop water

waste.(e.g. drip irrigation and using brackish or salt water for growing tomatoes and other crops).

- Significant increase of industrial water recycling that began on a large scale in the 1970s has proved very effective. In Japan and Germany, total industrial water use has not risen in more than a decade despite a large increase in number of factories. It has been estimated that farmers can reduce water consumption about 25%, and industry could save as much as 90% by recycling (**23**).
- Water-quality objectives are increasingly used in Europe as an important policy instrument to prevent, control and reduce pollution in surface waters, including trans-boundary waters. They aim at ensuring the multi-purpose use of fresh water, while supporting and maintaining aquatic life and/or the functioning of aquatic ecosystems. Water authorities are setting targets for maintaining or achieving threshold values for water quality within a certain time period.
- In seven years (1990 – 1997) Australia's land-clearing rate has decreased by two-thirds and planting of trees increased – impact mainly of green politics since the 1980s.

5. WATER, WAR, LAW AND TRADE

5.1 Will there be war over water?

The doomsayer prophecy that struggles for freshwater would be the cause of future wars. So far they have still to be proved correct. In one of the most politically volatile and water-short regions of the world, the Middle East, far from going to war over water, Jordan and Israel have set a good example of co-operation. Hungary and Slovakia, under the auspices of International Court of Justice, are finalizing an amicable settlement without recriminations over the Gabcikovo Dam on the Danube River, even though the damage inflicted on the forests, wetlands, fishing and nature in general had not mobilized people against construction of the dam. In 1997, Bangladesh and India have concluded an agreement on sharing the flow of the Ganges River. So far the truth is that inter-State conflicts over sharing of water in international watersheds have, up to the present, been a source of peace.

With Palestine also requiring additional freshwater for development, sharing of waters of Jordan and Yarmuk rivers in the Middle East is still a politically hot issue. Turkey is anxious to reach a water-sharing agreement with Syria and Iraq on the Tigris-Euphrates River so that it could secure financing from the World Bank needed to complete its water storage and use schemes in the upper catchment. Probably the Nile River remains the most talked about problem-river. However, unlike the Tigris-Euphrates basin, the upper catchment of the Nile River is still undeveloped. The question of a major conflict does not yet arise although Egypt is determined to take measures, which would ensure its future supply of water (**see www.bigbangyoga.org -CURRENT ISSUES: *There will be no war over Nile waters*).**

A major mitigating factor against war over water is the well-publicized fact that many countries can reduce water use by about 50% by implementing well-known conservation methods, introducing readily available new

technologies, and exploiting alternative sources of water (e.g. desalination) which have become affordable.

5.2 Water legislation

5.2.1 National basins

"Efficiency, equity and ecological integrity" are three basic tenets of sustainable water use, which must be injected quickly into the current policies, laws and practices (23).

Prophesying international wars over water is conjectural and detrimental to peace if not highly provocative. But within most countries, it is not unusual to have conflicts among states, districts and neighbouring farmers over sharing water resources in the same manner as for land and other resources. However, there is now another claimant of water: nature and ecosystems. It is not clear at this stage whether human freshwater crisis will determine the agenda of conservation of nature, or conservation will set the agenda for resolving the freshwater crisis.

Countries already have regulations and laws, even more important, enforcement mechanisms, which are used to mediate water-related disputes. A basic policy problem is how should water be allocated to meet the human needs and those of nature in the face of often divergent policies, priorities and interests of ministries and agencies for management and conservation of freshwater. Not all national water laws cover the new dichotomous demand. National nature NGOs such as WWF, have a big responsibility for generating sufficient public pressure on national water boards to prompt them to propose adjustments to national laws. Existing regional and international legal instruments, with inputs from scientific, economic, environmental, and other sectors, can help to revise national laws enabling enforcement authorities to judicially settle disputes, claims, internal differences, and social, ecological, environmental and economic interests related to water resources management in any national river basin.

Water legislation for protection of freshwater resources, aquatic ecosystems, and the environment in general evolves rather slowly. Surely this process has accelerated recently because there is considerable public awakening and concern which has emerged as a political force in the form of "green" political parties or has formed part of agendas of existing political parties in a number of countries.

5.2.2 International water legislation

About three hundred bilateral, multilateral and regional treaties and conventions, of which some 150 in Europe alone, have been concluded to ensure equitable use and conservation of waters, and to prevent deterioration of water quality. Usually accords are implemented through permanent or ad hoc joint commissions. Most agreements were for single purpose – mainly irrigation water supplies. Seeing the adverse impact of water pollution and wounded nature, riparian States have begun to take interest in the ecosystem approach to integrated water resource

management in order to protect the entire shared-river basin from ecological disaster. As a result, since 1990, some 20 bilateral and multilateral agreements in Europe have been revised, supplemented and updated to meet the exigencies of integrated water management, including the prevention, control and reduction of trans-boundary water pollution (**2**).

These treaties constitute the main source of international water legislation, which cannot be applied in basins other than those to which it belongs. In shared river basins, governments themselves become claimants and disputants, because they have the duty to further their country's interests, or at least guard them. "Should they fail to agree, there is no supreme authority automatically available and mutually acceptable to whom they can refer"(**34).** Even minor water disputes can become political issues and assume exaggerated significance.

TYPES OF HUMAN WATER-RELATED CONFLICTS

- **Increased disparity in water's availability to rich and poor (conflict resolvable under national policies and laws).**
- **Sharing of the limited resource between countries, e.g. USA-Mexico, Israel-Palestine and India-Bangladesh (so far settled amicably through bilateral negotiations or international arbitration).**
- **Increased inequality of water use in communities in similar water-short areas but in different countries, one using 2000 litres per day per family and the other less than 150 litres (an ethical conflict which can be bridged only through economic goodwill and societal globalization)**

In order to forestall aggravation of conflict arising from complex environmental issues and to facilitate negotiations, European countries have agreed to co-operate under a Water Convention which covers five programme areas: joint bodies, assistance to countries with economies in transition, integrated management of water and related ecosystems, land-based pollution control, and water supply and human health (**21)**. Many obstacles to the abatement of water pollution cannot be resolved unless relevant national policies and strategies are rendered compatible at the international level.

5.3 World water convention

Global phenomena such as bio-diversity, climate change, and desertification did not have much national legislation or regulations. International conventions have therefore been promulgated with the hope that countries would weave them into national laws and practices. Water, as a resource, has been taken as absolute national sovereignty subject to national laws. Consequently, international water law has developed slowly. Three milestones described below provide a good basis for preparing a world water convention.

- 1966 - General Rules of International Law Applicable to the Use of Waters of an International Drainage Basin ("Helsinki Rules") adopted by the International Law Association in 1966.

- 1992 - Convention on the Protection and Use of Trans-boundary Watercourses and International Lakes adopted in Helsinki by the UN Economic Commission for Europe, covering environmental and ecological aspects as well.
- 1997 - UN Convention on Law of the Non-Navigational Uses of International Watercourses, adopted by UNGA after thirty years of heated discussion. It provides a legal framework for addressing international water issues. Whether the Convention will receive universal endorsement by the international community is questionable. The sensibility over developing substantive rules is likely to debilitate further progress in this field.

While national water law can also incorporate appropriate articles of these conventions, a judicially promulgated “World Water Convention” giving prominence to ecological approach in integrated water resources management would form a sound basis of an international water law.

5.4 Trade and investment

Trade and investment, and national, international and trans-national corporations all have a powerful influence on the environment. According to World Bank estimates, the flow of private money to the third world has jumped from $44 billion in 1990 to $244 billion in 1996. The bulk of this amount supports environmentally destructive forms of development, including mines and logging. International agencies must ensure that these funds are directed towards environmentally safe investments. It augurs well that The World Bank has started to attach environmental conditions to its loan agreements in the water sector. Because investment in third world countries is largely private, responsibility for environmentally safe projects rests with the governments themselves and also depends on investors; whether they are ecologically enlightened.

Trade has been treated as an isolated phenomenon of little concern to the world of natural. The World Trade Organization (WTO) deals with governments and big corporations. Global trade agreements through WTO and regional agreements such as NAFTA and MAI (Multilateral Agreement on Investment) favour investment and trade over protection and conservation of freshwater supplies. They often conflict with international environmental conventions. In a limited way, WWF has been able to influence parties and organizations concerned so that such agreements should not be negotiated solely by those concerned with commerce, because market forces exert a heavy burden on ecosystems and freshwater **(13**).

Social and cultural values in many countries and present financial mechanisms can be expected to continue to foster loss of ecosystem benefits, although this attitude is somewhat changing with respect to water resources. In most industrialized countries, prices of goods and services at least partially reflect the costs of water use but not of loss of ecosystems. Producers pass these costs to citizens. In a similar manner, national accounts record financial indebtedness and loss of capital assets, but not loss incurred by depletion of natural capital in the form of water resources (**35**).

How should adverse influence of trade and investment on aquatic systems be moderated so that articles of agreements and environmental decisions derived from it are benign? IGOs with responsibility for any aspect of water resources should join hands in order to exert pressure on e.g. WTO and other existing and planned commercial agreements to include ecological and water conservation clauses. Such pooling of IGOs effort is possible only if the water sector of the UN group is restructured and co-ordinated to effectively address:

- Changing WTO fundamentally so that freshwater in the context of ecosystems forms part of decisions on trade;
- Modifying WTO and international trade agreements to ensure that globalization of trade does not trade off local or planetary support systems or increase the environmental debt, and that they conform with the international legal conventions;
- Promulgating legislation penalizing those circumventing environmental articles of international conventions.

6. INTERNATIONAL PLAYERS

6.1 Promises made and forgotten

Problems of water stress are real. Traditional approaches of IGOs and NGOs based on benevolence towards thirsty populations have not produced the desired long-term results mainly because the “principle of sustainability” was not honoured. The aid programmes were scattered and were rarely tuned to the economic level of communities, and public participation was rare. The rhetoric of the international community in 1992 Dublin Conference on Water and the Environment that became Chapter 18 of UN’s “Programme of Action from Rio” (Agenda 21) succeeded in making a lot of smoke. A number of other recent international agreements and conventions pertaining to environment also cover freshwater. They whip up a lot of hope but few hope-fulfilling actions and results. **Table 6-1** summarizes the state of some of the promises made by the international community.

6.2 New challenge

In their report on “Integrated river basin development” to the UN in 1958, the seven eminent water experts, a number of IGOs themselves and NGOs had wisely recommended that water resources sector should be co-ordinated by one of the IGOs of the UN family (**34)**. Despite strenuous efforts by ECOSOC, the IGOs failed to heed advice and could not reach agreement. Since then, each of the twenty-four agencies developed its own independent water programme, all preaching to States that they should co-ordinate their water sector.

The quarrelling of IGOs for leadership in the water sector has been acrimonious. Some have blamed government for lack of co-ordination among national institutions dealing with water and failure of aid projects. The fact is that each country has one water resources development programme drawing from one budget often supported by a national water

law. Water sector is co-ordinated far better at the national level than it is among the IGOs. IGOs have often undermined national co-ordination in order to safeguard their own interests. For example, two different IGOs executed two separate projects in the same national water unit, one to strengthen the hydrological programme in Bangladesh and the other to set up a flood forecast and warning system there. Both projects were UNDP-funded. That the executing agencies of two projects were not on talking terms is incredible.

Recently, World Bank has adopted a holistic approach but with emphasis on socio-economic aspects. Having its own funds to loan to governments for investment projects in water, gives the Bank certain power to enforce its ecological policies in countries (**36**). Other IGOs, however, do not have such possibilities.

NGOs such as WWF find it difficult to co-ordinate its water programme with those of IGOs because often each one covers usually only a sub-sector targeted to meeting specific human needs and not necessarily to conserve nature and water resources. There is no effective inter-agency co-ordinating mechanism to overcome this drawback.

The existing UN Administrative Committee on Co-ordination Inter-Secretariat Group for Water Resources has been successful in exchange of information, but has not been effective in achieving concrete results through joint action. Frequent co-ordination meetings have helped to whitewash the glaring defects in particular duplication.

6.3 The new front

The ecosystem-based approach to resolve water resources issues has been endorsed in principle by all agencies, but it is difficult for them to put it into practice. One reason is that this approach has opened a new front with trade, industry, food production and migration implicating programmes and agreements of such bodies as WTO and FAO as well as regional economic agreements such as NAFTA. Dealing with this new front at the national level with ecosystem approach is even more intricate.

Global Water Partnership (GWP) has found (**30**) that few ongoing international programmes come even close to covering the complete set of IWRM. IGOs dealing with natural resources and the environment find themselves in a dilemma as to how to promote the ecosystem approach in WTO and FAO and weave it into trade and agriculture and land use agreements, global and national, without causing undue hardship to the people.

To make an impact on trade and production processes, it is necessary to co-ordinate policies and programmes of IGOs so that the water sector would function as a whole and not made up of independent parts, at the international level. An IGO has no meaning in isolation; it has to relate to all others. Countries will also find it more practical and productive if they can address one or two IGOs on issues related to water resources and E&E, than trying to seek solutions from twenty four IGOs scattered around the globe. We believe that there is a strong case for grouping water-

related actions and programmes of these agencies into a unified or co-ordinating organization. A strategy and proposals for co-ordinating water sector are detailed in www.bigbangyoga.org, CURRENT ISSUES, Facing the future: breathing new life into the UN system.

7.1 POLICY OPTIONS AND SUGGESTIONS

7.1 Ecosystem-based water management approach

The traditional approach to “integrated river basin development” was conceived as the orderly marshalling of water resources of river basins for multipurpose to promote human welfare. Now the human welfare is seen in terms of the whole environment and can be achieved only through the holistic ecosystem approach in which humans are central to the well-being of the system **(34, 37).** The approach recognizes the ways in which humans use nature, inland water resources, riparian vegetation, wetlands, riverine floodplains and associated wildlife and habitats. It has, therefore, intrinsically a long-term vision, essential for sustainable water management.

Table 6.1 – Environment and ecological promises made and forgotten

PROMISE	REALITY
a. Convention on Biological Diversity	Increasing loss of species as humans take away the water supply of ecosystems. A weak promise signed by 161 countries is waiting for an action plan
b. Convention on Climate Change	Implication for water have been sidelined and completely ignored in the revised Kyoto (December, 1997) promise
c. Dublin Statement on Water and Environment	Probably the most quoted "Guiding Principals" in recent meetings and papers
d. Convention to Combat Desertification	"Urgent" action that delegations had called mainly for Africa has slowed down to a standstill because most Sahelian countries had good rains in recent years and fear of "crouching sand" has evaporated and with it the intention to contribute funds.
e. Rio Declaration on Environment	The rhetoric and promises of Rio have not been backed by strong action
f. "5 years after Rio"	Many conference, papers by experts many of whom had developed Dublin and Rio recommendations, repetition and complaining, but little progress. "Considering the urgent need for action" the UNGA has referred the matter back to UNCSD!
Global Water Partnership (GWP)	Trying to address the "global water sector" through IWRM but not sure whether it is one of the "teeth" of environment and ecosystems or an over-arching "comb" itself. It has identified cross-sectoral/sub-sectoral gaps and recommended actions but GWP is unable to find what it will do: a *clearinghouse* or a *network manager* or another "old boys club".
World Bank	It has an overarching policy on management of water resources to reduce poverty by promoting equitable, efficient, and sustainable development, which it has successfully used to safeguard E&E in some of its projects. Unlike most other IGOs, being a funding agency gives it leverage to enforce E&E principles. Hopefully it will strengthen this role.

Water fulfils five environmental and human functions (**38):**

- Maintaining human health
- Maintaining environmental health
- Supporting two production functions:
    (a) Biomass production, necessary for the supply of food, fuel wood and timber
    (b) Economic production, since industrial development has traditionally been « lubricated » by easy access to water
- Supporting two carrier functions:
    (a) Water plays an active role in diluting and transporting waste
    (b) In the natural erosion and land processes of the global water cycle
- A psychological function

“In developing and using water resources, priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems”**(1)**. Governments and international organizations have been preoccupied with identifying and meeting the basic human needs. What remains to be done is to identify and meet the basic water requirements of ecosystems, so that the goods and services provided to humanity by nature can be maintained indefinitely.

7.2 Holding meetings: a substitute for financing and action

According to the World Bank (**39)**, water resources development that has taken place so far in the third word countries has been 90% national effort and 10% external support of which about half is World Bank contribution. Bilateral input forms a sizeable amount and contribution of other IGOs is less than 2% of the total effort. This also explains why IGOs have not been effective in water and E&E issues?

As sequel to General Assembly’s June 1997 decision numerous conferences and meetings have tabled hundreds of recommendations repeating what has already been said before. It seems that holding of conferences and meetings in the water sector has become a substitute for action. We must break away from this trend. A recommendation is meaningful and realizable if it would answer seven questions:

- What is the root cause of water stress or shortage?
- What are practical and financial implications?
- Which approach brings early and cost-effective result?
- Is there an on-going locally funded activity?
- Whose initiative is it?
- Is the externally supported programme sustainable locally on a long-term basis?
- Are financial and human resources available locally or externally?

It is quite evident that IGOs, other than funding organizations such as the World Bank, are not capable of implementing what most of the recommendations demand, because they do not have the necessary funds

and their efforts are not co-ordinated at the same level of co-ordination as that at the national level and

7.3 Another opportunity

This is an opportunity for us to make our first commitment. Having led to a global water scare, it is incumbent upon IGOs and NGOs to plan the use of their 2% contribution in such a way that it would mobilize countries and civil society to arrest further aggravation of water crisis. At the same time give pragmatic advice to panicked countries which are taking very urgent but ecologically unsound measures related to, for example, building large dams, long distance water diversions etc.

This is an opportunity to assist more than 50% of the countries that are able to use less than 1% of their renewable freshwater resources, and their people might be doing the greatest per capita damage to ecosystems in their search for food and water. Enhance their income generating activities accompanied by increased use of water and reduced pollution which would lead to social security and economic growth. The prescription: “use less water” is not a universal cure.

7.4 Agenda

The aim is to meet “human requirements for the use of freshwater, whilst maintaining the biological diversity, hydrological and ecological processes necessary to sustain the composition, structure and functions of the ecosystems that support human communities. It is a holistic approach that considers all the relevant and identifiable costs and benefits of alternative management options to all shareholders, and ensures that the plan which is adopted is that which is most acceptable to all stakeholders” (**41).** We must recognize that the environment and ecosystems (E&E) to be a user of water and also a major supplier of water and “the engine of the hydrological cycle” (**24**). “Windows 97” meeting of GWP (**30**) has identified eight major cross-sectoral drawbacks as listed below. Of these, two concern ecosystems (

1. IWRM is a political, not technical, issue.
2. Lack of skilled professional.
3. Lack of cross-sector allocation and conflict resolution mechanisms.
4. Limited recognition of the benefits of ecosystem services and functions.
5. Inadequate protection of water resources and associated ecosystems.
6. Inadequate tools for integrated river basin management.
7. Incomplete knowledge base.
8. Lack of global IWRM representation.

7.5 Projects for influencing national water policies and accelerating of actions

Some specific projects in the list below have been proposed bearing that can be taken up by national NGOs. They are grouped according to types of

measures, identified in Section 4 above, for water conservation and efficient use.

7.5.1 Public education projects

- Launch a campaign to raise awareness of need for change and respect for water i.e. reconnect modern society to water's life-giving qualities;
- Encourage governments to involve private sector organizations, land-owners and public-interest groups, in the preparation and implementation of concerted action developed by policy makers, industrialists, farmers, planners, water managers, scientists and the general public;
- Assist communities to spread the ecosystem approach along with channelling substantial water management responsibility to local authorities concerned with land-use, giving priority to small-scale measures (see Section 4);
- Promote water ethics: Right to use of water should be accompanied by recognition of obligations to preserve and protect it: the central goal in all what we do.

7.5.2 Legal projects

- Review water laws and legislation of countries and joint river commissions, and take measures to include in them, where needed, clauses concerning maintenance and improvement of conditions in aquatic ecosystems clearly defining social and legal aspects of trade-offs between ecosystem-maintaining functions of water and short-term economic benefits;
- Promote amendments to water legislation to include obligatory environmental impact assessments (already practised in many European countries) for water-related investments as hydropower projects as well as non-water related activities which may have an adverse impact on water resources such as construction of oil and gas pipelines, open-cast mining and sludge storage;
- Introduce water accident ordinances as a preventive measure against hazardous water pollution incidents and accidents, and also policies which enable authorities to respond to such accidents;

7.5.3 Hydro-economic projects

- Promote setting of water prices especially in agriculture because wasteful irrigation and water losses are greatest in this sector;
- Urge government to re-examine and reduce water subsidies, the principal tool for promoting efficiency in water use and promoting equity between earnings from rain-fed agriculture and from irrigated agriculture;
- Review existing trade, investment and other economic agreements which influence ecosystems, from global to local scales, so as to make legal and economic frameworks address serious freshwater and biodiversity issues; and apply environment related agreements to relevant aspects of international trade and investment;
- Help authorities to revise trade and investment instruments to take into account water resources as a vital component of ecosystem, so that prices of goods and services should include cost of water production, treatment and delivery.

7.5.4 Ecological projects

- In selected river/lake basins, demarcate ecosystem boundaries superposing political or administrative borders and promote action to conserve nature and water;
- Promote through selected projects, assessments of environmental impact which is the tool for augmenting sustainability of water resources for all sectors and preventing environmental degradation;

Equally important are projects on engineering and management measures, which usually function together. They concern mainly water production, cleaning and distribution. Such projects already receive considerable attention of the international community.

Actions which play a central role in redressing water scarcity/stress are:

♦ ***Need for change*** - Start an efficiency revolution using tools and technologies readily available in agriculture, industry and urban zones.

♦ ***Reactive measures*** - Transform policies, laws, management, pricing and marketing practices that encourage wastefulness and misuse into more efficient, ecologically sound and sustainable patterns of water use.

♦ ***Proactive measures*** - Include into water laws, operations and management of non-market functions of water:

- Environment improvement, in general
- Habitat protection
- Species preservation
- Recreational uses
- Aesthetic values

♦ ***Propagating water ethics***

8 CONCLUSIONS

Lately water experts have recognized that the freshwater crisis is not global but local and regional both for humans and ecosystems. A number of developed countries are beginning to rehabilitate their aquatic systems, which they had seriously damaged a few decades ago. They have committed themselves to improve them further nationally and in shared river/lake basins through binding international agreements and conventions. This has been possible because

(a) Large parts of these countries have abundant water supply;
(b) These countries have stable population and the needed financial and expert human resources.

This is a result of their technological and social advancement and considerable commercial advantage over third world countries. They have been able to transfer large volumes of water to needy areas with scare

freshwater, but not without causing considerable ecological damage. The situation in developing countries can be summarized as follows:

(a) In many third world countries from times immemorial water crisis has continued to persist in water scarce-areas. Water crisis persists even in countries with adequate renewable water resources because their economic progress and management know-how cannot meet the challenge of rapid increase in population, urbanization and industrialization. Augmenting the proportion of budget for water resources development and management and organizing public education on water conservation and efficient use can produce desired results. The most appropriate external input would be undertaking collaborative joint ventures and investment. Improving the quality of life of people and efficiency in water use leading to rehabilitation of ecosystems.

(b) Over 50% of world's countries that use less than 1% of renewable water resources require special attention to increase the level of water use. Creation of food and water security is the only way of creating social stability and safeguarding of ecosystems.

(c) Water used for irrigation, the principal user and loser of water, can be reduced by almost one-half by applying new methods and equipment and improving water conveyance systems and management.

(d) Using ecosystem-based approach to water management can mitigate the crisis. For this it is necessary to increase investment in the ecosystem sector in general and the aquatic environment sector in particular and to mobilize greater participation of people.

(e) International agencies have done commendable work in alerting the world of the emerging freshwater crisis. They need to take some immediate concerted measures to meet the challenge. For this, they must co-ordinate their own programmes and translate their limited resources into constructive measures that would help water-stressed countries to improve their ecosystems.

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